Conservation and Environment Protection Authority

2019 State of Environment Report for Papua New Guinea

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THE PAPUA NEW GUINEA STATE OF ENVIRONMENT REPORT 2019

Forward message from the Prime Minister of Papua New Guinea

Papua New Guinea (PNG) is undergoing a drastic transformation in the last 44 years since she became an independent nation. However, the country is still not fully economically independent. The way we do business, trade and development are below par. We have also inherited some problems we have created ourselves over the years, from the way we do business and commerce, trade, and making poor decisions at the international geopolitical level, and at the national and local level.

There are many problems and challenges PNG has experienced in our brief history as a sovereign nation. Most of our institutons are performing below par than expected as well. We have seen our Human Development Index (HDI) deteriorating at appalling conditions. We have seen services and institutions not fuctioning vibrantly. Our environment and culture are also under immense pressure and threat never experienced before. Some of our unique biodiversity and culture are going into extinction or are under threat.

Nonetheless, I have confidence that we can turn all the negativities into positives. We can learn from our mistakes by forging a new direction to do business, work with our development partners and stakeholders, and improve our performance in improving the State of the Environment (SoE) for PNG. The Marape-Steven government envisage to make PNG one of the richest nation in the world within a decade. This translates to preserving our culture, species, and environment for our future generation.

We must have some decency and courtesy in the way we behave, to ensure our population is satistifed with the goods and services provided by the environment. That means we have to rebuild our economy without compromising the future of our children and their children. We have some of the best policies that can aid us achieve a green economy and sustainable development. Both the government and investors will be scrutinised in the way we deal with environment, social, economic as well as the welfare of the people.

The global community is now embarking on meeting new financial, trade and development sustainability and environment criteria, to mitigate the downside legal, market and reputational risks associated with goods and services that degrade environmental assets such as conventional forestry, agriculture and and mining are offering.

This is increasingly being reflected in assessments by Credit Rating Agencies (e.g. Moody's and S&P), statements by regulators, powerful investor disclosure initiatives (e.g. CDP), and ultimately, in higher insurance premiums for commudities worldwide. This change in investor sentiment is also nudging producers and supply-chain managers to seek alternative business models that improve environmental and social conditions, and that address consumer concerns; e.g. chemicals in food, deforestation and waste. The United Nations is also tasking member States to become economic sustainable through implementing the Sustainable Development Goal 'Agenda 2030'. Hence, conventional business models that destroy natural ecosystems must be phased out. Therefore, I believe this SoE Report is timely and will measure our progress in the next five years on how we manage our environment.

Honarable James Marape, MP

Pime Minister, Papua New Guinea

Forward message from the Minister of Environment and Conservation and Climate Change

PNG is endowed with rich natural resources and culture and is known as one of the cultural and mega biodiversity hotspots globally. Located on the eastern part of the island of New Guinea, PNG contains roughly 1 percent of the global landmass, with four major islands and over 600 islands and atolls. PNG also has one of the diverse reef system in the world and has a total of 3.12 square kilometers of economic exclusive zone (EEZ) of marine territory. Over 840 spoken languages exist and spoken by over 1000 different tribes.

PNG has now emerged as one of the strong advocate for environmental stewardship such as the global climate change. Over the years, several multilateral agreements have been signed by the Government of PNG, ratifying various international conventions and protocols sanctioned by the United Nations General Assembly, which PNG is a member. Conservation and Environment Protection Authority (CEPA) is currently the focal point for 14 Multilateral Environmental Agreements (MEA) such as the Convention on Biological Diversity, the Ramsar Convention and the Categana Protocol, just to name a few.

These conventions and protocols were adopted by the government of PNG and enacted in parliament. Hence, these MEAs have been recognised by laws for enforcement and implementation, for the conservation and management of the rich and diverse natural resources and environment PNG has.

CEPA is required to submit periodic reports to the respective MEAs secretariats. Since 2009, only 6 reports were submitted and this is not good enough. For various reasons, a national country report on the State of the Environment (SoE) is yet to be submitted to the United Nations. The 2019 State of the Environment Report is long overdue towards achieving the best environmental governance at the national level.

I am thankful to those multilateral partners such as United Nations Development Program (UNDP) and United Nations Environment Program (UNEP), and our regional partner Secratariat for Pacific Regional Environment Program (SPREP), for assisting PNG to support us delivery this Report. I am also grateful CEPA, together with contributions from other government agencies and other stakeholders participated in contributing to the finalisation and completion of this important document.

For transparency purposes, this SoE Report can be used by the public for reporting and planning purposes, because it provides a comprehensive review of many environmental issues, threats and pressures the country is facing or is vulenarble to.

Therefore, on behalf of the Marape-Stephen government, I recommend that all government agencies, development partners and donors, and civil society representatives use this SoE report to inform their actions related to the eight themes covered in this document: Environment Monitoring and Governance, Atmosphere and Climate, Land, Marine and Coastal, Biodiversity, Freshwater Quality, Built Environment, and Culture and Heritage. Thus, I invite you to help CEPA address the problems that are identified, to achieve a green and prosperous economy and a sustainable future.

Honorable Jeffery Kama, MP

Minister, Environment and Conservation and Climate Change

Forward Message from the Managing Director, Conservation and Environment Protection Authority

CEPA is the mandated government statutory body which is recognised by law for the management and conservation of PNG's vast natural resources, biodiversity and cultures. Despite many challenges faced by CEPA over time, this Report presents the lates update on the State of Environment (SoE) in PNG. Although information are scaterred, at least this Report provides a snapshot of where the country is, given the diverse pressures and threats the country is facing from both natural and anthropogenic causes.

With CEPA being the lead agency working with the Secretariat of the Pacific Regional Environment Programme (SPREP), information were collected from various national stakeholders and professionals. Hence, I am grateful to you all for your involvement, commitment and collaboration in producing this very important document.

Since the Government of PNG has ratified the United Nations Millenium Development Goals (MDGs) in 2009, implementation was below average and not much had been achieved. However, I commend the previous governments for developing national policies such as the Vision 2050, National Development Startegic Plan 2010-2030, National Sustainable Responsible Strategy for Development (STaRS), and the Medium Term Development Plan I-3, which captures PNG's vision for future development and environment sustainability priorities.

In 2015 the United Nations Agenda 2030 or the Sustainable Devleopment Goal (SDG) was proposed and adapted by member States including PNG. The Agenda 2030 provides international targets which PNG must report on as well.

Recognizing PNG's vulnerability to both human induced anthropogenic drivers and pressures and natural threats such as climate change, invasive speices, species extinction, pollution and environment degradation, the SoE Report is an assessment of the status and conditions of the major environmental resources in PNG. The SoE Report uses the DPSIR1 reporting model to create a comprehensive account of the state of environment in PNG. It identifies Driving Forces and Pressures that result in the current State of Environment and suggesting a potential Response strategy. It concludes with a set of actionable recommendations for future legislative or other actions. Hence, I envisage the general public, development partners, business entities and State agencies will work collaboratively to address issues flagged in this Report.

While PNG is proud to have produced this comprehensive Report, all stakeholders must know that our journey does not stop here. We are committed to producing regular updates every 5 years by tracking and evaluating the progress we have made. Only by knowing what is happening on the ground, we can be able to make inform decisions in fulfilling our international obligations to conserve and manage our natural assests sustainably. Thus, I am encouraging you all stakeholders to work collaboratively in collecting, storing, sharing and managing data and information.

Gunther Joku

Managing Director

Forward message from the Director of SPREP

The natural environment has always been part of Pacific island cultures. It has shaped and influenced our way of life over the centuries and as the primary source providing for our Pacific communities, it has fed, clothed and kept us safe over the years.

Despite its immense value, our environment is under growing pressure due to economic development, tourism expansion and the threat of global climate change. Therefore, it is important that we continue monitoring and maintaining the quality of our environment for future generations.

The 2019 Papua New Guinea (PNG) State of Environment (SoE) Report is the first report completed in November 2019. The report assesses eight themes as well as the baseline information for new and emerging environmental challenges.

This report places the emphasis on data-based conclusions and presents supporting evidence for all indicators.

The 2019 SoE Report is a new baseline for future reports and can help Papua New Guinea with national, regional and international reporting obligations, including multi-lateral environmental agreements. This report will inform environmental planning and decision-making, and certainly will guide the development of other MEA reporting and environment management strategy.

SPREP is pleased to have partnered with the Conservation and Environment Protection Authority (CEPA) in developing this document, as well as the many other agencies and civil society organisations that contributed during the consultative process.

I would like to sincerely thank individuals and all the government ministries and departments for their contributions. It is important that regular updates to this SoE Report are conducted to assess Papua New Guinea's environmental conditions. I encourage you all to use this report to help track, manage, plan and report on natural resources and the environment.

Kosi Latu

Director General
Secretariat of the Pacific Regional Environment Programme

Acknowledgments

Introductory information specific to country.

COORDINATION AND PLANNING

ENVIRONMENTAL DEPARTMENT NAME:

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2.0 SECTION 1: INTRODUCTION, BACKGROUND AND HIGHLIGHTS OF THE 2019 SOE REPORT

BACKGROUND, ACKNOWLEDGEMENT AND TIMELINE

The 2019 Papua New Guinea State of the Environment Report was nested within the lead agency of the Conservation and Environment Protection Authority (CEPA), which is based in Port Moresby.

An initial inception workshop to facilitate the participation by key staff from National Government Agencies, Development Partners, Universities, private entities, professionals, Non-government Organisation and other stakeholders was held at the CEPA's office on Thursday July 11^{th} 2019. It became apparent that this was also a socialisation of the different entities and thematic experts to understand the significance and purpose of the SoE. The SoE where relevant agencies or professionals are connected or involved with were invited to assist in the writing process by their agency expertise.

Data in the form of reports and papers was collated by the lead author to ensure the SoE is populated. The draft was redistributed to key persons in various line agencies for comments in a pre-writeshop.

A writeshop was latter held and various thematic experts who received the draft report, especially those who attended the pre-writeshop or were invited latter reconvene to discuss the report on 24^{th} of July 2019. Technical input provided were then incorporated into a series of drafts, including discussion points provided during thematic group discussions from the pre-writeshop and writeshop. Concurrently all mapping options available on the UNEP and UNBiodiversity Lab site and available within PNG and elsewhere were collated along with other graphics and images. Table 1.1 below shows the timeline of the State of the Environment (SoE) 2019 report.

Table 1-1 Timeline of Papua New Guinea SoE Report 2019

Year	Month	Activities	Consultaive groups
2018	December	• Recruitment of National Coordinator and Consultant	
2019	January-March	Data Collection and consultation	Line Agencies
	April	• Data collection • SoE drafting • SoE Report writing training	Line Agencies and idesktop
	May-June	• SoE drafting and	Office
		•	
	July	• SoE editing	Office

		• SoE Pre-writeshop • SoE Writeshop	Line agencies and professionals
	August	• Submission of final SoE Themetic draft to SPREP completed	SPREP
	August	• Final Draft	SPREP
	September	• Vetting of the Report • NEC submission to State Solicitor with comments from agencies • PM, Minister, MD and DG to soign	
	October	• Final Document for PRinting	
	November	• Publication, printing and launching	

EXECUTIVE SUMMARY

PNG is rapidly changing and so is the environment. The changes are driven by broader social, political, economical, technological and cultural forces referred to as 'drivers'. These include population growth, urbanisation, lack of enforcement and monitoring, tourism, economic development, government policies, increasing access to external markets, a growing middle class, the clash of traditional and contemporary values, and greater access to technology. In hindsight, these drivers are a source of further pressure on the environment but coincidently they can also offer potential solutions to problems faced in country.

The 2019 State of Environment (SoE) Report for Papua New Guinea (PNG) is the first SoE Report, and uses the Drivers, Pressures, State, Impact and Response (DPSIR) model of reporting. The main aims of this Report are to:

- Identify the key drivers and pressures behind the changing environment in PNG;
- Identify and document PNG's environmental conditions through use of the best available information for seven key thematic areas: Atmosphere and Climate, Inland Waters, Land, Marine, Biodiversity, Culture and Heritage, and Built Environment;
- Document the social, economic and environmental impacts that result from changes in the state of the environment;
- Document current responses by PNG to address changes in the state of the environment that better protect and manage resources; and
- Provide recommendations for PNG o address key challenges and build on existing strengths, which are linked to actions outlined by the National Environmental Management Strategy (NEMS).

This Report is comprised of three discussions:

1. Drivers and Pressures in PNG: A summary of the main points discussed in the Pressures and Drivers section of the report.

2. The State of Environment and Impacts on the Society, Economy and Environment: Key findings for each of the eight themes.

3. Responses and Recommendations – Challenges in moving from Policy to Action: This presents key responses, opportunities, challenges and recommendations.

Section 1 discusses the purpose of the 2019 PNG SoE Report, the significance, what it is measured against, what model it is using, what audience it is addressing and how to read this Report. It provides a background information in understanding the Report.

The Environment Act 2000, Part II Section 4 (c) and (j), clearly spells out the objects and general environment duty of promoting wise use and management of resources and the environment from harmful effects, ensuring development is done holistically to improve the quality of life and thereby maintained the ecological processes and environment quality.

Of particular interest to this Report, Section 4 (c) and (j). Section 4 (c) recognises the *objects and principles in respect of environmental conservation matters contained in international agreements and treaties to which the State is a party*. Section 4 (j) states CEPA has *to provide a means for carrying into effect, obligations under any international treaty or convention relating to the environment to which Papua New Guinea is a party*. This means CEPA is oblige to present reports, including the State of Environment (SoE) on a timely basis to Multinational Environment Agreements (MEA) Secretariats where appropriate.

The purpose of the 2019 Papua New Guinea (PNG) State of the Environment Report (SoE) is to present the best available information about the current state of the environment as the basis for effective environmental management and planning, and reporting. The SoE Report examines and evaluates 11 major drivers of change to the environment that emerge from global, regional and national development experience. It also disucsses the main environmental pressures namely land development, resource extraction and consumption and wastes created by these drivers, and examines their social, economic and environmental impacts on the wellbeing of the population.

This 2019 SoE Report for PNG is significant because it is an internationally accepted reporting method that analyses the condition of a geographic area or jurisdiction's ecosystems, and associated natural resources. It compiles and analyses quantitative and qualitative data from a variety of local, national, regional, and international sources to provide a holistic picture of a country's or locations' current state of the environment. It also identifies environmental trends, including anthropogenic impacts to natural environments. Most SoE reporting formats or information are different for each country, however, some issues are cross-cutting.

The priority of the SoE report is to show the state of most important environmental attributes of a given location, country or region and identify issues that impact the state of the location's environment. It provides the condition of flora and fauna species as well as habitats such as native forests, marine and inland water bodies, soils, and vegetation cover.

Based on the findings, the SoE Report predict a PNG's future state, which is often related to problems within that environment. These predictions can help to address growing concerns, for instance, about the impacts of climate change, by offering ideas of the future state of the environment under 'business as usual' scenarios. It provides well-researched information for local, municipal, and national planners and managers in areas such as natural resource management, climate change adaptation and resilience, town and urban planning, tourism, and resource development. This Report can be used by a variety of people and targets namely:

- PNG government agencies and personnel, particularly those in the environment, planning and infrastructure, culture, health, and education;
- Citizens and community groups;
- Donor organisations and development partners;
- Non-governmental organisations and other Community based organisations; and
- Research institutions and universities, and researchers with specific interests to the SoE report's thematic areas.

The 2019 PNG SoE Report is the first report ever done for PNG. The Report came about when a letter of interest was sent to the Director General of Secretariat for Pacific Regional Environment Program (SPREP) by the Managing Director of Conservation and Environment

Protection Authority (CEPA) on April 18th, 2018. This prompted the work on the Report and other activities to eventuate.

There is nothing for this Report to measure against. However, the report discussed briefly about the 176 international Protocols and Conventions PNG has ratified, which are managed by various government agencies. It also talks breiftly on CEPA as the focal point for 14 Multilateral Environment afgreements (MEAs). It also iterates on the Millennium Development Goal (MDG) 2010-2015 which nothing much has been achieved by the Government of PNG (GoPNG).

Table 1-2: Major Drivers of environment change and indicators

#	Drivers	Key indicator
1	Population demographics and migration	Regional and national population changes, migration and household composition
2	Globalisation	Shipping patterns and connectivity, importation of consumer products and Multilateral Environment Agreements
3	Economic development	Access to internet and communication, global and economic sectors trends and GDP per capita and income distribution across pacific and PNG
4	Government policies	Policies to improve standard of living and sustainable development and green growth
5	Governance and enforcement	Trend in resource management, governance and enforcement of rules and laws in project development
6	Land-use change	State of the forest, land, sea pertaining to logging, agriculture, mining, and fire
7	Invasive Species	Trend in Invasive species
8	Extractive industries	Trend in resource development
9	Climate change and variability	Trend in climate change and vulnerability on terrestrial, coastal and marine ecosystems
10	Pollution	Trend in pollution on land, marine, air and water
11	Development access-corridors	Trend in resource utilisation and development

Table 1-3. Major pressures on PNG's environment

Pressures	Land Development	Resource Extraction	Consumption and Waste
Key Indicators	Urban and Development	Logging	Energy consumption
	Agriculture	Over hunting and fishing	Solid and liquid waste Generation
	Roads and infrastructure	Illegal trade	

The 2019 PNG SoE Report also elaborates on government polcies such as the Vision 2015, National Development strategic Plan (DSP) 2010-2030, Strategy for Responsible sustainable Development (StaRS), and Medium Term Development Plan (MTDP) 1-3. It discusses the challenges and intention of the GoPNG to achieve sustainability goals. Others policies and plans such as the National Biodiversity Strategic Action Plan (NBSAP) and CBD and Acts of parliament were discussed, yet most have achieved very little outputs.

The 2019 PNG SoE Report uses the standard Drivers, Pressures, State, Impact and Response (DPSIR) Model used righ across the Pacific shown below. The drivers, pressures, state, impact and response are discussed which will be discussed briefly below (Fig. 1-1). The model is a global standard for State of Environment reporting and part of a systems approach that takes into account social, political, economic, and technological factors, as well as forces associated with the natural world. These drivers and pressures are discussed in Section 2 which discusses the major Drivers and Pressures in the Report. There are eleven main drivers behind environmental change in PNG that are discussed. These drivers have global, regional and national indicators discussed (Table 1-2). Furthermore, the major pressures on the Papua New Guinea's environment are also discussed (Table 1-3).

Section 3 discusses the eight thematic areas or 'theme,' which important ecosystems and environmental issues being discussed for each theme. For example, the Marine Environment theme is divided into seven sub-topics and looks at:
1. Offshore marine environment and fish biomass;
2. The Inshore marine environment and fish biomass;
3. Marine managed areas;
4. Live coral cover;
5. Lagoon water quality; and
6. Endangered marine mammals and cetaceans, rays, sharks and turtles.

The standard reporting format and symbols for the PNG SoE Report was developed and produced by SPREP and are used throughout the Pacific Island countries. The SoE Report condenses a large amount of information on various aspects of the environment into a readable and actionable report.

Given the broad spectrum of topics covered, the report has been broken down into themes for easier utilization. Hence it can be read as a whole, or according to different themes, noting that most of the themes are connected to each other and to the pressures and drivers behind them.

Symbols were designed for each indicator to summarise the State, Trend and Confidence in each assessment as indicated below (Fig. 1-2). The Guide to interpreting the Report is also provided in Table 1-4. A total of 52 symboles are available to choose from depicting the Status, Trend and Data confidence and having different colour codes.

The SoE Report assessments integrate many data sources and expert opinions. For the PNG SoE Report, there may not be enough information available to make quantitative assessments of the state of an environment using, for example, an index of 1-10, or a quantitative threshold figure, that could be compared across themes. Consequently, a generic index was developed that used expert opinions and best available data to inform 'Status' ratings of either 'Good', 'Fair', and 'Poor'.

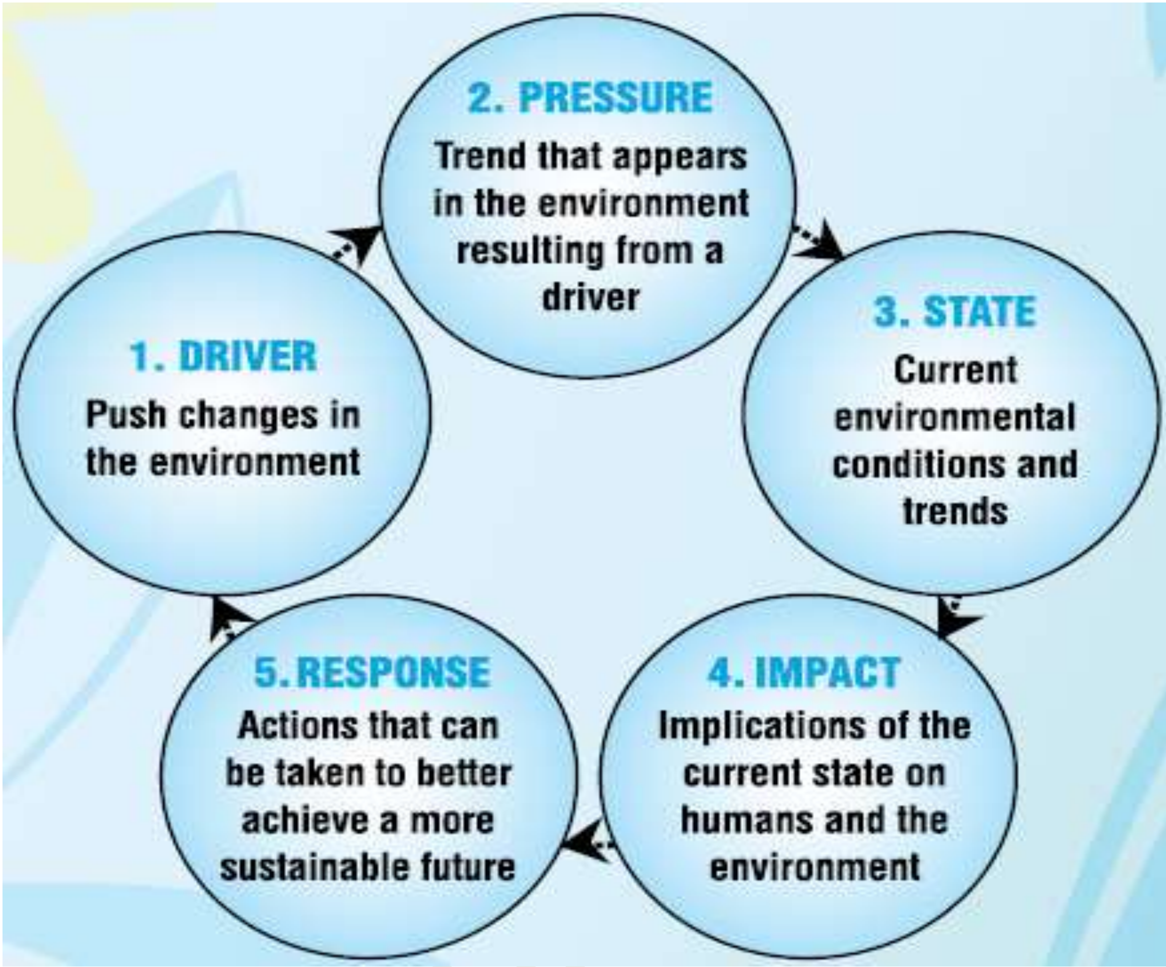


Figure 1-1. DPSIR model used in the State of the Environment Report

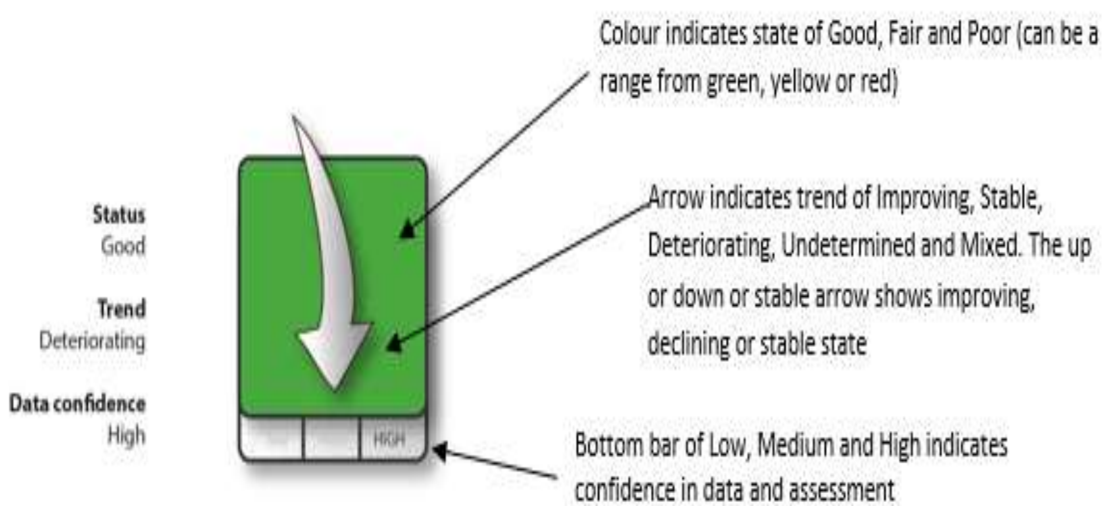
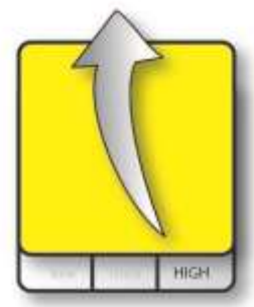
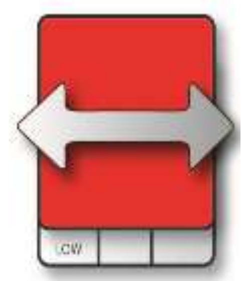


Figure 1-2: Example of the summary of the state of the Environment.

Table 1-4. Guide to interpreting the symbols

	Category	Description	How is it derived?	Symbol Example
State (can be a range)	Good Fair Poor	The level to which the indicator meets or exceeds (good), is close to meeting (fair) or is well below (poor) a given standard for healthy ecosystems, habitats, species, airsheds, watersheds or an urban environment.	Assessment is based on 1) recent trends, 2) comparison with similar jurisdictions, and 3) comparison with 'healthy' habitats and systems. Where limited data exists to make an assessment based on these criteria, expert opinion is used.	
Trend	Improving	The state of the environment related to this indicator is getting better.	Trends show a significant increase, or based on weight of evidence that indicators are improving.	
	Deteriorating	The state of the environment related to this indicator is getting worse.	Trends show a significant decrease, or based on weight of evidence that indicators are worsening.	
	Stable	The state of the environment related to this indicator shows there is no detectable change.	Trends show no significant increase or decrease, or, based on weight of evidence that indicators are stable.	

	Mixed	The state of the environment related to this indicator shows a mixed trend: sometimes the state is getting better, worse, or there is no change.	Used primarily for sub-topics with multiple indicators, or in cases where data shows two distinct trends.	
	Undetermined	Not enough data exists to determine trend.	Insufficient data available to generate trend.	
Cofidence	High	Data is of high quality and provides good spatial and temporal	Trusted and comprehensive time series and/or national	
	Medium	Data is either lower quality, geographically sparse	Data is derived from many sources, and is not always consistent, with	
	Low	Data does not meet any of the above criteria.	Data is very coarse and outdated, and limited to single country sites.	

Moreover, in Section 3, a general summary or highlights of each themes was provided as for the readers. Different themes and indicators identified for PNG are then discussed in detail with the Definition of each indicators defined upfront. This Section also listed the Sustainable Development Goal (SDG) and the Convention on Biodiversity (CBD) Aichi Targets for each themes and indicators which can be used in addressing issues pertaining to the state of the environment and how to manage those impacts.

Furthermore, the Status and Trend (state) of the themes and indicators are discussed also in summation of the available information and data. The Impact section provides opinions on how to mitigate or address the state of the environment, especially when the environment becomes degraded or is degenerating. Finally, the Reponse section provides recommendation on how to address or mitigate those identified issues.

All in all, Section 3 discusses the State of the Environment by Theme, State, SDG and CBD Archi Target, State of Trend, Impact that may ahhen to the environment and Response to Indicators within the eight themes and subdivided into topics. The eight thematic areas or themes covered in the SoE report are:

- **Governance and monitoring** (Approved government budget, Approved Environment Impact Statement for

Development, MEA Reporting requirements and Environment cases prosecuted);

- **Atmosphere and climate** (Trend in Greenhouse Gases (GHGs) emissions; Trend in Consumption of Ozone-depleting Substances (ODS); Physical Climate (air temperature, precipitation, and extreme climatic events); Climate-related Disaster Loss; and Climate Adaptation and Disaster Funding (food security, water security, health and flood risks);
- **Freshwater resources** (Access to freshwater and Freshwater quality);
- **Land** (Forest, land under cultivation, Wetlands and Terrestrial protected areas);
- **Coastal and Marine** (Offshore marine environment and fish biomass, Inshore marine environment and fish biomass, Marine managed areas, Endangered marine species, Live coral cover and Lagoon water quality);
- **Biodiversity** (Species diversity and endemism, Endemic and native species, Threatened species and species of concern, and Invasive or exotic species);
- **Built Environment** (Household waste capture rate, Per capita generation of municipal waste, Household waste recycle, Access to quality sewerage treatment, Transport Energy, Solid and liquid waste management and Energy consumption management); and
- **Culture and heritage** (Culture and history, Traditional diet and medicine and Customary land tenure).

Section 4 provides the Summary and Recommendations of the 2019 PNG SoE Report. It provides conclusion of the report and recommendations to building on successes and strengthening weaknesses on how PNG could manage its environment.

PNG in its young history has never been faced with increasing threats from direct and indirect drivers caused by globalisation and escalating population, climate change and other natural or man-made issues.

The demand for goods and services has escalated rapidly in the last 44 years as pressures from both anthropogenic and natural causes on the environment increases and our livelihood has increased spontaneously. It has never been more urgent now to address those issues in a more robust and holistic approach than ever before. PNG and the world has never before been under immense pressure to conserve and protect its environment from a wide array of threats, and the future of this nation and our children depends much on the decisions and actions we make today that will last forever in the annals of history.

Overall the state of the environment shows mixed result in the trend, status and data confidence indicating mixture of good, fair, poor and some unknown states (Figure 1-3). The staus of the environment is still good and some habitats and ecosystems are still intact or pristine but degrading with 43% being high, medium with 35% and low with 22% (Figure 1-4). Since data is lacking in many areas, data confidence can be summed as good with 22%, Fair, Fair to Poor and Good to Fair comprised 16% each while Good to Poor consists of only 5% (Figure 1-5). Hence, more research are needed to verify the findings of the status and condition or trend of the environment in the future.

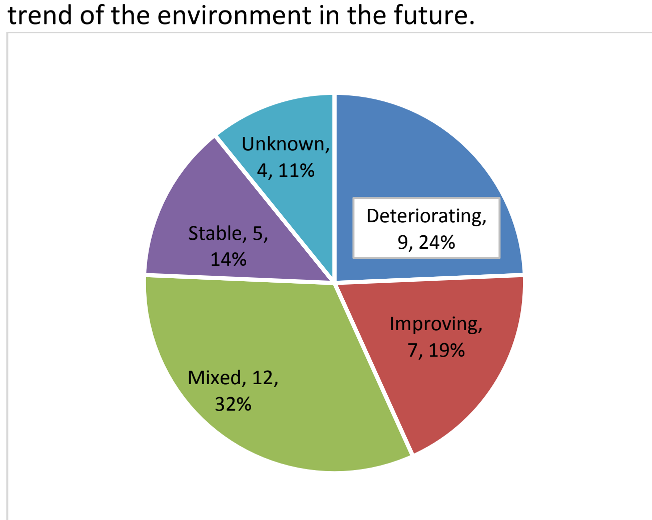


Figure 1-3: Trend of state of the Environment

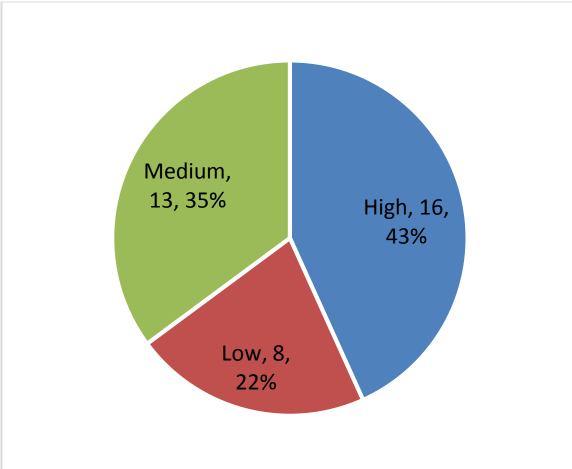


Figure 1-4. Status of state of the Environment

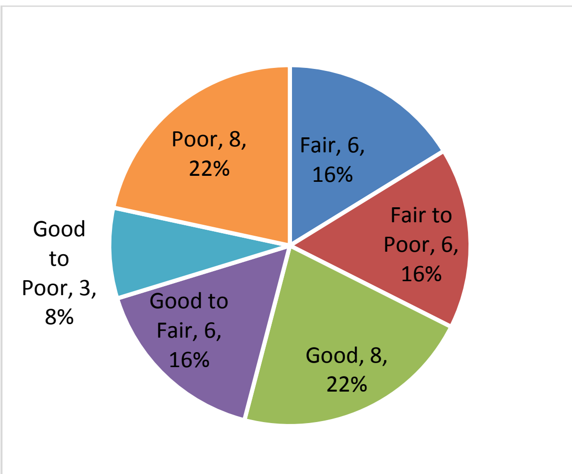


Figure 1-5. Data Confidence of state of the Environment

Given that over 22 percent of the "state" conditions in this Report are Poor and Good, 16 per cent are Fair, Fair to Good and Good to Fair, while 8 percent are Good to Poor, and 44 percent fair, it is advisable that PNG conduct an environmental audit and legislative review of exisiting Laws. This must be in the form of research to help determine if existing laws and regulations are sufficient to protect the environment and guide development, or if the challenges lie in the implementation of the existing policies and regulations.

A major challenge in conducting the 2019 PNG SOE was compiling, analysing and processing data held by various departments, agencies and ministries. A key recommendation for future work is to build off the base line set in this Report and develop monitoring to fill the data gaps. A data storage solution is needed which has already developed by CEPA which will allow intra and inter-department/ministry data sharing through signing of Memorandum of Understanding or Memorandum of Agreement for data analysis and data sharing for the SOE and other reporting processes, including those to multilateral environmental agreements. A mandatory amendment to the existing laws should enable this to happen.

Most of the negative trends in the SoE indicators can be traced back to unplanned and unregulated development, settlement and commercial activities. PNG should consider complementing their environmental impact assessment (EIA) and Environment Impact Statement (EIS) process with a targeted programme of mitigation for many of the indicators addressed in the SOE by:

- Strengthening monitoring and enforcement of standards of septic systems to reduce sewage effluent;
- Improving waste collection, landfill management and recycling as waste generation rates are likely to increase with the rising urban population;
- Developing urban planning and policies, as well as Strategic Environment Assessment (SEA), to better address urban liveability and green spaces;
- Establishing a professional Body or Association for Environment Impact Assessors. Practitioners are mandotary required to become members and their practices are guided by the constitution of the Association. If damages are done to the environment, their membership will become invalid, hence they may not practice or be suspended from practising

EIA/EIS. Such penalty should ensure practices are conformed to regulations;

- CEPA has now increase fees for environment non compliance in the new PA bill. This would probably deter bad environment practices. A new environment maximum determined environment bond fee should be charge to companies exploiting the resources. Hence, any environment degradation or destruction means this money should be used to mitigate issues. These funds should be kept in CEPA's conservation and environment trust fund;
- Use an EIA and EIS to assist the regulatory focus on key projects and sites. This means human capacity, resources, knowledge and laboratory should be upgraded to ensure independent assement of EIA or EIS;
- Train enforcement officers for monitoring and enforcement activities to deal with paralegal matters;
- Conduct a national environmental planning process using the SoE results and recommendations as a platform for future SoE;
- Develop templates for data collection and enact laws that allows for flow of information from top to bottom tiers of government to ensure data is collected for all environment indicators.

Finally the challenge for PNG to move on is to conduct efficient enforcement and monitoring, research, capacity building awareness raising and data storage. An office specifically for managing all MEA reports should be established within CEPA. The role of this office is to ensure it developed its own monitoring and evaluation programs, and is capable of managing funds and use them for such work on MEAs. This office needs to develop or digitised environment modelling maps using the Digital Elevation model (DEM) for both marine and terrestrial thematic environmental indicators.

In conclusion, this office must be accreditated with internationally recognised systems to managed funds for MEAs. This will enable the office to report directly to MEA secratariats and to access funding directly from donor and whatever management fees raised can be used to manage the MEAs focal poinst in PNG, including the SoE reporting. Also Appropriate MOUs need to be singed by CEPA, line government agencies and other stateholders and provincial government to ensure collaborative work is done.

ACRONYMS

ADB	Asian Development Bank
AFB	Adaptation Fund Board
AIACC	Assessment of Impacts and Adaptation to Climate Change
ANZAC	Australian and New Zealand Army Corps
ARD	Acid Rock Drainage
AusAID	Australian Agency for International Development
BCS	Bogia Coconut Syndrome
CBB	Coffee Berry Borer
CBD	Convention on Biological Diversity
CBDAMPIC	Capacity Building for the Development of Adaptation Measures in Pacific Island Countries
CELCOR	Center for Environment and Community Rights
CFC	Chlorofluorocarbon
CfRN	Coalition for Rainforest Nation
CH_4	Methane
CHARM	Comprehensive Hazard and Risk Management
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLIMAP	Climate Change Adaptation Programme for the Pacific
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CO_2	Carbon dioxide
COT	Crown of Thorns (starfish)
CPI	Corruption Perception Index
CPB	Cocoa Pod Borer
CSIRO	Commonwealth Scientific International Research Organisation of Australia
DAL	The Department of Agriculture and Livestock
DEC	Department of Environment and Conservation
DLPP	Department of Lands and Physical Planning
DO	Dissolved Oxygen
DPR	Daily Pollution Release
DSTD	Deep Sea Tailings Disposal
DPSIR	Drivers, Pressures, State, Impact and Response
DRM	Disaster Risk Management
EAFM	Ecosystem Approach to Fisheries Management
EbA	Ecosystem-based Adaption
EC	Electrical conductivity

EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ENSO	*El Niño* - Southern Oscillation
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
FIA	Fishing Industry Asssociation of Papua New Guinea
FSSLP	Food Security for Sustainable Livelihoods Programme
GCRMN	Global Coral Reef Monitoring Network
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Greenhouse Gases
GoPNG	Government of Papua New Guinea
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
IAS	Invasive Alien Species
IBA	Important Bird Areas
ICRAF	Individual and Community Rights Advocacy Forum
IFAD	Inshore Fish Aggregating Devices
INDC	Intended Nationally Determined Contribution
IPPC	International Plant Protection Convention
IUU	Illegal, unreported and unregulated fishing
JNAP	Joint National Action Plan
KBA	Key Biodiversity Areas
KPAF-SRIC	Kyoto Protocol Adaptation Fund Project Proposal Strengthening Resilience of Our Islands and Communities
LULUCF	Land use, Land-Use Change and Forestry
LTDG	Long Term Development Goal
MDG	Millennium Development Goal
MEA	Multilateral Environment Agreement
MFF	Multi-tranche Financing Facility
MMA	Marine-managed Area
MOA	Ministry of Agriculture
MOIF	Ministry of Infrastructure and Planning
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MSG	Melanesian Spearhead Group
MSW	Municipal Solid Waste

MSY	Maximum Sustainable Yield
MTDP	Medium Term Development Plan
NA	Nesting Aggregation
NBIS	National Biodiversity Information System
NBSAP	National Biodiversity Strategic Action Plan
NCP	National content Plan
NDoH	National Department of Health
NEMS	National Environmental Management Strategy
NESAF	National Environment Strategic Action Framework
NSLUP	National Sustainable Land Use Policy
NGO	Non-governmental Organisation
NH_4	Ammonium
NMDI	National Minimum Development Indicator
N_20	Nitrous Oxide
NO_3	Nitrate
NSDP	National Sustainable Development Plan
NZAid	New Zealand Agency for International Development
NZD	New Zealand Dollar
ODS	Ozone-depleting Substances
OPM	Office of the Prime Minister
PACC	Pacific Adaptation to Climate Change
Pa Enua	Outer Islands
PASAP	Pacific Adaptation Strategy Assistance Programme
PCRAFI	Pacific Catastrophe Risk Assessment and Financing Initiative
PFC	Perfluorocarbons
PIC	Pacific Island Countries
PNA	Pacific Nauru Agreement
PNG	Papua New Guinea
PPAP	Productive Partnerships in Agriculture Project
PROCFish	Pacific Regional Oceanic and Coastal Fisheries Programme
SABL	Sustainable Agriculture business Lease
SF_6	Sulphur hexafluoride
SoE	State of Environment
SOPAC	Pacific Islands Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
SPCZ	South Pacific Convergence Zone
SPREP	Secretariat of the Pacific Regional Environment Programme
SST	Sea Surface Temperature

StaRS	National Strategy for Responsible Sustainable Development
SUP	Sanitation Upgrade Project
SWOT	State of Worlds Sea Turtles
TDS	Total Dissolved Substance
TNC	The Nature Conservancy
TREDS	Turtle Research and Monitoring Database System
TSS	Total Suspended Solids
UNCED	United Nations Convention on Environment and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Sceintific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
USD	US Dollar
UVC	Underwater Visual Census (survey method)
VCA	Vulnerability and Capacity Assessment
VTD	Vessel Tracking Device
WATSAN	Water Waste and Sanitation Unit of ICI
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WHA	World Heritage Area
WWF	World Wildlife Fund

3. INTRODUCTION AND READER'S GUIDE TO THE 2019 SOE

3.1 Background on environmental reporting in Papua New Guinea (PNG)

The Environment Act 2000, Part II section 4, clearly spells out the objects and general environment duty of promoting wise use and management of resources and the environment from harmful effects, ensuring development is done holistically to improve the quality of life and thereby maintained the ecological processes and environment quality. Of particular interest to this Report, Section 4 (j) states that CEPA has *to provide a means for carrying into effect, obligations under any international treaty or convention relating to the environment to which Papua New Guinea is a party*. In addition, Section 4 (c), recognises the *objects and principles in respect of environmental conservation matters contained in international agreements and treaties to which the State is a party*. This means CEPA is oblige to present reports, including the State of Environment (SoE) on a timely basis to Multinational Environment Agreements (MEA) Secretariats where appropriate.

This SoE report is the first of its kind for PNG. In April 2018, the Managing Director of CEPA wrote to SPREP inviting it to assist PNG furnish a SoE Report. Hence a consultant was hired by SPREP to work with them and other key partners in PNG to collate and compile information and to write this Report. Inputs from a wide array of people and organisations were sought, including datasets and where appropriate information that are not available, information were sought form published reports and other sources elsewhere.

A five year cycle to this initial SoE report would be conducive until such a time when someone is recruited fulltime to improve the report over time.

3.2 Purpose of the State of Environment Report

The purpose of the PNG SoE Report is to present the best available information about the current state of the environment as the basis for effective environmental management and planning, and reporting. The SoE Report examines 11 major drivers of change to the environment that emerge from global, regional and national development experience. The SoE Report also evaluates the main environmental pressures namely land development, resource extraction and consumption and wastes created by these drivers, and examines their social, economic and environmental impacts on the wellbeing of the population.

The SoE reporting is an internationally accepted reporting method that analyses the condition of a geographic area or jurisdiction's ecosystems, and associated natural resources. SoE Reports also compile and analyse quantitative and qualitative data from a variety of local, national, regional, and international sources to provide a holistic picture of a country's or locations' current state of the environment. The SoE Report also identifies environmental trends, including anthropogenic impacts to natural environments. Most SoE reporting formats or information are different for each country, however, some issues are cross-cutting.

The SoE Report prioritise the most important environmental attributes of a given location, country or region and identify issues that impact the state of the location's environment. The report have included the condition of flora and fauna species as well as habitats such as native forests, marine and inland water bodies, soils, and vegetation cover. The report also address key aspects of highly modified agricultural and built environments, and the changing culture and heritage.

Many SoE Reports also predict a location's or country's future state, which is often related to problems within that environment. These predictions can help to address growing concerns, for instance, about the impacts of climate change, by offering ideas of the future state of the environment under 'business as usual' scenarios. Consequently, this can inspire climate change adaptation and mitigation strategies that address emerging issues and threats. The same predictions can be made on deforestation, waste management, water quality, agriculture development amongst others.

SoE Reports also provide well-researched information for local, municipal, and national planners and managers in areas such as natural resource management, climate change adaptation and resilience, town and urban planning, tourism, and resource development.

3.3 Audiences

The main audiences for the PNG SoE Report are:

- PNG government agencies and personnel, particularly those in the environment, culture, planning and infrastructure, health, and education;
- Citizens and community groups;
- Donor organisations and development partners;
- Non-governmental organisations e.g. World Wildlife Fund for Nature (WWF), The Nature Conservancy (TNC), Wildlife Conservation Society (WCS), Partners with Melanesia (PwM), Tree Kangaroo Conservation Alliance (TKCA), Research Conservation Foundation (RCF), PNG Forest Stewardship Council and other Community based organisations; and
- Research institutions and universities, and researchers with specific interests to the SoE report's thematic areas.

3.4. Comparing the last version of SoE Report (*if applicable*) and previous State of Environment (SoE) Reports

PNG has ratified a large number of Multilateral Environment Agreements (MEA) that has reporting obligations. Currently, about 15 MEAs are managed by CEPA and most reporting are lagging behind because there exist challenges in producing timely reports. One reason is that the MEAS are very costly to implement and need substantial amount of resources, such as financial and human resources. Given the lack of availability of resources, it results in poor reporting and implementation of the MEAs (GoPNG and UNDP, 2010).

In total, there are 176 international Protocols and Conventions PNG has ratified, which are managed by various government agencies. For instance, the United Nation Framework Convention on Climate Change (UNFCCC) is managed by the Climate Change and Development Authority (CCDA) as the focal point. The Convention on the Law of the Sea is managed by the Department of Justice and Attorney General. There are also many conventions PNG is signatory to such as the manged by the International Marine Organisation (IMO) such as Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS Protocol) and others which CEPA administers indirectly because they are environment and conservation oriented.

Table 1.2 shows 14 international and regional MEAs managed by CEPA and the year adopted and ratified by the government of PNG.

Table 1.2: 14 MEAs manged by CEPA and the year ratified by the Government of PNG (CEPA)

MEA	Year Ratified
Convention on Biological Diversity (CBD)	1993
Convention to Combat Desertification (CCD)	2000
Convention on International Trade in endangered Species of Wild Fauna and Flora (CITES)	1973
Convention on Wetlands of Importance, especially as Waterfowl Habitats, (Ramsar)	1971
Convention for the Protection of the World Cultural Natural Heritage	1972
Basel Convention on the Trans-boundary Movement of Hazardous Wastes and their Disposal	1989
Protocol on Biosafety (Cartagena Protocol)	
Stockholm Convention on Persistent Organic Pollutants (POPS)	
Rotterdam Convention on the Prior Informed Consent Procedure for certain Hazardous Chemicals and Pesticides in International Trade (Rotterdam Convention)	
Vienna Convention for the Protection of the Ozone Layer	1985
Convention to Ban the Importation in Forum Island Countries of Hazardous Waste and Radioactive Wastes and to Control the Transboundary Movement and Management of Hazardous Wastes within the South Pacific Region (Waigani Convention)	
Convention on Conservation of Nature in the South Pacific Region (Apia Convention)	1996
Convention for the Protection of the Natural Resources and Environment of the South Pacific Region and related Protocols (SPREP Protocol)	1986

Since there was no previous SoE report to report against, a good measure to start with would be to report on the Millennium Development Goal (MDG). Between 1990 and 2010, there were mixed results in achieving the MDG goals because there was little progress to stagnancy, or deterioration in achieving the targets. Most MDGs were incorporated or tailored into the government policies such as the Development Strategic Plan 2010-2030 (DSP), Medium Term Development Plan I-I (MTDP) and National Strategy for Responsible Sustainable Development (STaRS).

The challenge was to have complete achieving those targets, however lack of reliable data to measure those global indicators against the local policy indicators were lacking. In otherwords, not much has been conducted to meet those targets or goals. Even though those global MDG indicators and targets were incorporated into the national development policies targets, most were fairly achieved while others were not achieved due to lack of implementation. In addition, most if not all MDGs were not captured in local plans of each provincial and district governments. Hence, achieving those targets were never achieved between 2010 and 2015.

Consequently, this affects the achievements of international MDGs progress. Issues such as HIV/AIDs epidemic, increasing population and development activities that put stress on the environment and development, lack of governance, deficiency in service delivery, poverty of opportunity, gender culture and gender disparity, climate change, and environmental degradation were yet to be addressed in most sectors. In addition, sustainable livelihood, spatial disparity and low level of formal education and literacy, nonexistence or deficient legislation, policy and plans, conversion of economic growth into human development, extreme cultural diversity and poor database for monitoring of MDGs also exist (GoPNG and UNDP, 2010).

It was concluded that during the 14 years between 1990 and 2015 cycle, the MDG was unsatisfactory, thus PNG was not on track to achieve most of those global MDGs. With the new 'Agenda 2030' known as the Sustainable Development Goals (SDG) cycle (2016-2030), the chances of achieving those goals and targets is still remote. More recently MTDP III also incorporates those national targets as well together with StARS, DPS 2010-2030 and Vision 2050.

Given the appalling condition of implementing the MDG and recently SDG, it must be noted that PNG has its own challenges in prioritization and implementation of many international goals, indicators and targets. There seem to be a growing inconsistency with activities on the ground and PNG's commitment to sustainable development at international level.

For instance, though PNG is a founding member for Coalition for Rainforest Nations (CfRN) that strongly calls for REDD+ in response to Kyoto Protocol, logging industry has been a lifeline for the country. Sherman et al. (2008) reported several major driver of deforestation and forest degradation include large-scale commercial logging, followed by large-scale clearance for agriculture commodities and small-scale clearance for shifting cultivation and gardens. Large scale commercial logging accounts for 48.2% of forest change in PNG while subsistence agriculture accounts for 45.6% of forest change. Special agriculture and business leases (SABLs) were also promoted that threatens the forest conservation and management efforts PNG is committed to because of lack or poor capacity, monitoring and enforcement by regulatory bodies (Babon and Gowae 2013).

Most of PNG's development and budgetary aspirations can be seen as driving resource exploitation. With corruption and poor management by bureaucrats and politicians being rife and government red tapes are present in fast tracking project developments, resource exploitation is becoming a major concern among many, including NGOs, development partners and local landowners.

For instance, even though logging contributes immensely to the development of the country, there still exists disturbing facts about the industry. It was reported that there is little or no profit made in the logging industry, hence, 30% of the required income tax was not paid to the government, with transfer pricing occurring within the industry (The Oakland Institute, 2016).

In addition, the implementation of MDG's or SDGs in the country has been cumbersome and challenging as well, given the perennial constraints such as geographical isolation and cultural barriers. Translating environment into development comes with enormous challenges, especially in terms of coordination, implementation, monitoring and evaluation (GoPNG, 2015).

In hindsight, PNG is actively involved in international dialogue, making commitment to sustainable development. Its first National Strategy for Sustainable Development was launched after the 20th Waigani Seminar on "From Rio to Rai: Environment and Development in PNG" in 1994. It was called *"Stretim Nau*

Bilong Tumora" and was supported by action plan entitled *"Yumi Wankain" (*Mowbray 2014).

Over the years, the National Biodiversity Strategic Action Plan (NBSAP) was formulated and launched in 2007. According to GoPNG (2010a), it is a strategic plan that aligns, strengthens and ensures the implementation of the government's environmental commitments espoused by the major national development policies, in particularly the Medium Term Development Strategy 2000-2005 and the Long Term Development Goal (LTDG). NBSAP does not incorporate the CEPA Corporate Plan, and other plans such as the Vision 2050 strategic plan and Medium Term Development Plans (MTDP) because it was developed earlier than these documents. According to Mowbray (2014), over the decades, much of those earlier plans seemed to be greatly forgotten. The NBSAP plan is currently under review at the time of writing of this Report.

In 2007, Vision 2050 was published, setting out the road map for what was termed a visionary development strategy to guide PNG's socio-economic development, with the theme, ***'We** will be a Smart, Wise, Fair, Healthy and Happy Society by 2050.'* It was an aspirational statement and a vision for the future, however, the strategies and targets set are economic and development oriented which contradicts the ultimate aim of sustainable development (Mowbray 2014).

In 2010, PNG developed its first Medium Term Development Plan (MTDP) 2010-2015 '*to build its foundation and prosperity*' (GoPNG 2010b). PNG has shown a concerted effort to develop an improved governance structure through StaRS which was developed in in March 2014. The Minister for National Planning and Monitoring, Mr Charles Abel, presented a new 'development revolution' for PNG that looks at sustainable green growth (GoPNG 2014a). In 2015, MTDP 2 2016-2017 was developed (GoPNG, 2015). Coincidently, GoPNG (2014b) reported that the Department of Environment and Conservation (DEC, now CEPA) also developed the national capacity self-assessment report and plan of action for the implementation of the United Nation's Convention on Biodiversity (UNCBD), Convention to Combat Desertification (UNCCD) and the Framework Convention on Climate change (UNFCCC). Execution of this plan is yet to be realised.

In 2018, MTDS 3 was developed, and focuses on implementation and investment of different sectors (GoPNG 2018). The MTDS 3 has failed to consider improvement of biodiversity, ecology and conservation and has regressed to the old paradigm of socio-economic growth previously undertaken. Under the StaRS, ecology matters were not primary focus and unless PNG is not ecological considerate, hence environmental and conservation outcomes would be lagging behind. StaRS is still more environment and people oriented and is a great way forward for sustainable development than the MTDS 3. In fact StaRS is a resurrection of an earlier PNG National Sustainable Development Strategy (NSDS) accepted back then by the National Executive Council (NEC) in 1994 but was long forgotten. Hence, if the MTDS 3 can be tailored to complement the StaRS, the MTDS 3 strategy would at least achieve some of PNG's MEAs obligations, with support from the government of Papua New Guinea.

Despite the doom and gloom picture, it is acknowledged that there are environmental opportunities and challenges at national level and within CEPA as the national entity responsible for environment protection. Improvements on CEPA policies, action plans and strategies, efficient implementation and vigorous enforcement and governance would provide an equitable and sustainable outcomes for PNG. In order to achieve that, there exist some major constraints and barriers that persists within CEPA that require urgent and profoundly addressing.They are:

- Poor Agency Coordination and Collaboration: Institutional linkages and synergies is poor at both vertical (different levels of government) and horizontal (sectoral) institutions;

- Ineffective, inefficient and incompetent monitoring/ evaluation and compliance/ enforcement as per Environment Act;
- Poor initiation and facilitation of sectoral programs within the organisation which is funded by the GoPNG. Most are project-oriented programs funded by donor agencies of which CEPA coordinates its implementation on ground within a timeframe;
- Lack of enforcement of sustainability principles; and
- At organizational level: CEPA is understaffed and lack officers. Capacity building is an on-going issue. There are also communication gaps to report back on the MEAs probably because of lack or poor services such as internet, stationeries, and staff welfare or incentives including uniforms are lacking, to boost staff morale.

All in all, the overall outlook for enhanced, effective and competent MEAs achievement and implementation by CEPA is not necessarily bleak. There is still potential to harness whatever CEPA has, to improve its functions as the national body responsible for implementing the MEAs PNG is signatory to. This Report may provide a new pathway to mobilize the necessary support for the efficiency of CEPA's mandated function when reporting to MEAs.

3.5 Biodiversity integration into planning processes

The Constitution of Papua New Guinea recognizes the 4th National Goal of the 5 Directive Principles and Goals thus establishes an adequate foundation for sustainable development, including the protection and management of biodiversity, natural resources and the environment. The National Goal and Directive Principles set out in the preamble of Constitution, are the principle guidelines that sets the blueprint for policy making in the country, and is intended for the formulation of law and policy. The 4th National Goal provides for preserving the natural resources and the environment Papua New Guineans, by stating: ***"We declare our fourth goal to be for Papua New Guinea's natural resources and environment to be conserved and used for the collective benefit of us all, and be replenished for the benefit of future generations."***

This goal calls for:

1) the wise use of natural resources and the environment whether in or on the land or seabed, in the sea, and in the air, in the interests of development and in trust for future generations;

2) the conservation and replenishment of the environment and its sacred, scenic, and historical qualities, for our benefit and prosperity; and

3) all necessary steps to be taken to give adequate protection to our valued birds, animals, fish, insects, plants and trees.

Hence, the 4th goal is undertaking new direction and is finding its place in new policies and strategies development, consequently promoting environmental sustainability. A major policy that was developed from the Directive Principle and National Goals is the *Vision 2050.* This policy 2050 aspires that by 2050 "*PNG will be Smart, Wise, Fair and Happy*".

The Vision 2050 has 7 pillars which looks at:
Pillar 1. Developing its people;
Pillar 2. Developing resources and creating wealth;
Pillar 3. Developing Institutions and delivering services;
Pillar 4. Improving security and International relationship;
Pillar 5. Sustaining our environment;
Pillar 6. Developing the spirit, culture and community; and
Pillar 7. Planning, integration and coordination.

Pillar 5 promotes conservation and sustainable development. It generally encompasses people to be stewards of the environment and natural resources that caters for the survival and betterment of current and future generations. It promotes sustainable development and resource management, and climate change impact resilient.

Other major policies and strategies stated above complement Vision 2050 by capturing sustainable resource use and management. This mandates the government to promote the protection of the natural environment. Consequently, this warrants the country to manage and develop its natural resources in an ecologically sustainable way over longer periods. However, as mentioned above, some policies such as MTDS III is shallow than StaRS or other polcies.

Despite PNG's effort to take some action towards biodiversity conservation since RIO and the signing of the Convention on Biodiversity (CBD) in 1992, the progress has been slow. In the last three decades, the country has faced socio-economic woes, the government was unable to implement effectively the Vision 2050 plan through with adequate funds and resources. Thus the development of the above mentioned policies and the establishment of the PNG Institute of Biodiversity (PINBIO) and the National Biodiversity Strategic Action Plan (NBSAP) to address issues of biodiversity and sustainability cannot be realised. The development of the PNG National Biodiversity Strategy Action Plan (NBSAP) was also poorly implemented, hence need revision (GoPNG, 2016a). Currently work has been done to update the NBSAP.

Since PNG is a signatory to the Nations Convention on Biodiversity (CBD), it has already committed that by 2020, it will establish a "comprehensive, effectively managed and ecologically representative national systems of protected area". This includes specific target of coverage of land and sea by protected areas. This was captured in the PNG Policy on Protected Area 2016 (GoPNG, 2016b). It is anticipated that once the Protected Area Bill (currently with First Legislative Council since 2018) is passed by parliament and enacted as a law, conservation of the environment may be looking promising.

However, existing threats to biodiversity conservation from large-scale development activities on land, sea and forests may continuously become obstacles to promote sustainable environmental management, andthus this is unwelcoming. Other additional barriers to environmental management in PNG that may hinder conservation efforts include; i) the weakness of relevant institutions at national, provincial and local levels; ii) a weak policy and legal framework iii) traditional land tenure systems that are a constraint on integrated land use management and planning; iv) lack of awareness on natural benefits of conservation and environmental values; v) existing gaps in data collection, collation, storage and disbursement for effective decision making and planning; vi). Lack of incentives for environmental protection; vii) limited resources which makes implementation difficult; viii) lack of monitoring and enforcement; and ix) corruption.

Nevertheless, the Protected Areas Policy 2016 emphasis more on conservation at community level and the intending legislative review presents an opportunity for PNG to capture the new approach in the national policy and legal framework for biodiversity protection (GoPNG, 2016b). This Policy sets the foundation for strengthening the efforts towards biodiversity protection, capturing the most relevant objectives of the MEAs that PNG is signatory to. The Policy also equally captures the marine protected areas (MPA) as equally important as terrestrial PAs, given past gaps in previous policies and legal framework for protected areas. MPAs are now appropriately addressed and duly recognized in the new protected areas policy.

The focus on sustainable financing to ensure community benefits, participates and controls PAs also gives the new Policy originality. This is because under existing land tenure systems, the need for incentives in the work of conservation is necessary to promote conservation. The new Protected Area Bill once endorsed by NEC and enacted by Parliament may provide direction to achieve the directive principles and goals of the 5 Pillars of the PNG Protected Area Policy, thus giving enough teeth for doing conservation work in PNG when it becomes law.

Moreover, under the Protected Area Policy, it is anticipated that there will be establishment of Protected Areas on customary land. This will entail for collaboration between Government (National, Provincial and Local) and landowners, to develop transparent processes for the establishment of Conservation Benefit sharing agreements. It is anticipated that this agreements will take account of biodiversity and socio-cultural context and practices of the area. It is also anticipated to identify the roles and responsibilities of the customary landowners in the establishment, implementation and monitoring of the protected area.

Several Acts of Parliament and policies that also set the tone for biodiversity conservation and sustainable environment management are:

- Fauna (Protection & Control) Act 1966 (Fauna Act);
- Conservation Areas Act 1978;
- International Trade of Endangered Species (Fauna & Flora) Act 1978 (ITESA) and Regulation;
- Crocodile (Trade & Protection) Act 1978 and regulation;
- Environment Act 2000 and its regulations;
- Conservation and Environment Protection Authority Act 2014;
- Fisheries Management Act 1998 (FMA) and Regulation;
- Dumping of Wastes at Sea Act 1979 and Regulation (DOWASA);
- Prevention of Pollution at Sea Act 1979 (POPASA) and Regulation;
- PA Policy in December 2014 and the PNG Maritime Zones (Amendment) Act 2015 in June 2015;
- Protected Areas Policy 2014; and
- National REDD+ Strategy 2017.
-

In addition, several institutions are also established by the Act of Parliament and are mandated to manage and conserve the environment and resources. Below are some laws that enable those institution to operate:

- Conservation and Environmental Protection Authority (CEPA). The Conservation and Environmental Protection Authority Act No. 9 of 2014 establishes Conservation and Environment Protection Authority to manage all environment and conservation activities;'
- PNG Forest Authority (PNGFA). The Forestry Act 1991 establish the PNG Forest Authority to manage all forest activities and development;
- National Fisheries Authority (NFA). National Fisheries Authority Act, establishes the National Fisheries Authority (NFA) to manage all fisheries and marine activities;
- Climate Change and Development Authority. Climate Change and Development Authority Act 2014 establishes Climate Change and Development Authority to regulate and monitor all climate change activities on adaptation and carbon trade;
- Department of Lands and Physical Planning (DLPP). i) Lands Act 1996 and its regulation; ii) Land Registration Act 1981 (amended 2009) and its regulation; iii) Land Group Incorporation Act 1974 and its Regulation and iv) Physical Planning Act 1989; Petroleum, Oil and Gas Act 1998; and Land Dispute Settlement Act 1975; and

- Provincial and Local Level Government. Organic Law on Provincial and Local-Level Governments 1995.

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4.0 APPROACHES TO THE 2019 PNG SOE REPORT

4.1 The Drivers, Pressures, State, Impact and Response (DPSIR) Model in SoE reporting

Figure 1.1: SoE Report Framework (DPSIR Model)

The State of Environment in Papua New Guinea and Impacts on the Environment, Society and Economy:

Information was gathered from local stakeholders and experts on the eight major themes to provide a summary of the state, impact and response to number of topics. A brief synopsis is included at the beginning of each theme for a quick review. The following provides a summary of each major topic covered in the SoE Report:

The Drivers, Pressures, State, Impact and Response (DPSIR) model (Figure 1.1) is used in SoE reporting. In this reporting, the Definition of each theme and indicators, plus which Sustainable Development Goal (SDG) and the Convention on Biodiversity (CBD Aichi Targets each themes and indicators are addressing are also indicated. It also looks at the the Trend and Status of the themes or indicators and the impact individual thems and indicators are facing. The model is a global standard for State of Environment reporting and part of a systems approach that takes into account social, political, economic, and technological factors, as well as forces associated with the natural world.

4.2 Themes for the PNG 2019 State of Environment Report

The 2019 SoE Report includes eight thematic areas or 'theme' with important ecosystems and environmental issues addressed under each theme. Themes were divided into habitats or sub-topics, and indicators were developed for each one. For example, the Marine Environment theme is divided into seven sub-topics: Offshore marine environment and fish biomass. The Offshore generally looks at the volume of catch of identified indicator species such as tuna, tuna-like species and sharks harvested. The Inshore marine environment focuses on fish biomass, coral cover, lagoon water quality, reef fish and sea cucumber biomass and density, and % of marine area or EEZ protected. Other marine themes discussed include Marine managed areas, Live coral cover, Lagoon water quality and Endangered marine mammals and cetaceans, rays, sharks and turtles, focusing on their health and trend status, movement and abundance.

Table 1.3 shows the indicators for each habitat or sub-topic are used to assess the state of that specific habitat or sub-topic. For example, the sub-topic specific to country has four key indicators, specific to the country. The indicators are individually rated for their States (Good, Fair, Poor), Trend (Deteriorating, Stable, Mixed, Improving) and Confidence in the Data (Low, Medium, High). The indicators are then integrated into the sub-topics under each theme (highlights section), and a similar rating for State, Trend and Confidence is assigned to each theme. For more information, refer to *A Guide to Interpreting State, Trend and Confidence Symbols* (Pages 32 to 34).

1.3. Themes, sub-topics and indicators for the 2019 PNG SoE Report

Theme	Sub-Topic	Indicator (s)
Environment Monitoring and Governance	Ministry of Environment Budget	Percentage (%) allocation of national budget allocated to Environment Ministry or equivalent.
	Approved EIAs for development proposal	Percentage (%) of Environment Impact Assessments (EIAs) approved out of all submitted development proposals
	MEA reporting requirements	Percentage (%) of MEA reporting requirements met on time.
	Environment Cases Prosecuted	Percentage (%) of environmental cases prosecuted in national courts.
Atmosphere and Climate Change	Trend in Greenhouse Gas emissions (GHG) Emissions	Trend of nationally determined contribution and mitigation efforts to date
	Trend in consumption of Ozone-depleting Substances (ODS)	ODS consumption trends and reduction efforts to date
	Physical Climate	The local weather pattern of the area or a place over time
	Climate related Disaster Loses	Total dollars of financial loss occurring due to climate-related disasters, defined as cyclones, flooding, landslides and drought
	Climate Adaptation and DisasterFunding	Funds received to implement ecosystem-based approaches to climate adaptation
	Renewable Energy	Trend in percentage production of energy from renewable sources
	Access to Freshwater	Percentage (%) of population having access to safe and clean water

Freshwater Resource	Freshwater quality	Percentage (%) of access to fresh and quality clean water sources
Land	Forests	Percentage (%) of native tree cover of total land area areas and trends over time
	Land under Cultivation	Percentage (%) of total arable land that is under cultivation that is under cultivation and .agricultural use
	Wetlands	Percentage (%) cover of wetland areas and mangroves
	Terrestrial Protected area	Percentage (%) of land area formally protected for conservation
Marine and Coastal	Offshore Marine Environment and Fish Biomass	Volume catch of identified indicator species
	Inshore Marine Environment and Fish Biomass	Status of marine environment and fish biomass for inshore fisheries
	Marine Managed Areas	Percentage (%) of EEZ formally protected for conservation and trend in conservation of marine habitats and species
	Endangered Marine Mammals, Rays, Sharks and Turtles	Population abundance of identified endangered marine species
	Live Coral Cover	Percentage (%) of live coral cover in coastal and marine environments
	Lagoon Water Quality	Trend or state of water quality
Biodiversity	Species Diversity and Endemism	The number of species and how unique and abundant they are in an area
	Endemic and Native Species	Status and abundance of identified species
	Threatened Species and Species of Concern	Status of species that are under threat from extinction and those species that are only found in PNG

	Invasive Species	Number of priority sites with multi-invasive taxa management programmes
Built Environment and Consumption	Household waste captured rate	Percentage (%) of total household waste captured by authorised provider.
	Per capita generation of municipal waste	Annual per capita generation of municipal solid waste
	Household waste recycle	Waste recycling rate
	Access to Quality of Sewerage Treatment	Percentage (%) of households connected to central sewage system.
	Transport Energy	Percentage (%) of energy used by the transport sector
	Solid and Liquid Waste Management	Percentage (%) of solid and liquid waste generated and managed
	Energy Consumption and Use	Rate of energy consumption
Culture and Heritage	Culture and History	Trend in culture, heritage and history of the country
	Traditional Diets and Medicine	Trend in diets and medicines
	Customary Land Tenure	Trend of landownership in Papua New Guinea

5.0 A Reader's Guide to the 2019 State of Environment Report

5.1 How to read the report

The standard reporting format and symbols for the PNG SoE Report was developed and produced by SPREP and are used throughout the Pacific Island countries. Thus, the State of Environment (SoE) report condenses a large amount of information on various aspects of the environment into a readable and actionable report. Given the broad spectrum of topics covered, the report has been broken into themes for easier utilization. The report can be read as a whole, or according to different themes, noting that most of the themes are connected to each other and to the pressures and drivers behind them.

Symbols were designed for each indicator to summarise the State, Trend and Confidence in each assessment. Symbols were also designed for groups of indicators that describe a habitat or sub-topic within a theme. For example, the Land theme is broken into four areas or sub-topics covering forest, land under cultivation and wetlands and terrestrial protected areas. Symbols were not designed for each theme because the variety of potential states limits a meaningful summary statement. In this case, colors were used to differentiate the different themes.

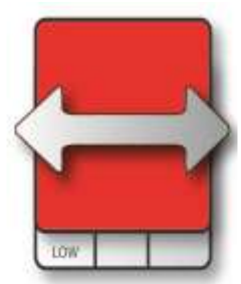
52 Guide to the symbols used

The SoE Report assessments integrate many data sources and expert opinions. For the PNG SoE Report, there may not be enough information available to make quantitative assessments of the state of an environment using, for example, an index of 1-10, or a quantitative threshold figure, that could be compared across themes. Consequently, a generic index was developed that used expert opinions and best available data to inform 'Status' ratings of either 'Good', 'Fair', and 'Poor'.

Figure 1.2 shows an example of the assessment symbol and summarises the 'State' of each indicator. The assessment symbols for each indicators establish baselines to compare the state of each indicator for future assessments, including SoE Reports. The symbol includes ratings for 'Status', 'Trend' and 'Confidence'. Table 1.4 provides a guide to interpret the symbols, and explains how the symbols were derived.

Figure 1.2: Explanation of the Indicator symbol

Table 1.4. Guide to interpreting the symbols

	Category	Description	How is it derived?	Symbol Example
State (can be a range)	Good Fair Poor	The level to which the indicator meets or exceeds (good), is close to meeting (fair) or is well below (poor) a given standard for healthy ecosystems, habitats, species, airsheds, watersheds or an urban environment.	Assessment is based on: 1) recent trends; 2) comparison with similar jurisdictions; and 3) comparison with 'healthy' habitats and systems. This is where limited data exists to make an assessment based on these criteria, expert opinion is used.	
Trend	Improving	The state of the environment related to this indicator is getting better.	Trends show a significant increase, or based on weight of evidence that indicators are improving.	
	Deteriorating	The state of the environment related to this indicator is getting worse.	Trends show a significant decrease, or based on weight of evidence that indicators are worsening.	
	Stable	The state of the environment related to this indicator shows there is no detectable change.	Trends show no significant increase or decrease, or, based on weight of evidence that indicators are stable.	

	Mixed	The state of the environment related to this indicator shows a mixed trend: sometimes the state is getting better, worse, or there is no change.	Used primarily for sub-topics with multiple indicators, or in cases where data shows two distinct trends.	
	Undetermined	Not enough data exists to determine trend.	Insufficient data available to generate trend.	
Confidence	**High**	Data is of high quality and provides good spatial and temporal	Trusted and comprehensive time series and/or national	
	Medium	Data is either lower quality, geographically sparse	Data is derived from many sources, and is not always consistent, with	
	Low	Data does not meet any of the above criteria.	Data is very coarse and outdated, and limited to single country sites.	

6.0. SECTION 2: DRIVERS AND PRESSURES ON PNG'S ENVIRONMENT

6.1 What are the Drivers of Environmental Change in the PNG?

Human activities, such as urban development and overfishing are placing pressures on the natural environments of the Pacific islands and their exclusive economic zones (EEZs). These activities are driven by broad social, economic, technological and cultural forces. These drivers interact to produce changes in the environment, which impact the livelihoods and well-being of individuals, communities and nations. The 2019 PNG SoE Report has 11 broad-level drivers of environmental change. Drivers can have diverse social, economic and environmental impacts, are not exclusively negative or positive, and should be viewed objectively with respect to their various management contexts. Table 2.1 further elaborates on these drivers.

Table 2.1: PNG environmental drivers and key indicators used in the SoE Report.

#	Drivers	Key indicator
1	**Population demographics and migration**	Regional and national population changes, migration and household composition
2	**Globalisation**	Shipping patterns and connectivity, importation of consumer products and Multilateral Environment Agreements
3	**Economic development**	Access to internet and communication, global and economic sectors trends and GD per capita and income distribution across pacific and PNG
4	**Government policies**	Policies to improve standard of living and sustainable development and green growth
5	**Governance and enforcement**	Trend in resource management, governance and enforcement of rules and laws in project development
6	**Land-use change**	State of the forest, land, sea pertaining to logging, agriculture, mining, and fire
7	**Invasive Species**	Trend in Invasive species
8	**Extractive industries**	Trend in resource development
9	**Climate change and variability**	Trend in climate change and vulnerability on terrestrial, coastal and marine ecosystems
10	**Pollution**	Trend in pollution on land, marine, air and water
11	**Development access-corridors**	Trend in resource utilisation and development

6.1.1. Population Demographics and Migration

Population growth is one of the major drivers of changes to the environment with pressures on both the built and natural environment. Figure 2.1 shows the historic, current and projected populations for the Pacific region from 1970 to 2050 (SPREP, 2012). Polynesia and Micronesia have lower historic and projected growth rates compared to Melanesia, in particular Papua New Guinea.

PNGs census are normally conducted every 10 years. Figure 2.2 shows PNG's population at different census periods between 1980 and 2011 grew substantially at a faster rate. Since 1980, the population of 3 million people double to 7.3 million in 2011 in 31 years (NSO 2011a). The final figure for 2011 is still disputed because some areas or people were excluded during the census, hence may not be final. The next census is due in 2021. Hence some estimates have been made at over 8 million which is used throuout this Report.

Between 1980 and 1990 census, the population growth rate was 2.3%. In comparison, between 1980 and the 2000 census, the population growth rate reached 2.7% while between 1980 and 2011, it was 2.9%. Moreover, between 2000 and 2011 census, the growth rate increased to 3.1%, thus indicating the population grew by 40%. It is projected that by 2021, at the current rate of 3.1%, the population would reach 10,185,454 (NSO 2011b).

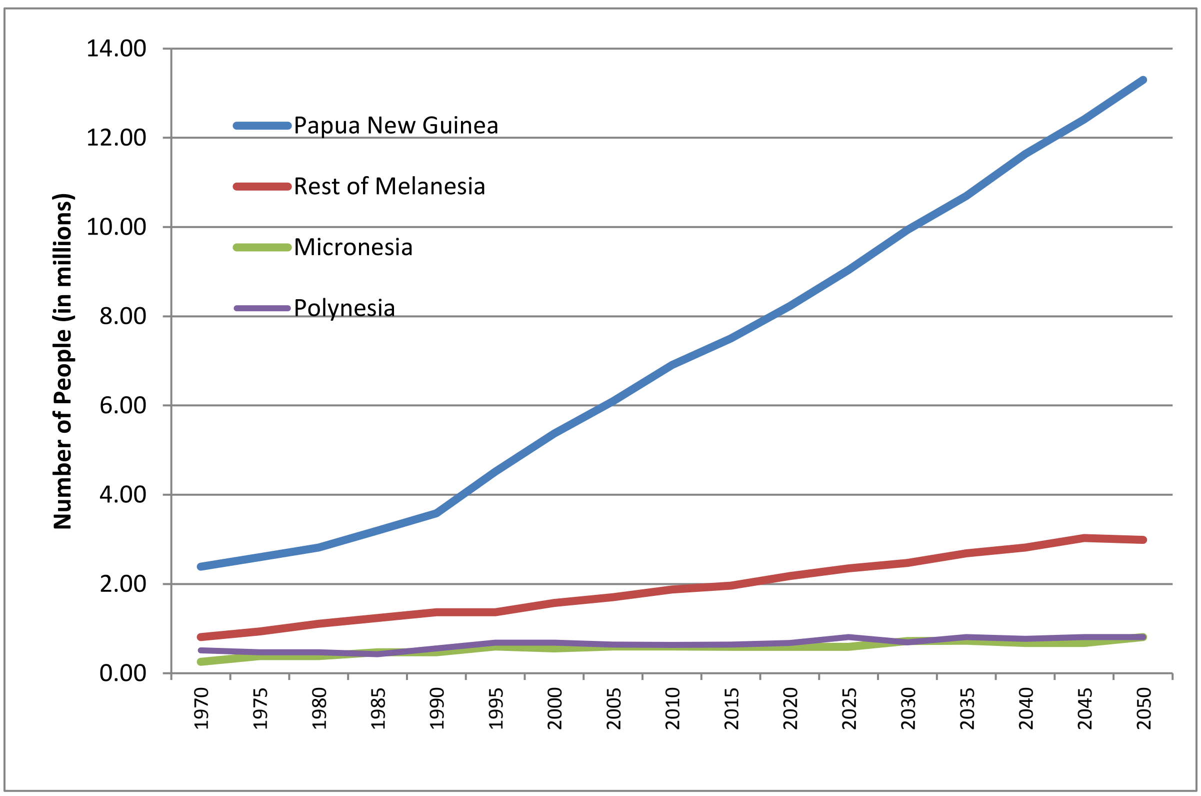


Figure 2.1: Pacific Islands Past, Current and projected Population (SPREP, 2012)

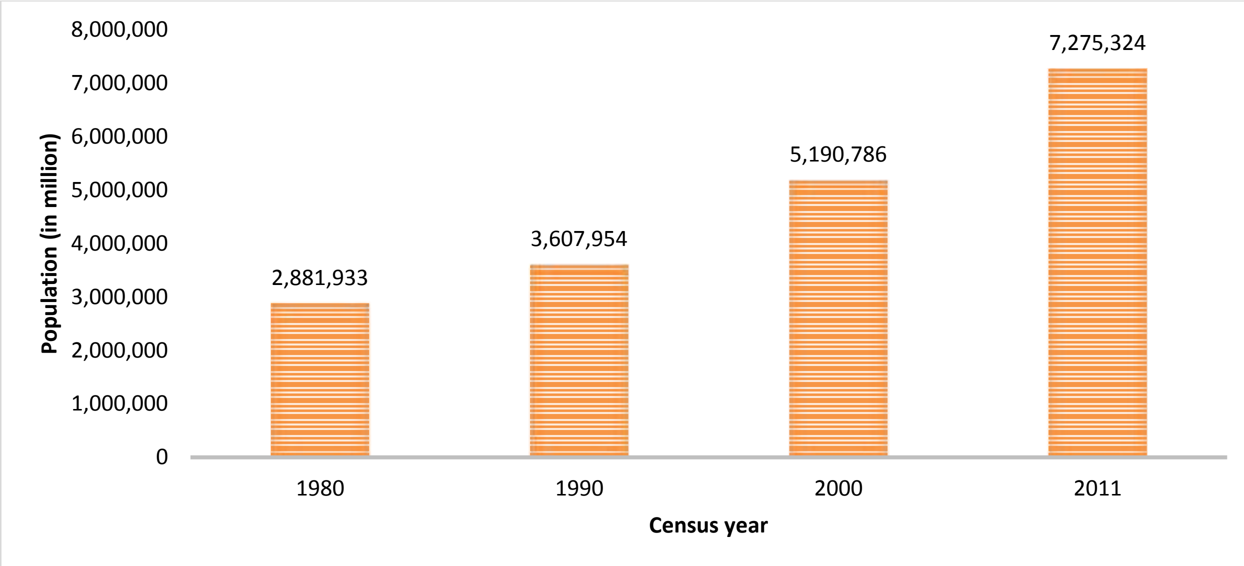


Figure 2.2: PNG's population over 40 years between 1980 and 2011 (NSO 2011b)

Since the first census was conducted for the whole country in 1966, the population sizes seemed variable throughout different provinces because of varying and uneven population sizes. Table 2.2 indicates that in the 1980 census, the rural population constitute about 87.7%, 84.9% in 1990, 86.9% in 2000 and 87.5% in 2011. In comparison to urban population, it was 12.3% in 1980 compared to 12.4% in 2011. These figures show that over 80% of the population live in rural areas. In terms of sex ratio, it seems the number of female to males is almost proportional at 50% or at a ratio of 1:1. The number of non-citizens has also increased substantially over the census periods, with more males than females.

Figure 2.3 shows the population pyramid of different sexes and age groups, indicating a large population base of 0-19 years. The next biggest age group is between 20-49 years. As age increases from 54-69, the number of elderly people decreases. It is very small around 70 years age groups, depicting only few people live up to 'very old' age. All in all, improved diet and health services have increased the average life expectancy of most Papua New Guineans to 65.5 years compared to 40 years old in 1960 (NSO 2011b). Howevere increase life style disease is a threat to the population (Section 8.9.4).

The population of non-citizens seem to decline over the years between 1980 and 2011. Figure 2.4 indicates the top four countries where immigrants come from are the United States of America, the Philippines, Indonesia, other Asian countries. Australia, other European countries and China, Other Pacific countries, Malaysia and other closely follow behind comprising approximately 5-8% of the non-citizen population.

Since PNG has a dual economy of subsistence and commercial nature, the increasing population has seen the need for government services and resource exploitation increasing drastically. The number of people migrating to towns and cities has also increased substantially in the last 40 years. Hence, the drivers of increasing population growth rate, immigration, emigration and increasing family sizes are having a marked impact on the society and the environment in PNG. This exerts so much stress on resource uses, wastes, consumption and usage of import products which can be detrimental to the environment that can cause other environmental impacts.

Table 2.2: Total population for male and female PNG Citizens and non-citizens, including urban and rural population between 1980 and 2011. (NSO, 2011)

Summary Indicators		Census Year			
		2011	**2000**	**1990**	**1980**
PNG citizen Population	**Total**	**7,254,442**	**5,171,548**	**3,582,333**	**2,978,057**
	Male	3,757,198	2,679,769	1,887,867	1,557,077
	Female	3,497,244	2,491,779	1,694,466	1,420,980
PNG Urban Citizen Population	**Total**	**902,891**	**675,403**	**539,331**	**365,547**
	Male	474,300	365,533	300,216	212,202
	Female	428,591	309,870	239,115	153,345
PNG Rural Citizen Population	**Total**	**6,351,551**	**4,496,145**	**3,043,002**	**2,612,510**
	Male	3,282,898	2,314,236	1,587,651	1,344,875
	Female	3,068,653	2,181,909	1,455,351	1,267,635
Non-citizen Population	**Total**	**20,882**	**19,235**	**25,621**	**32,670**
	Male	15,666	11,975	14,716	18,595
	Female	5,216	7,260	10,905	14,075

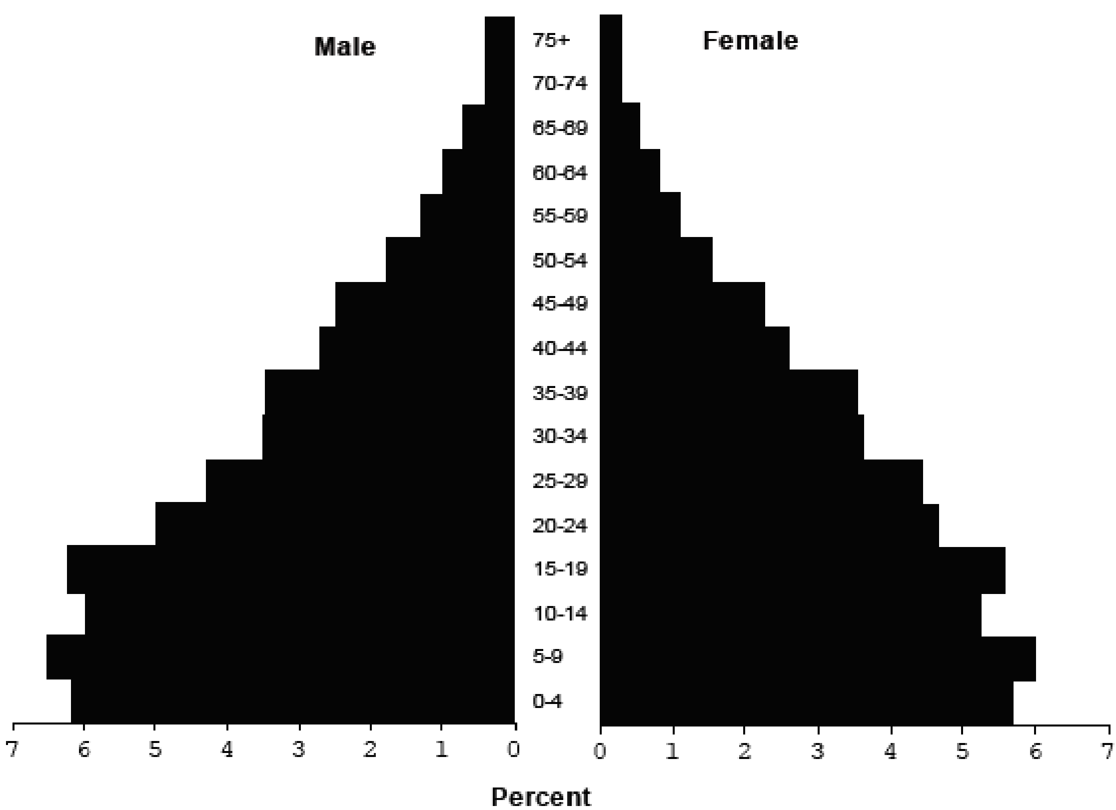


Figure 2.3: Citizen Population by age and sex in 2011 census (NSO, 2011b).

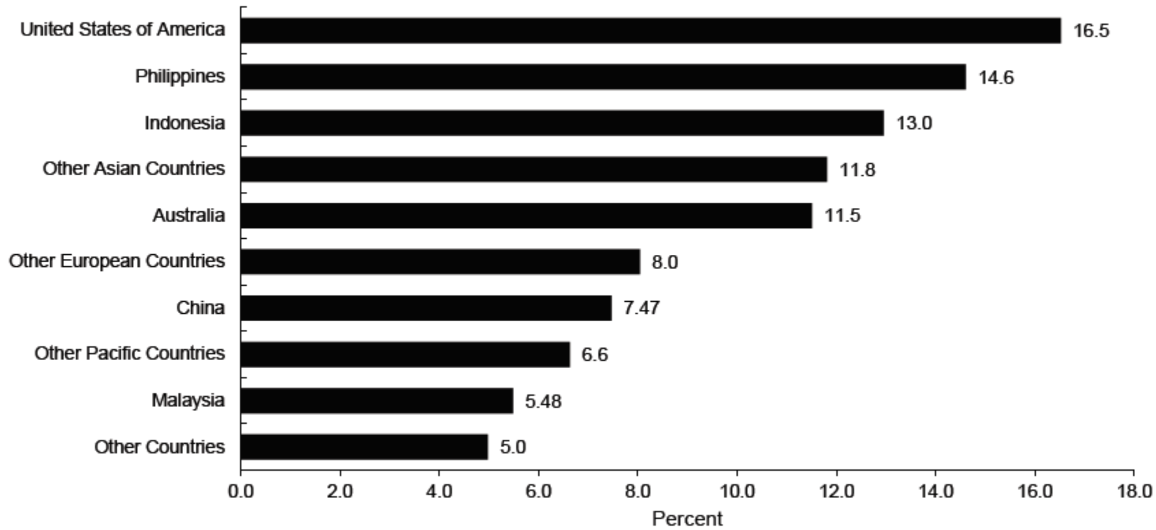


Figure 2.4: Population of non-citizen over forty years between 1980 and 2011 (NSO, 2011b).

Drivers of exploitation of resources in PNG have cross-cutting issues, that some may argue is unclear. Increasing pressures inserted by the rising population, in terms of demand for use of environmental services are eminent. Population pressure on the resources and environment can be described as wanton, leading to the 'tragedy of the commons' where humans acted independently, contrary to the common good of all users to deplete or destroy their environment and resources. This can happen at the local or national settings.

Furthermore, many Papua New Guineans are migrating to cities and towns because of pull and push social and economic factors, may be because of tribal fighting, to access better services, for employment or in anticipation of better life. Consequently, these factors exert more pressure on the land and resources in towns and cities thus creating ecological footprints like wastes and pollution.

6.1.2. Globalisation

PNG is the largest island in the pacific and has one of the highest population, with one of the fastest growing population growth rate as well. This means it has its own share of problems and challenges as seen in the number of drivers listed herein this Report.

PNG is still isolated from many countries, in terms of market accessibility. This market accessibility also is compounded by the topographical ruggedness of the country and poor suitable transport systems. Table 2.3 indicates PNG has four different geographical regions in Momase, Islands, Highlands and Southern regions, which comprises of almost 21 provinces. Figure 2.5 shows the map of PNG in the global world.

PNG is rich in natural resources, such as oil, gold and copper, timber and fisheries. The most important sector of the economy is the natural resource extraction, which, accounts for 60 percent of GDP and a large share of government revenues (Oxford Business Week, 2015).

Agriculture is also important, since it employs up to 85 percent of the population. Revenues from natural resource exploitation have resulted in high government spending and a construction boom.

In hindsight, PNG is also one of the poorest and isolated countries in the world, but has recently been growing consistently in recent years. Despite its wealth of natural resources, and revenue from these resources could contribute to reducing poverty and improving the lives of PNG citizens, many citizens continue to remain in poverty. PNG is also one of the most corrupt countries in the world. It was ranked 135 out of 180 countries in the Transparency International's Corruption Perception Index for 2017, with its score improving from 25 to 29 over the past two years (PNGEITI, 2018).

Education, communication, technology, airline and banking services among others have also transformed PNG significantly.

Figure 2.5: Map of PNG and insert world map (Worldbase Map produced by Gerald Natera)

Table 2.3: Four distinct region of PNG and provinces

Southern Region (Papua)	Highlands Region	Northern Region (Momase)	Islands Region
Central	Enga	West Sepik	New Island
Northern (Oro)	Hela	East Sepik	Manus
Milne Bay	Western Highlands	Madang	East New Britain
Gulf	Jiwaka	Morobe	West New Britain
Western	Chimbu		Autonomous Region of Bougainville (AROB)
National Capital District	Eastern Highlands		

Although PNG is located near the thriving Asian, Australian, US and New Zealand markets, it is still isolated, in terms of connectivity to major shipping routes. In the Asian region, PNG is in a strategic location, yet it doesn't have a major port. Most ships coming from overseas go to Brisbane, Australia before coming to ports in Vanimo, Wewak, Lae, Madang and Port Moresby. Local shipping agents and the government also charge exorbitant landing freight charges and as a result, have an impact on prices of goods and services.

Figure 2.6 shows major global ports where trading of containers (e.g. manufactured goods): yellow; Dry bulk (e.g. coal, aggregates): blue; Tanker (e.g. oil, chemicals): red; Gas bulk (e.g. liquefied natural gas): green; and Vehicles (e.g. cars): purple (Business Insider, 2019). Figure 2.7 shows major and intensity of shipping lanes in PNG waters.

Given PNG's vast natural resources, wealth creation is eminent, hence exportation of natural resources has been the mainstay of the economy. Increase in trade of oil and gas, minerals, forests and fisheries products contributes to most of the country's export commodities (Bito and Petit, 2016). Hence, the PNG development policies such as the MTDP 3 and the StaRS provide the road map for increase global trade.

PNG economy is dual meaning its either subsistence or commercial. The importation of products from overseas is taking the bulk of the trade volume. In 2011, PNG imported mainly from Australia (40.58%), followed by US (27.30%), Singapore (12.55%) and China (4.65%) - together sharing 84.69% of imports (BPNG, 2016). By 2016, imports from Australia constituted 43.49%, followed by US (19.72%), Singapore (7.01%) and China (6.41%) - together contributing 77.03% of imports to PNG.

PNG's top five export markets in 2014 were Australia, Japan, China, Chinese Taipei and Germany. Figure 2.8 shows the percentage share of major trading partners in 2014. This import composition also shows high country concentration, hence some considerations could constrain import flow into PNG.

Moreover, the total value of PNG's merchandise exports to the world stood at USD 9.9 billion in 2014, making PNG the Pacific Islands' biggest exporter. Exports grew in value by an average of seven per cent per annum between 2010 and 2014, thus placing PNG 91st out of 220 countries in ITC world export rankings. In 2014, PNG was in the top five merchandise exports for fuel, with a value of USD 4.4 billion, precious stones at USD 2 billion, wood at USD 990.1 million, ores at USD 842 million, and fats and oils at USD 569.5 million.

The total value of PNG's primary sector exports stood at USD 2.2 billion in 2014 or 22 per cent of the country's total export value for the year (SPC, 2015).

Figure 2.6. Major global shipping port (BusinessInsider.com.au)

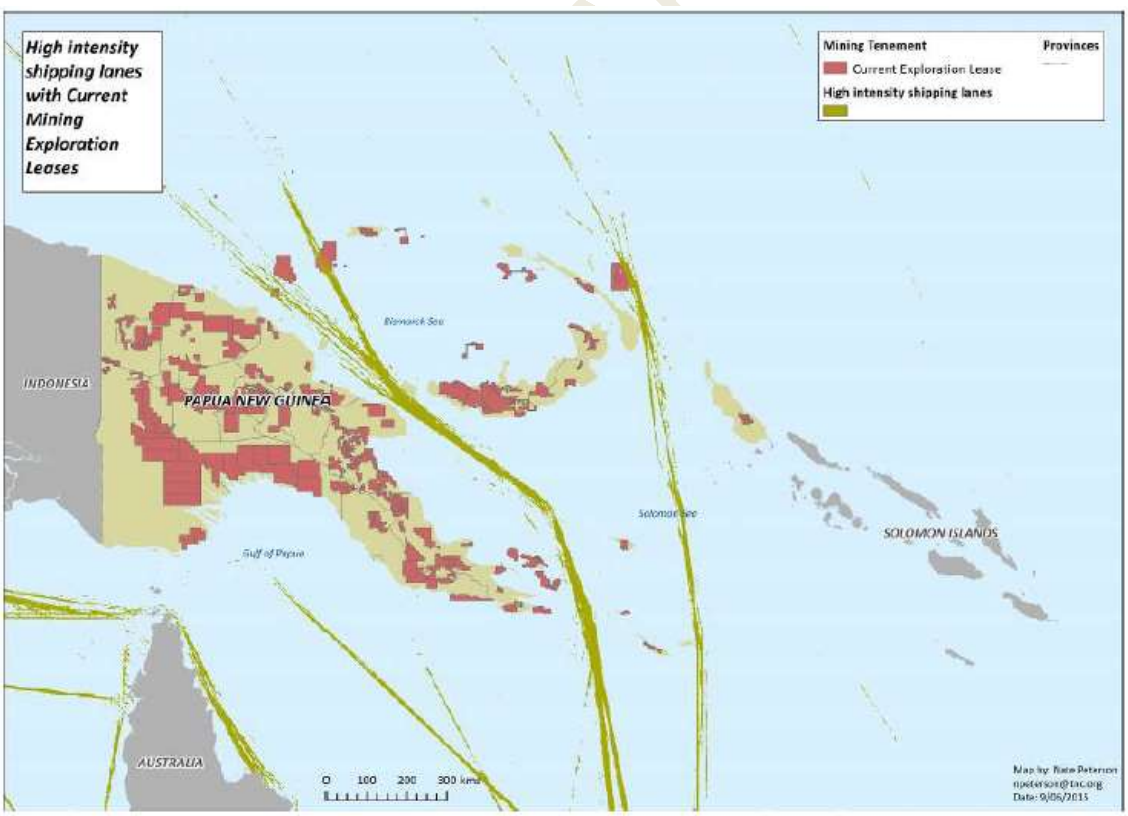


Figure 2.7. High intensity shipping lanes in PNG (GoPNG, 2015c)

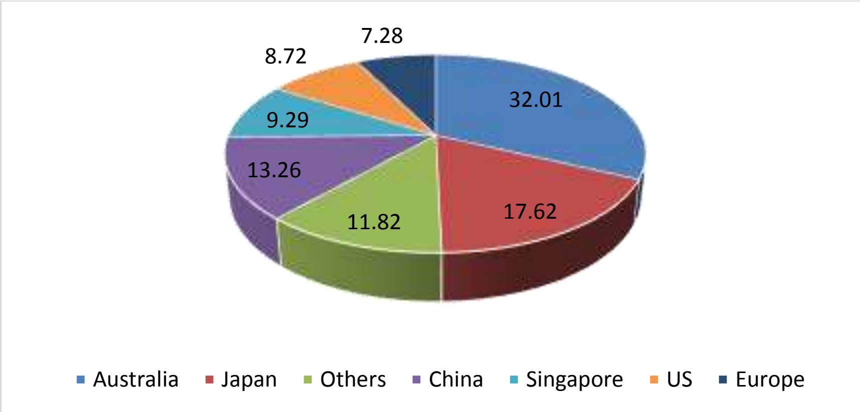


Figure 2.8: Percentage share of total trade by value in 2014. Source BPNG 2016

Figure 2.9a shows the trend of trade over 13 years between 1991 and 2015. There was an increase in exports, balance of trade and imports respectively. PNG recorded a positive balance of trade throughout the period 1990-2016, yet this does not influence imports. Openness of PNG's economy declined because imports were mostly controlled irrespective of export performance.

The composition of exports show high concentration, thus exposing the export sector to fluctuating world prices and thereby instability (ADB, 2018a). ADB argues that in terms of country-wise distribution of exports and imports, there seem to be concentration in few countries while trade in services shows consistently negative balance of trade.

Figure 2.9b shows that the value of import and export also increase overtime but peaked for exports in 2017 and declined for imports in 2014. Figure 2.9c shows most of the revenue for the country comes from other sources with resource revenue and foreign aid being the next important sources (ADB, 2018a).

Poor commodity prices and other factors such as the fallen Kina value against major currencies, corruption and mismanagement of public finances, and low volume of dollar bills earned from exports has hit PNG very hard in recent times (ADB, 2018a).

Although the local economy improved notably around 2008, it then declined but recovered slightly around 2014. That was when export increased whilst import dropped drastically, resulting in a mini recession and low volume of import. This happened around after the construction phase of the PNG LNG project in 2013.

Figure 2.10 shows the percentage of GDP of trade between 1990 and 2016, indicating a downturn around 2013. Figure 2.11 also shows the GDP growth rate was between 0.5% and 3% between 2016 and 2018 but was projected to rise to between 2.7-3% in 2019 (ADB, 2019).

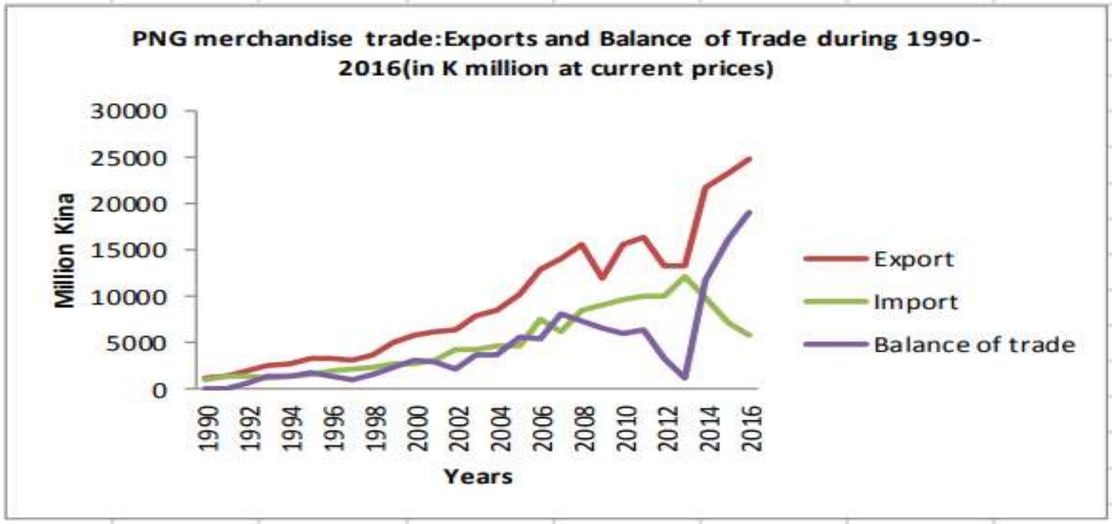


Figure 2.9a: Export and import of Merchandise Trade between 1990 and 2016 (BPNG, 2016).

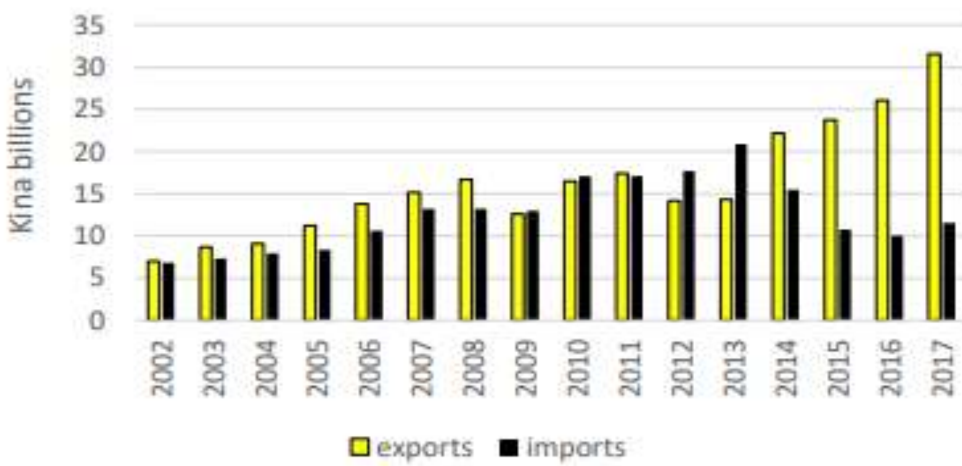


Figure 2.9b: Values of exports and imports of goods and services. Source BPNG QEB March 2018 (ADB, 2018a)

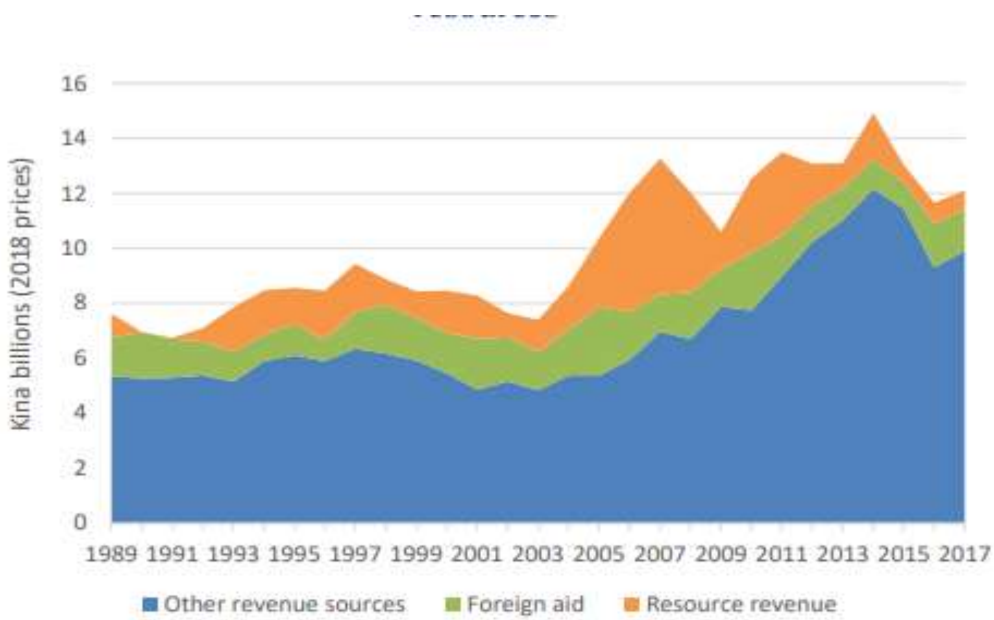


Figure 2.9c: Government Revenue: Source BPNG QEB, March 2018 (ADB, 2018a).

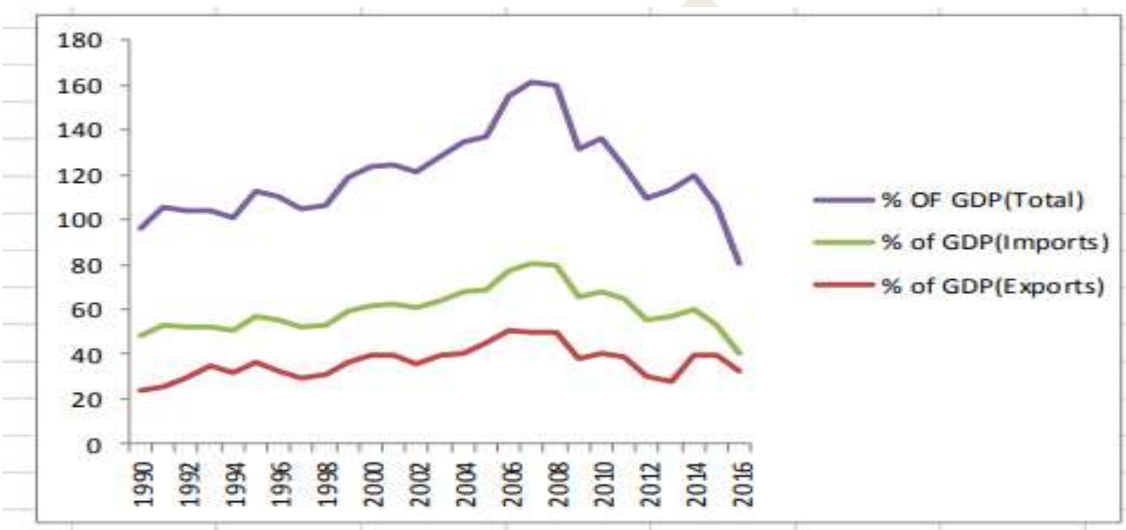


Figure 2.10: Percentage of GDP total, imports and exports between 1990 and 2016 (BPNG, 2016.

Table 2.4 indicates that in the Pacific in 2018, PNG has one of the lowest GDP in the region. The reason was the downturn in the economy due to external shock, increasing external debts, declining global commodity prices, reduction in foreign reserves, natural disasters and fluctuating global oil prices. Since 2009, these external shocks have affected the GDP growth and economic performance of PNG, hence it has been fluctuating s (BPNG, 2019).

Figure 2.12 shows the GDP per capita of PNG reached a peak of 12.5 % in 2014 but dropped to 2.2% in 2017. From 2009 to 2017, the annual growth rate was 4.03%. In 1997, the GDP was on a record low of -6.34%, caused by the nationwide drought and *El Nino* effect. Figure 2.13 depicts the GDP per capita for PNG was US$2,401.60 in 2017, and has increased 77% from US$1862.60 in 2009.

Moreover, the increase in household income of Papua New Guineans, and access to goods and services, has directly or directly inflict environment change in the country (World Bank, 2019). Figure 2.13 shows the GDP per capita for the world, middle income countries and PNG since 1960. In real dollars, GDP has increased worldwide, and although driven by the wealthiest countries overall, low and middle income countries have also increased proportionally. PNG is among the low income earning countries, having less than US$ 7 600 dollars per capita income. PNG's GDP growth is lowest in the Pacific in 2018 at 0.5% but could increase in the future (ADB, 2018a), with Figure 2.14 showing PNG's GDP growth is expected to increase to 3% in 2019.

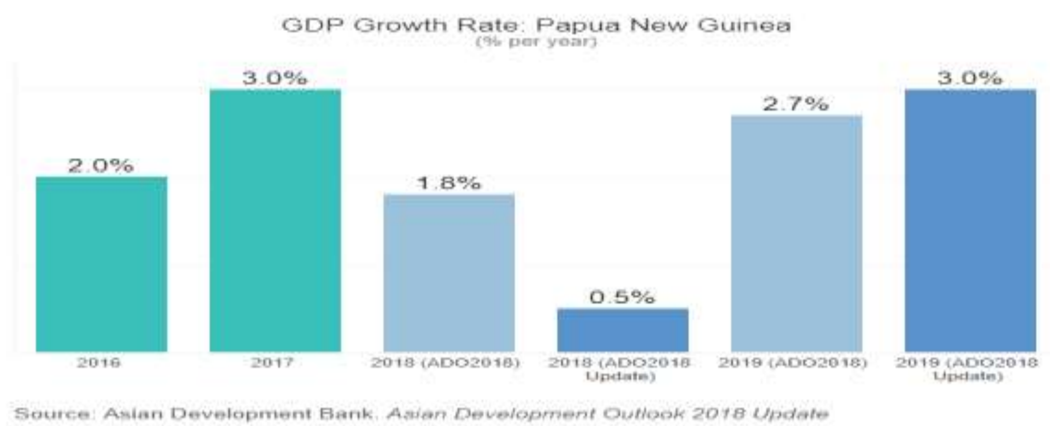


Figure 2.11: GDP growth rate for PNG. (Asian Development Bank, 2018a)

Table 2.4 GDP Growth Rate 2018 (ADB, 2019).

Country	GDP Rate (%)
Tuvalu	3.8
Fiji	3.6
Cook Islands	3.5
Solomon Islands	3.2
Vanuatu	3.2
Marshall Islands	2.5
Kiribati	2.3
Federate States of Micronesia	2.0
Palau	1.0
Timor-Leste	0.6
Papua New Guinea	0.5
Samoa	0.5
Tonga	-0.3
Nauru	-3.0

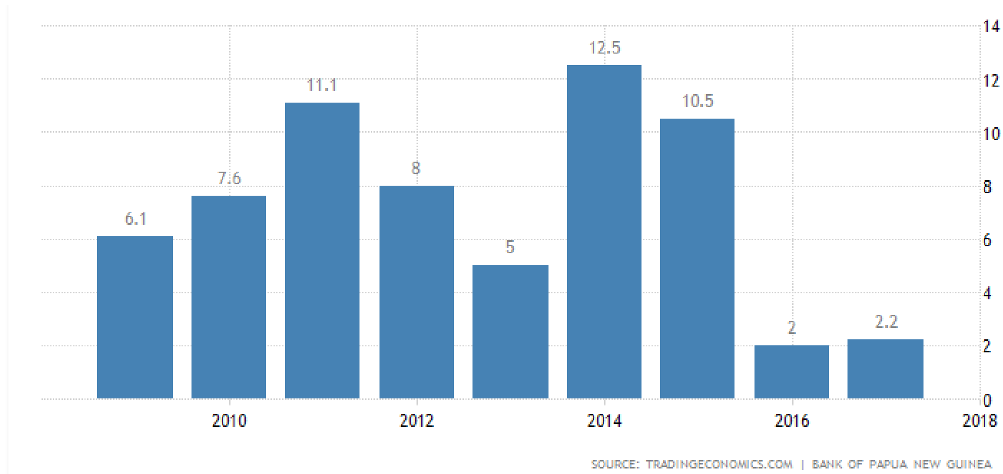


Figure 2.12: Percentage growth of PNG economy by GDP per capita between 2009 and 2017 (WB 2019, Trading Economy).

Figure 2.13: GDP per capita (current US$) showing PNG and the world GDP. (Source World Bank open data portal https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?end=2017&locations=PG&start=2017&view=map)

Figure 2.14: PNG GDP per capita between 2010 and 2017 ((http://tradingeconomy.com)

As the country is developing into and adapting to changes, more pressures have been exerted on the environment and resources as demand for energy and globalisation increases. This simultaneously puts strain of the environment, finances and the economy, thus producing footprints such as environment degradation, wastes and economic and social problems.

The increasing global demand for resources and increasing trade will definitely exert pressure on the environment, as PNG increases trading activities with other countries. Resources will be exploited and so many products from outside PNG will enter the economy as well. The world is no more isolated and is connected, hence natural resources will be exploited vigorously.

Consequently, both positive and negative impacts will be felt by the country, especially on its environment. There will be increase in pests and diseases, wastes, pollution and deforestation among others off shooting as a tradeoff from increased development and trading activities. Therefore, the onus is now on the Government of PNG (GoPNG) to manage its environment and resources sustainably by adapting prudent development policies, thereby not to be left behind in this fast changing world.

6.1.3. Economic Development and growth

Since the industrial revolution in the 1700s, the world has gone through a very massive change in technology, rising population, globalisation and improved standard of living. A study by Syriquin and Chenery (1989) shows there is strong association of economic structure with the level of income. The changes in structure accompanies economic growth as one transist from a low-income economy to an industrial urban economy with substantially higher income through various transistion pathway. Development patterns are not invariant over time. Technological changes and other exogenous factors influence the patterns of structural change, especially at the micro level. As the country develops so too its pattern of development and growth.

After PNG gained its independence from Australia in 1975, access to better health and educational services, infrastructures, communication, and other services emanated from economic development led to improvement in living standard of Papua New Guineans. Nonetheless, some development status of PNG's living standards are yet to be improved.

Table 2.5 shows PNG world development indicators against the average East Asia Pacific Country value in 2017 (PNGEITI, 2018). It provides general information on the population, economy, health and infrastructure for PNG, which indicates PNG has some of the worst or less improved indicators (lowest or highest) compared to the East Asian Pacific region and the world.

Table 2.5: PNG's world development indicators against the average East Asia Pacific Country Value in 2017 (PNGEITI, 2018)

	Indicator	**2014**	**2015**	**2016**	**2017**	**Average East Asia Pacific Country Value (2017) Population**
Population	Surface Area (sq.km)	426,840				-
	Population, total	7,755,785	7,919,825	8,084,991	8,251,162	-
	Population Density (people per sq.km of land are)	17.13	17.49	17.85	18.2	93.54
	Population growth (annual %)	2.12	2.09	2.06	2.03	0,70
	Urban population (% of total)	12.99	13.01	13.04	13.10	57.50
	Rural population (% of total)	87.02	87.00	86.96	86.90	42.50
Economy	Gross Domestic Product (GDP) real growth (annual %)	12.5	10.5	2.00	3.0	-
	Gross National Income (GNI) per capita, Atlas Method (current US$)	2,160	2,780	2,530	2,410	9,858
	Inflation, DDDP deflator ((annual %)	5.20	6.0	6.7	5.4	2.10
	Ease of doing business index (1=most business-friendly regulations)	-	133	119	109	-
	Unemployment, total (% of total labour force) (modelled ILO estimate)	2.58	2.48	2.49	2.7	4.10
	Labour force, total	3,404,688	3,501,238	3,598,105	3,695,703	-
	Labour force, female (% of total labour force)	49.00	48.97	48.94	48.90	43.30
Health	Fertility rate, total (births per woman)	3.76	3.71	3.66	-	1.80
	Improved sanitation facilities (% of population with access)	18.90	1890	-	-	77.21
	Improved sanitation facilities, rural (% of rural population with access)	13.30	13.30	-	-	64.33
	Improved sanitation facilities, urban (% of urban population with access)	56.40	56.40	-	-	87.10
	Improved water source (% of population with access)	40	40	-	-	94.14
	Improved water source, rural (% of rural population with access)	32.80	32.80	-	-	90.19
	Mortality rate, under-5 (per 1,000 live births)	99.10	57.30	54.30	-	16.4
	Life expectancy at birth, total (years)	65.23	65.38	65.50	-	75.40
Infrastructure	Fixed broadband subscriptions (per 100 people)	0.18	0.20	0.2	-	18.80
	Fixed telephone subscriptions (per 100 people)	1.94	1.97	1.90	-	15.60
	Individuals using the Internet (% of population)	6.50	7.90	9.60	-	52.90
	Mobile cellular subscriptions (per 100 people)	44.93	46.65	46.8	-	110
	Access to electricity (% of population)	20.26	22.20	22.90	-	96.90
	Access to electricity, rural (% of rural population)	12	14.7	15.5	-	94.10
	Access to electricity, urban (% of urban population)	76.36	72.1	72.7	-	99.00

Improvement in the economy and increase in income by citizens also result in demand for more global commodities and services that indirectly or directly influence the way of life of the people. Moreover, new and emerging technologies and innovations also have the potential to radically transformed business operations, efficiencies and competitiveness, thus driving e-commerce, media, entertainment, information communication technology and efficiencies, thus influencing consumer markets in supply chains and manufacturing (PNGEITI, 2018).

Despite some positive changes are occuring, the country also suffers from endemic corruption and lacks a functioning legal system, with inequality increasing. Consequently, there is a middle class system already developing in PNG for formal working class population. This has infleubce standard of living and lifestyle.

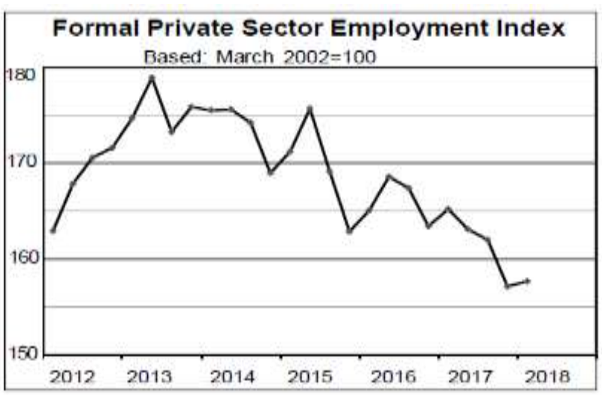


Figure 2.15: Formal Private Sector employment index (BPNG, 2018)

For instance, Figure 2.15 shows the employment rate is declining in the private sector, while increasing in the formal private sector by 0.3 percent in the March quarter of 2018 compared to a decline of 2.3 percent in the December quarter of 2017 (BPNG, 2018). In addition, in all sectors, excluding the mineral sector, employment declined in the manufacturing, transportation and retail sectors. This also affects the Consumer Price Index (CPI) causing an increase in 1 percent in March quarter of 2018 compared to 1.3% in December 2017. Figure 2.16 simply indicates that the CPI in PNG is very high thus causing high inflation in goods and services, at above 1 % since 2013 (BPNG, 2018).

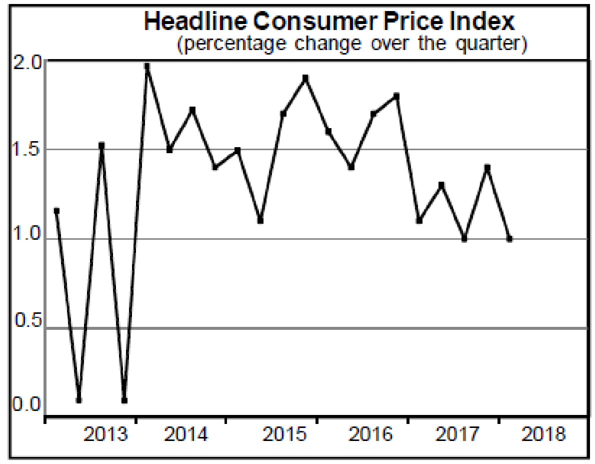


Figure 2.16: Headline Consumer Price index (BPNG, 2018).

The general picture described above indicate that the challenge the government is facing to create employment opportunities and better living conditions for its citizens. Consequently, this will put more stress on its natural resources to meet the export quota that favours the government's budgetary requirement. The increasing demand for PNG's natural resources will grow as indicated in the PNG government development policies, thus putting more stress on the environment and resource sustainability. This may also trigger other effects which will be discussed further below for other drivers.

Lack of employment is a concern for PNG as the gap widens. This must be addressed profoundly before it becomes sinister for the country in the future.

The overall labour force participation rate for economically active citizen population is aged 10 years and over in 2000 and 2011 was 68% and 61% respectively (NSO, 2011b). It was slightly higher for males than females at 62% and 61% respectively. Figure 2.17 depicts the age group where majority of the workforce found are between 25 and 59. It can be noted that the number of children labour also increases

because in PNG, children often help their parents in household activities and other livelihood activities such as farming and gardening.
In terms of the type of employment, Figure 2.18 shows wage job is mainly centered in the urban population and other self-reliant jobs whereas Figure 2.19 shows most rural population participate in gardening and fishing activities.

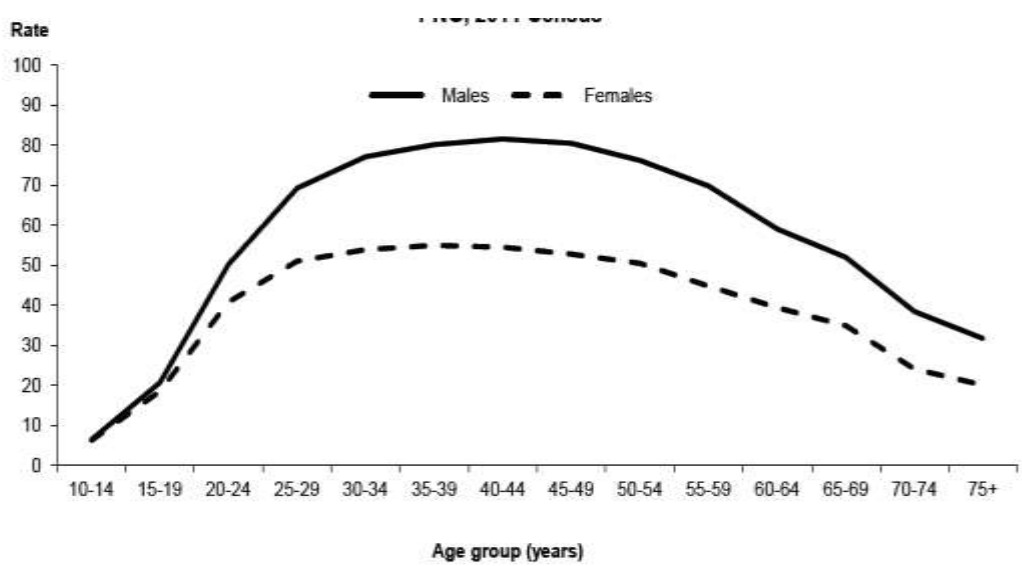


Figure 2.17: Urban citizen labour force by age and sex (NSO, 2011b).

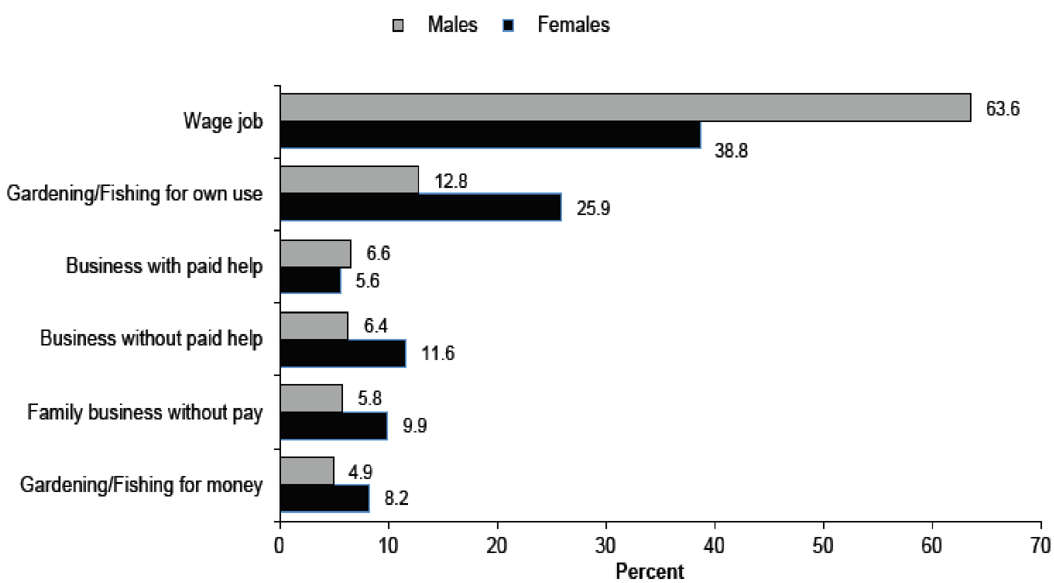


Figure 2.18: Type of employment by sex in urban areas (NSO, 2011b)

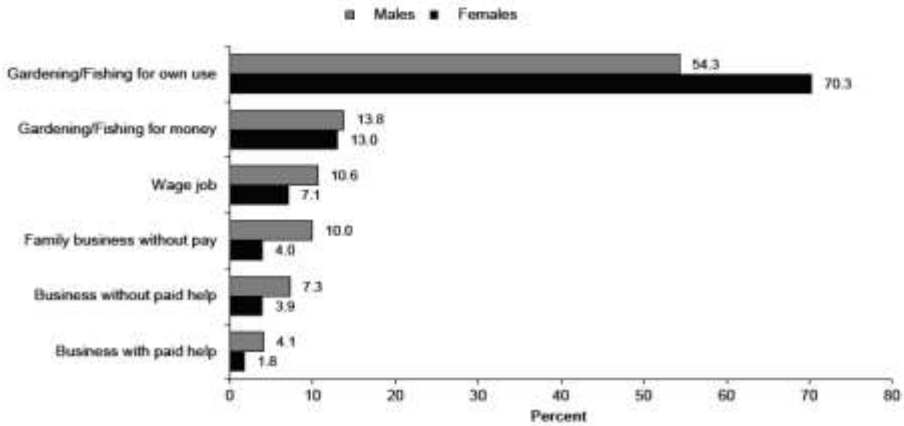


Figure 2.19: Type of employment by sex in rural areas (NSO, 2011b)

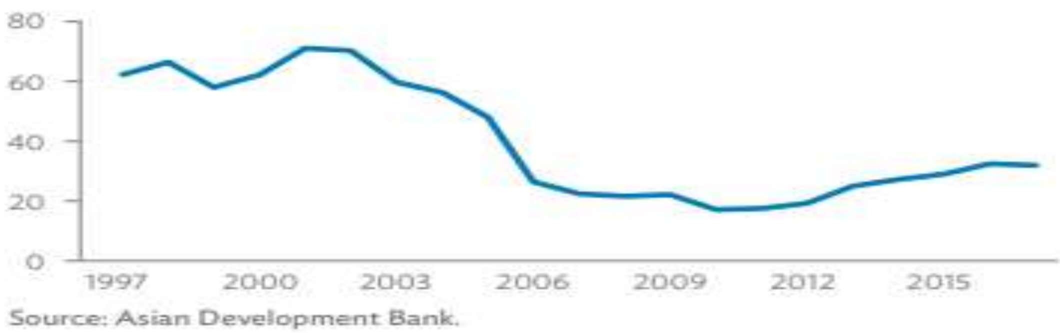


Figure 2.20: PNG Public debt % of GDP (ADB Pacific Economic Monitor, 2018)

When the global economy reached a decline in 2019, several risks may become eminent. The global growth forecast for 2018 and 2019 has been revised and is now at 3.7% for both years, which is 0.2 percentage points lower than the forecast made earlier in 2018 (ADB, 2018). This largely reflects moderation of economic activity in advanced economies due to escalating trade conflicts. Meanwhile, developing Asia and other emerging economies posted stable growth in the first half of 2018 and despite some capital outflows, are expected to reach their growth forecast for the year.

The slowdown in the global economy will certainly have a negative impact on PNG's national budget as well. For instance, PNG's domestic debt accounted for about 73% of total debt at the end of 2017 (ADB, 2018). Tighter global oil supply due to production declines in certain countries and the latest economic sanctions in Iran have led to a rise in oil prices. Hence, prospects for key pacific exports are mixed. Natural gas prices increased by 21.8% in the third quarter of 2018 reflecting strong demand for electricity due to the unusually hot weather in Asia and Europe (ADB, 2018). Growth in tourist departures from New Zealand to major south Pacific destinations jumped by 14.1% (y-o-y) over the first 8 months of 2018, about 2.5 times the increase for other destinations.

Figure 2.20 shows PNG's public debt between 1997 and 2017 has fluctuated over time and since 2006 has increase substantially. In 2006, the PNG government legislated a prudent fiscal rule under its Fiscal Responsibility Act to limit its public debt to within 30% of gross domestic product (GDP). This was later revised in 2017 to a threshold of 30%–35% to accommodate PNG's growing debt, with a view to reducing the ratio to below 30% by 2022 (SPC, 2015).

A second fiscal rule, which requires PNG to target a zero average annual non-recourse primary balance over the medium term, was also included in the amended Fiscal Responsibility Act 2017.

In 2001, the ratio reached a peak of 71.2%, during an economic period that was challenged by drought, the Asian financial crisis, and weak macroeconomic management but by 2010, the debt-to-GDP ratio had fallen to 17.0% after several years of strong economic growth, buoyant commodity prices, and improved economic management (SPC, 2015). In 2013 and 2014, the economy continued to perform strongly due to favourable commodity prices for liquefied natural gas investment through the PNG LNG Project.

However, the government adopted a strategy of fiscal expansion and incurred large budget deficits, equivalent to 6.9% of GDP in 2013 and 6.3% in 2014, as it embarked on a growth drive during this period. This trend continued into 2015 but was brought to an abrupt end following a sharp decline in worldwide commodity prices, compounded by the end of the liquefied natural gas investment cycle and drought (SPC, 2015).

SPC reported that the consequential fall in government revenues necessitated immediate fiscal adjustment by slashing capital expenditure, with the end result being a fiscal deficit equivalent to 4.1% of GDP, which was still high. This was followed by a further deficit in 2016 of 4.6% of GDP, as the government continued to struggle to adjust to the new economic circumstances. These deficits contributed to an increase in public debt, which rose from K7.4 billion in 2011 (equivalent to 17.4% of GDP) to K21.9 billion in 2016 (equivalent to 32.4% of GDP). In 2017, a further deficit was recorded at 2.5% of GDP; although this was below economic growth of 3.0%, meaning that the debt-to-GDP ratio trended slightly lower to 31.2% (SPC, 2015).

It seems the cost of interest and access to debt from domestic and international markets varies widely between countries, and this is a significant determining factor for a country's debt capacity. Most advanced economies can afford to have higher debt burdens because interest costs are lower, and debt can easily be raised from a variety of sources (a result of better credit risk profiles and larger, more diversified economies).

On the other hand, developing countries must pay much higher rates of interest and have far fewer options to source debt. PNG's recent 10-year sovereign bond, for example, was priced at 8.38%, a significant premium to the 10- year United States treasury yield of around 3.00%. PNG's local debt also carries relatively high interest rates, currently priced at between 4.70% for 6 months' duration and 12.60% for 10 years' duration, although, due to inflation of around 5.00%, the real interest rate on domestic debt is lower (SPC, 2015).

It was projected that growth is to remain relatively modest in 2018 and 2019 in petroleum, mining, forestry and agriculture. Most sectors are expected to expand, with the APEC meetings providing an additional boost in 2018. However, recent natural disasters such as an earthquake, volcanic activities and flooding will hold back growth in petroleum, mining, forestry and agriculture sectors. The continued difficulty in accessing foreign currency and fiscal constraints will also limit growth (ADB, 2018).

Improved commodity prices of oil and gas, metal prices, agricultural products, timber, and fisheries will translate into higher growth. However, oil and gas are expected to contract as oil production declines as a result of natural disasters such as the 2018 earthquake which forces some oil and gas operations to suspend activity for an undetermined period. (ADB, 2018). The agriculture, forestry, and fishery sector is projected to grow by about 3% in 2018 and 2019 as output increases for all major crops with favorable growing conditions, as the area under cultivation expands, and heightened international demand in recent years. Palm oil production, which accounts for some 45% of agricultural exports, should grow modestly. Agricultural production for the domestic market will expand as well in line with a growing economy, an expanding population, and investment in the sector (ADB, 2018).

Therefore, continuous debt services, demand for foreign currency and need for improvement of services and standard of living for the population will force the government to do more exploitation of its resource for the much need revenues which will result in exerting more pressure on the resource and the environment.

6.1.4. Government policies

Since it was highlighted earlier, the rapid increase in population, globalization and global demand and trade for natural resources, and growing debts will exerted enormous threat and pressure on the environment and resources. Hence it depends much on the government to use the right policies to address the economic and environmental challenges, PNG is currently facing. Policies such as the National Development Strategy (1976-1985), National Development Plan (1986-1990) and Development Plan (1989-1997) will not be discussed. Only the recently endorsed policies, namely Vision 2050, Development Strategic Plan (DSP) 2010-2030, National Strategic for Responsible Sustainable Development (StaRS) and Medium Term Development Strategy 1-3 are discussed.

Straight after independence in 1975, the Constitution's directive principles has been the guiding principle, where the founding fathers of the nation wants PNG to be. Successive governments were implementing the National Development Strategy (1976-1985), National Development Plan (1986-1990) and Development Plan (1989-1997) to address the vision of the country.

In October 2009, the then Somare Government developed the Vision 2050. This is the first level of PNG's planning framework launched which reinterpret the Constitution of PNG to define the aspirations of the nation for the year 2050 and sets the long-term direction for the country with guidance from the Constitution. That is, the .Vision 2050 envisage Papua New Guineans "*will be a smart, wise, fair, and happy society by 2050*; and '*to be ranked in the top 50 in the United Nations Human Development Index by 2050*' (GoPNG, 2010). Vision 2050 focuses on seven pillars or 'Strategic Focus Areas', from 2010 to 2050 which are:

- Human Capital Development, Gender, Youth and People Empowerment;
- Wealth Creation;
- Institutional Development and Service Delivery; Security and International Relations;
- Environmental Sustainability and Climate Change;
- Spiritual, Cultural, and Community Development; and
- Strategic Planning, Integration and Control.

The second level of policy developed and endorsed by the government is a roadmap for development called the Development Strategic Plan 2010-2030 (GoPNG, 2010). The DSP translates the focus areas and aspirations of Vision 2050 into concise directions for all sectors in achieve governance and improving human resources, economy, and foreign policy, managing environmental issues, addressing climate change and fostering partnership to improve quality of life. Hence the DSP focuses on:

- Strategic planning;
- Systems and institutions;
- Human development;
- Wealth creation;
- Security and international relations;
- Environment and climate change; and

- Partnership with churches for integral human development.

For the first time, the DSP document attempts to translate the dreams of the founding fathers contained in the directive principles of the National Constitution into workable plans. At the same time it maps out the how to get PNG to "where the Papua New Guinea Vision 2050 wants us to be". It therefore sets out the broad framework, targets, and strategies to achieve the vision of the Government.

DSP is designed to quadruple the national income which should give all Papua New Guineans an improved quality of life by exploiting the available opportunities and enable them to become key players in the overall socio-economic development of this country. It is designed to strategically inform and guide Papua New Guineans in all walks of life to engage in the development process of the country.

The third level of policy was formulated after the formation of the O'Neill-Dion Government in Alotau, after the 2012 elections, called the Alotau Accord I. 78 key priorities were identified and agreed upon as the 'Alotau Accord' for implementation during its five-year term in office (2013-2017). One of the priorities of the Accord was the review of the current PNG DSP 2010-2030. For many key government ministers, the existing plan was not strategic enough and a new roadmap built on the principles of green growth and sustainable development was needed to achieve Vision 2050.

This led to the formulation of StaRS in 2014 as the new development roadmap. According to the GoPNG (2014), '*the central theme of this new development road map is to shift the country's socio-economic growth away from the current unsustainable growth strategy towards a road map that is truly responsible, sustainable and able to place PNG in a competitive, advantageous position into the future.*

That is, the StaRS represents a policy shift in long-term planning to guide the actions of current and future governments to position PNG towards attaining the following goals:

- Being a leader in the promotion and establishment of the responsible sustainable development paradigm,
- Be a prosperous middle income country by 2030, and
- Be among the top 50 countries on Human Development Index by 2050.

This new perspective also acknowledges that the medium-term development challenges require some reliance on the exploitation of primary resources to fund the investment needed for an inclusive and innovative green economic growth in the future by integrating economic, social and environmental objectives (GoPNG, 2014).

StaRS provides the overarching strategic framework to reduce the future impact on eroding PNG's strategic assets such as biodiversity, forests, fertile agricultural land, water and fisheries and advocates for a paradigm shift towards sustainability and 'green growth framework'.

The fourth strategic policy was the formulation of the Medium Term Development Plans (MTDP). Implementation of the DSP 2030 is spelled out in the strategic planning framework of the MTDP in rolling 5-year. MTDP1 was developed for the period 2011-2015 (GoPNG, 2010) and MTDP2 for the period 2016-2017 (GoPNG, 2015).

The primary drivers for developing the MTDP2 have been to incorporate StaRS and the Sustainable Development Goals (SDG) of the United Nation (UN) into the Government's medium-term planning and to align the MTDP with the five year parliamentary cycle.

MTDP2 was expected to begin the move towards a more sustainable economy following the new guiding principles for development planning provided by StaRS (GoPNG, 2015).

In 2017, after the national election, the O'Neil government formulated the MTDP3 (2018 to 2022). The MTDP3 captures the main thrust of the Alotau Accord II and sets the Goal of *"Securing our future through inclusive sustainable economic growth"* by focusing on key investments to further stimulate the economic growth in the medium term. The key priorities of the Alotau Accord II are (1) inclusive Economic Growth with renewed focus in Agriculture, (2) continuing with Infrastructure development, (3) improvement of quality of Health Care, (4) improvement of quality of Education and Skills Development, and (5) improvement of Law and Order (GoPNG, 2018a).

Over the years, the building on the gains and experiences of MTDP 1 and 2 and the priorities of Alotau Accord II, propelled the government to plan and consider the principles of inclusiveness and sustainability prescribed by StaRS and the United Nations SDG. Under the MTDP3, the Government will focus on: (1) Increasing the revenue base and improving revenue collection, (2) increasing exports, (3) reducing imports, (4) improving and increasing opportunities for citizens to create wealth, and (5) improving the quality and effectiveness in the delivery of public goods and services.

Most of MTDP 1-2 were not achieved, hence MTDP3 came into effect. MTDP3 focuses more on economic and social development, and revenue generation. The only issue with MTDS3 is that biodiversity conservation and ecological processes are not having prominence in it.

Hence, government policies are important factors that can determine the state of the environment in PNG in the future. The MTDP3 2018-2022, is a five-year plan that drives the development agenda of the GoPNG, to secure the future, through inclusive sustainable economic growth. It is a Strategic Investment Plan that envisage to increase investment (GoPNG, 2018). However, this plan may impinge substantial impacts on the environment as well at certain economic trade-offs for the current and future generations.

The Goal 1 of the MTDP3 is to ensure that PNG has a "World class agriculture and livestock sector that is responsive to international and domestic markets for a diverse range of products. Agriculture is the mainstay of the economy and contributes around 26% of PNG's national GDP. Coffee, cocoa, copra, palm oil, rubber and tea are major renewable resources contributed K7.2 billion in export revenue between 2013 and 2016 (GOPNG, 2018a).

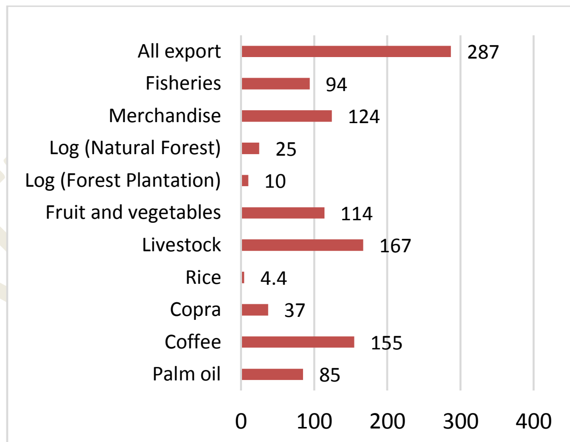


Figure 2.21: Projection percentage increase of export revenue for commodities from 2016 values to 2022 (MTDP 3, GoPNG, 2018)

Figure 2.21 shows the overall aim of the MTDP3 is to increase export of products by 287%, with agriculture exports a huge jump by 2022 compared to all other produces including timbers or logs. For instance, the plan looks at increasing export of Livestock by 167%, Coffee by 155%, Merchansie by 124%, Fruit and vegetables by 114%, Fisheries by 94% and palm oil by 85%. Export of logs will decline to 10% of the government stance on banning round log export by 2020. The plan focuses more on agriculture because 85% of people depend on their land and farm it.

In recent times, production output from commercial agriculture plantations has declined due to fluctuating world prices, rising labour and overhead costs, poor management and land tenure issues leading to the closure of major plantation estates, especially in the highlands. The sector is also faced with challenges associated with rapid population growth, food security, land shortages, and climate change and natural disasters that are slowing down the growth in the industry. This is posing a possible long-term threat on resource scarcity, relating to food supply and consumption.

Between 2011 and 2016, the agriculture sector was also affected by pests and diseases, such as the Bogia Coconut Syndrome (BCS), the Coffee Berry Borer (CBB) and the Cocoa Pod Borer (CPB) which adversely affect the level of production of these commodities (GOPNG, 2018). Consequently this has affect income streams for 80% of the country's population who live in the rural areas and depend heavily on subsistence and semi-subsistence agriculture.

Currently, the government is looking at rehabilitating large run down plantations, developing Special Economic Zones or Economic corridors (Sepik, Sandaun, Kikori, West Coast Manus, Baiyer Valley, and Ramu Valley), improving quality and value chains of products by smallholder farmers, establish dairy farms, promote rehabilitation of tea and spice farms, and ensure the growth of the sector is improved. The new Marape-Davis government in 2019 has put more emphasis on agriculture by allocating 3 ministers asisit the minister to develop and or revive the sector.

The government is now looking at increasing the volume of agriculture export by 21.9% for all commodities from the 2016 baseline of 900 tonnes to 3,483.33 tonnes. This is a significant increase of 287% to generate much need income for the country. This can be achieved through the economic corridors proposed in the DSP (GoPNG, 2010).

Economic corridors are proposed to alleviate poverty and transformed those identified regions into economic hub that can easily be integrated into the mainstream economy. Generally, an economic corridor is a region in which the Government provides a well-planned zoning system (Figure 2.22). It is a comprehensive and effective network of transport and utilities, and quality education and health services (GoPNG, 2010).

Within this region, businesses are able to operate at low cost and under well designed incentives, thereby encouraging foreign and domestic private sector investments, through construction of essential infrastructure within certain regions. This will then promote economies of scale and scope associated with large service sector infrastructure, thus reducing the cost to state owned enterprises and other providers of essential infrastructure, while raising their returns (GoPNG, 2010). It is envisaged that by building on this infrastructure will instigate effective sequential and spatial planning leading to expansion of economic activities like agriculture, tourism and manufacturing.

Nonetheless, development of large road corridors, power girds and shipping ports can have conflicting issues on the environment, including people. For instance, the Island of New Guinea, including PNG has one of the largest tracts of tropical rain forest that is so diverse. Currently, these forests are facing immense threats from forest exploitation and development activities where large tracts of forest are now opening up through development of excess corridor to secure natural resource (Sloan et al., 2019). This may lead to incision of invasive species, disturbance to water quality, speciation through isolation, increasing in hunting activities and resource use pressure, including many other threats.

The MTDP3 plan also looks at increasing palm oil export volume by 85% from the 2016 baseline of 540,000 tonnes to 1, 000,000 tonnes by 2022. There are six major palm oil project areas in PNG covering 144,183 hectares. It is grown by smallholders and large plantations supported by a mill, with at least 200,000 people are dependent on palm oil for their livelihoods. The industry has contributed K7.4 billion in export revenue between 2013-2018 and produced 3.4 billion tonnes of palm oil (GoPNG, 2018a). Unless production and agronomy practices are improved, more forest will be cleared.

The plan also looks at increasing coffee export by 155% using the baseline of 47,000 tonnes of 2016 to 120,000 tonnes by 2022. Coffee continues to be one of PNG's major agricultural exports and has contributed K1,827.4 million between 2013 and 2016 (GoPNG, 2018a).

Figure 2.22: Proposed Economic corridors. The light blue colour represent the economic corridor Source: GoPNG, 2010

In terms of cocoa, the Plan looks at ensuring "*quality cocoa production is increased and expanded for the betterment of livelihood of small scale cocoa farmers and economy of the nation*." Currently the cocoa industry supports almost 151,000 smallholder households in rural area in 14 provinces. PNG produces 90% of fine flavoured cocoa and supplies only 1% of cocoa in the world market, contributing about K1,067.4 million in export revenue between 2013 and 2016 (GoPNG, 2018a). However, disease and pest outbreak are the main threat to both coffee and cocoa. Hence, more research has been conducted to develop new varieties that are of high yield and disease resistant.

The Cocoa Board has a Strategic Plan (2016-2025) and plans to plant 13 million new cocoa trees, hence increasing PNG's current export yield of 40,000 metric tonnes to 160,000 metric tonnes by 2022. This alone could earn K800 million in revenue per year upon maturity of the nurseries (GoPNG, 2018a). The export earnings from cocoa is expected to increase by 57.4%, with an increase export volume of 298% from the 2016 baseline of 40,200 tonnes to 160,000 tonnes by 2022. In addition, the plan envisaged to increase production volume by 665% from the 2016 baseline of 40, 508 tonnes to 310,000 tonnes by 2022.

For coconut, the Plan envisage to increase export volume by 37% from the 2016 baseline of 43,500 tonnes to 60,000 tonnes by 2022. About 35% of total households in PNG or an estimated 2.6 million people are engaged in coconut income generation activities or for food (GoPNG, 2018a). On average, the industry contributes over K126.5 million per year in export revenue to the economy.

For rubber, the plan is to rehabilitate and expand into new areas and increase the export volume percentage up to 16% from the 2016 baseline of 2,400 tonnes to 2,800 tonnes by 2022 (GoPNG, 2018a). The rubber industry provides employment opportunities to over 200,000 people in Western, East Sepik and Central provinces, managed by smallholder rubber farmers and private sector investors.

For rice, the goal is to ensure "*domestic commercial rice production industry is established in partnership with private sector and small scale farmers to reduce the volume of imported rice and meet growing demand*" (GoPNG, 2018a). This is in response to the PNG National Rice Policy 2015-2030, so PNG can become both producer and exporter.

Rice is a staple food for most Papua New Guineans, hence PNG needs to produce sufficient volumes to adequately meet its domestic demand, thus reducing the high dependency on imported rice in the long term. Annually, PNG spends about K400 million to import rice to meet its domestic demand. Currently, PNG imports about 200,000 tonnes and by using the 2016 baseline it is expected to cut that by 25% by 2022 to 150,000 tonnes (GoPNG, 2018a). The Plan envisaged to increase domestic production from 4,500 tonnes to 4,700 tonnes or by 4.4%.

The Plan also looks at increase export volume and production in the livestock and fruit and vegetables sectors by 167% and 114% respectively.

In the fisheries sector, the Plan aims "*to maximize economic returns through sustainable management and development of the fisheries resources to foster wealth creation, poverty alleviation and food security*." Fisheries has the potential to contribute remarkably towards Government's priority in growing the economy.

The PNG's fisheries Exclusive Economic Zone (EEZ) of 2.13 million square kilometres is the largest in the South Pacific and supplies about 18% of the world's tuna catch, a percentage that has been steadily rising since 2010 (GoPNG, 2018). The total averaged revenue generated from both fresh and processed tuna exports annually since 2015 is between K600 to K800 million and has the potential to generate over 1 billion kina annually.

Hence, the Plan looks at increasing the revenue from the fisheries sector by 94% from the 2016 baseline of K573.1 million to K1,113.45 million fob. Other fisheries produces such as prawn and lobster, bech-de-mer and barramundi also have the potential to generate income that can meet both local and international demands which the government plans to tap into and increase export.

In the forestry sector, the Plan envisage to "*build a forest sector that is sustainable and highly profitable*." About 70% of PNG's land area (37 million hectares) is covered by forest which provides the rural population with food, fuel, traditional medicine and oxygen (recent estimates by PNGFA states 78% of PNG is forested). Forestry in PNG is dominated by large-scale log exports of which 10% of log export volumes are from plantations and 25% from land conversion projects mainly for oil palm and to a lesser extent, cocoa and tree plantation establishment (GoPNG, 2018a). The processing industry produces a wide range of manufactured wood products mainly for domestic consumption, with little being exported. Forest plantation development and expansion has also effectively ceased, but in recent years, the government is emphasizing on banning round log export by 2020.

This round log export means downstream processing is forthcoming and this is supported by the Marape-Davis government. This could add value on forest products and increase the export of forest by-products while simultaneously promoting environmental sustainability and plantation forestry. However, the industry is not yet prepared to take this leap because research and development of lesser known timber species, development of forest plantation and a need for huge capital investment are challenges that need to be addressed.

All in all, the MTDP3 looks at increasing all commodity group exports by 153% from the baseline of K24,908.20 million to K62,940.48 million. It also looks at increasing the volume of Foreign Direct investment (FDI) stock from US$4.2Billion to US$10billion. The Plan also looks at increasing the number of export and import partners from 93 to 99 and 170 to 190 respectively.

Apart from the MTDP3, the National Trade Policy provides a policy framework for trade agreements and trade negotiations, for the identification of sectors with comparative advantage, and for opening up market access in sectors that can have an impact on the economy and create jobs. Hence the Plan looks at increasing the export value of merchandise exports by 124% from K25,676.40 million in 2016 to K57,689.20 million by 2022.

In essence, PNG is a small open economy producing a diverse range of products from agriculture, forestry, fisheries, mining and petroleum. It is a net exporter of goods owing to the extractive sector but its services trade balance has reflected a deficit for the last few decades the government is looking at improving trade and investment in the country because of its export oriented nature, and to achieve sustainable green growth across all sectors. The goal is "*to maximize trade and investment by increasing exports, reducing imports on substitute goods and increase FDI that generate wealth and increase national economic growth*"(GoPNG, 2018a).

PNG does not produce many of the products it consumes, and relies on international trade for imports of physical capital, intermediate products and final consumer goods and services. With this policy direction, more pressure will be applied pertaining to balance the use and management of the environment, hence threats are imminent.

6.1.5. Governance and regulatory

Direct exploitation of the environment and resources are sometime economically driven as PNG becomes more globalised. However, there may be other reasons why PNG's natural resources are heavily or unsustainably exploited. One of the major concern is lack of good governance and stewardship.

When the government, and those in the public offices are not using wisely the revenue generated from the vast resources PNG has, it creats problems. That is, when the national budget is unwisely spent or misused and not accountable as per the national budget implementation plans, it puts a lot of strain on the government to deliver appropriate activities and services to the nation. When this happens, it sometimes exert more pressure to exploit more resources and rapidly, sometime without adhering to rules and regulations. Apparently, this can create more environmental footprints, just to generate the much needed revenue to support the government's budgetary requirements. Consequently, this may result in, for instance, declining forest resources and fish stocks, where more stresses are exerted on the resources to recover based on its carry capacity.

The issue of equitable distribution of revenue generated from the country's resources is a prominent issue faced in PNG. When the surplus funds or savings are exhausted, there is more pressure on the government to look for ways to generate money, hence it goes into more internal and external borrowings.

Consequently, it affects both the government spendings and savings thus creating a vaccum in the economy such as increased inflation and loan offsetting. This often leads to fast tracking resource development projects in the country. When this happens, coupled with lack of information and data that are not publically or readily available for State Negotiation teams to advise the government, inform decisions regarding Foreign Direct Investment (FDI), deals may environment impact studies or assessments and granting of Environment PErmit can be rushed.

Capacity sometimes is an issue, hence technical people with knowledge must be involve when negotiating any land, marine or resource development projects. Some government departments and agencies such as the National Fisheries Authority (NFA) and Department of Commerce and Industry (DCI) are facilitating direct foreign investments, and are involve in negotiations on behalf of the State. If there are no technical capable person in those organisations, it may compromise the sustainable management of PNG's natural resources. That is, lack of capacity to ensure compliance in laws and project agreements is achieved, may later instigate issues once projects are operational.

In hindsight, if DCI supports the development of a palm oil project without CEPA's technical input, problems may latter arise during monitoring of that palm oil project activities. Without having someone with the environment technical skills to assist DCI addresses environmental issues during the negotiation may create environment sustainability and governance issues latter during the operational stages of the project.

Moreover, during the operational phase of the palm oil project, the absence of a technical person from CEPA to assist DCI to ensure compliance and monitoring is done according to project agreement with the operator, monitoring and regulating the operation will be of sub-standard and or is compromised at times. Hence, lack of monitoring and effective enforcement can lead to many issues that were experienced in the forestry, mining, agriculture and other sectors.

A World Bank forestry review of the PNG Forestry Action Plan found rampant issues and instances of non-compliance to the Logging Code of Practice, police brutality, lack of Prior Inform Consent by majority of landowners, corruption in the sector, human rights abuses, environment and forest destruction and lack of sustainable forest management (World Bank, 2010). Prior to that in 1989, the Commission of Inquiry into the logging industry by Justice Tos Barnett had found gross abuse of the system, processes and practices. This include non-compliance and lack of monitoring, environment and forest destruction, corruption in the sector, human rights abuses, transfer pricing and police brutality among others. That review led to many changes in the forestry sector and the adoption of the PNG Logging Code of Practice 1996, the Forestry Act 1993 and the National Forest Services (NFS) transformed into PNG Forestry Authority.

Between 2010 and 2016, problem of acquiring large tracks of forest under Sustainable Agriculture Business Lease (SABL) has seen over 5 million ha being acquired by developers for agriculture purposes. However most forest were logged and few agriculture projects have developed into full operations. Many issues that were faced in the forestry sector before re-appeared, hence a commission of Inquiry was conducted subsequently. Consequently a moratorium or blanket ban on all SABL activities was announced by then Prime Minister, Peter O'Neill, however this is still unclear as some forest activities are continuing in some SABL land.

The only way to avoid most issues faced by the country is to ensure reliable information, data and technology are available to make inform decisions when monitoring of projects. With capable Papua New Guineans to negotiate on behalf of the State, sustainable resource development and management of the environment can be achieved. Hence, in any negotiation, someone with the technical knowledge, plus a team of technical professionals must be involved in the initial negotiations.

When the project is in operation, a closer working relationship must be ensue that State agencies must work with CEPA as the governing authority, to monitor project activities to ensure they are environmentally and socially compliant to the terms and conditions of the agreement. The agencies must also work in separation from politicians to ensure compliance mechanisms are followed and rules adhered to by developers. Upskilling of staff and provide resources and funding are also major set-backs and must be address amicably as well.

In hindsight, there are instances where decision makers and bureaucrats are often dictated by political direction, right from the top that sometimes suppresses all processes and procedures. That is, when political decisions are made, it overrides the technocrats to interfere in that decision, hence projects are often approved without due diligence. In some instance, the government may have equity in some resource projects such as in mining and oil and gas, thus compromising the government's agency's position (e.g. CEPA) to effectively regulate, enforce or monitor projects transparently, consequently resulting in breakdown in governance.

A recent report by Transparency International ranked PNG as one of the most corrupt countries in the world (tradingeconomic, 2019). According to Transparency International's Corruption Perception Index (CPI), PNG was placed at 138 out of 175 countries between 2009 and 2018. Despite some improvement in its ranking over time, the average CPI for PNG was 140.13, depictingPNG as one of the most corrupt countries in the world. The highest ranking was reported in 2007 where PNG was ranked at 162. This trend shows PNG governance issues are of concern hence need urgent redress. Figure 2.23 shows PNG's CPI trend over time between 2009 and 2018 was from 154 to 135 but fluctuate over time. The lower the ranking means corruption is low.

In order to address the CPI, those at the political level must work closely with the technocrats and be advised appropriately based on their technical understanding and knowledge to ensure transparency and good governance prevail in all sectors and any development or resource project. That is, once a project is in operation, a closer working relationship with CEPA as the environment governing body must occur in order to forge a stronger working relationship in terms of monitoring project's activities and to ensure compliance is met. That is why Project Monitoring and Evaluation (PME) is very important because it ensures compliance mechanisms are used by developers to reach the government's sustainable development goals and objectives.

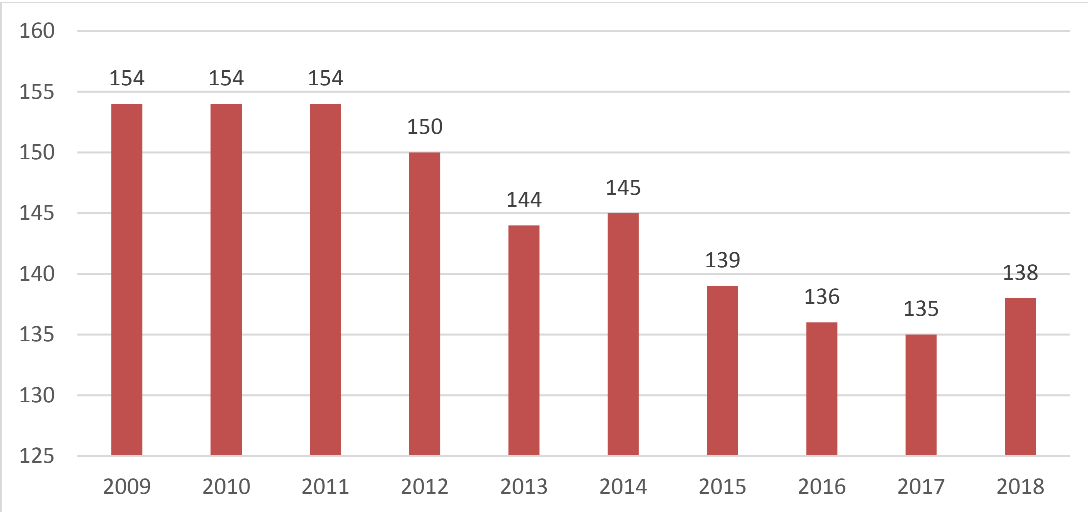


Figure 2.23: Papua New Guinea Corruption Perception Index 2009-2018 (Tradingeconomics.com)

Currently a National Content Plan (NCP) is undergoing development by DCI and once completed, would address the issues highlighted above. The NCP would most likely address the issues of implementing government policies effectively, such as Small Medium enterprise (SME), Vision 2050 and MTDP 3. This is a framework that envisaged to strengthen and provide greater participation by all stakeholders from the national level down to the provincial level, to ensure the investment projects are implemented effectively and in compliance with any agreements and laws of the country.

Currently, many policies are not working effectively but it is believed once the NCP is in operation, it may enable government agencies to get more involved in project development, starting at the initial phase of development and continuing during the operational stage.

A study on land rights and environment shows that on paper, PNG has comprehensive laws to protect the environment and ensure land deals are done appropriately (Woods, 2019). Unless laws are enforced effectively, PNG will still experience continuous governance issues across all sectors. Poor law enforcement, monitoring and lack of accountability that violates the laws is leaving the ecosystems and land vulnerable to achieve sustainable development, and equal participation, including landowner consent for development. Rush decision making by bureaucrats and politicians may drive unsustainable development.

Since there are often failures in the system, the environment is often compromised, hence may result in failure to implement existing government development plans and MEAs effectively.

Finally, research and development are essentially required as PNG is working towards a common goal of achieving sustainable development. It is not yet too late for PNG to improve, however PNG needs the political will and tough decision making to make now in order to mitigate those environment problems and to manage the resources and environment sustainably. Transparency is also critical when making decisions and PNG must have a robust and effective system of environmental compliance, monitoring and governance.6.1.6.

6.1.6 Land-use change

PNG is a signatory to several international conventions and protocols. In 1992 in Rio de Janeiro, Brazil, many countries around the world including PNG adopted the Agenda 21 of the United Nations Convention on Environment and Development (UNCED). This was one of the first international document highlighting the importance of land-use planning for sustainable development.

In 2018, a draft National Sustainable Land Use Policy (NSLUP) for PNG was developed by the Department of Lands and Physical Planning (DLPP). This policy is timely, given the current rapid economic development and unsustainable uses of natural resources. Most land-uses in PNG are done independently by various agencies without a national land-use plan.

Most government policies discussed earlier in this Report will certainly create a paradigm shift in the short, medium and long term course of the country. The draft NSLUP was formulated to provide a framework to substantially improve land use planning and also to make land available for investments and developments in PNG. "*It aims to provide direction for planning, allocation, wise use, management and best use of land and land resources both in urban and rural areas in order to achieve the policy objectives*." (GoPNG, 2018b). This policy also looks at both the land-use and physical planning, with the goal of improving planning, allocation and management of land and its resources in PNG through;

- Developing all the land use plans by integrating relevant sectoral land use plans that contributes towards alleviating poverty and promote economic growth;
- Strengthening and improving the physical planning system that drives the process of decentralization;
- Developing, integrating and establishing a centralized national land-use information management system that encompasses all appropriate sectoral land-use information;
- Promoting a balanced social, environmental and economic development for present and future generations; and
- Empowering capacity development at all levels in the maintenance of professional standards.

Moreover, the objective of the NSLUP is to promote best use of land to achieve sustainable development:

- To develop all (national, regional, provincial, urban, local and subject) land-use plans thus integrating relevant sectorial land-use plans;
- To strengthen and establish institutional structure at all levels of Government including the association of physical planning division to facilitate land-use planning;
- To establish a centralized land-use information management system;
- To guide and promote development that is in accordance with all approved land-use plans; and
- To empower and strengthen capacity development at all levels of government.

With paradigm shift in government policies, economic corridors are opening up because of much needed resources and services required by the masses. Generally, it is often the case that development activities, through globalization, increasing trade and rising population are exerting pressures on land-uses. Consequently, this has created effects such as deforestation and forest degradation through logging, mining, subsistence agriculture and commercial agricultural conversion (e.g. palm oil), which causes other offshoots such as pollution and waste runoff.

Most development activities or land-uses in the country, as it seem, are unplanned or uncoordinated and done by different government agencies to cater for mining, forestry, agriculture, conservation, urban planning and road construction to name a few.

Below are major activities identified as major drivers of deforestation and forest degradation that may have serious repercussion on biodiversity, ecosystem's health, culture and livelihood of the local people.

I. Major types of Land-uses in PNG

Increasing demand for forest resources such as timber are continually exerting pressure on forest cover change. In addition, demand for food, minerals, and infrastructure development like roads and airstrips also lead to clearance of forest thus enabling accessibility to forest resources or bringing new threats such as forest fires, forest clearance for settlement, ecological and habitat alteration, loss of species and introduction of invasive species (GoPNG, 2018c).

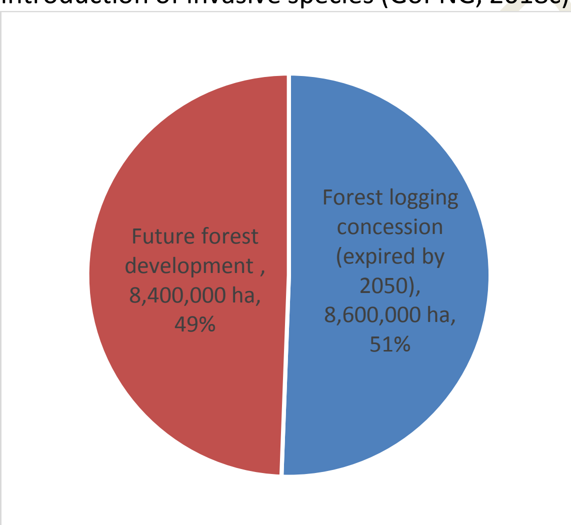


Figure 2.24 Current logging concession and future concessions

The commercial logging sector, is the largest driver of forest Greenhouse Gas (GHG) emissions, is planning to expand in the future. Figure 2.24 highlights there are currently over 8.6m hectares (ha) of forest under concession in PNG, with most timber permits not due to expire until 2050 (UNDP, in press). Meanwhile roughly 8.4m ha have been identified for potential future development.

Commercial agriculture, is the third major driver of GHG emissions in PNG, and is dominated by oil palm. In 2013 palm oil plantation covered an area of approximately 350,000 ha. Secondary cash crops, including cocoa, palm oil, coffee, and coconuts also contribute to deforestation and collectively cover an equivalent area of land. The PNG government has set ambitious plans for agricultural expansion, targeting a five-fold increase in agricultural production by 2030 which see an estimated additional 1.3 million ha of land converted to cropland (Bito and Petit, 2016; UNDP, in press).

Subsistence agriculture covers an area of 3.2 million ha in PNG, with production closely linked to domestic consumption, whilst surpluses are sold at the local market for cash. With population increasing rapidly in PNG (circa 3.1% per annum), and per capita consumption also rising, deforestation due to family agriculture is also likely to increase (UNDP, in press).

Figure 2.25 shows the percentage of different land-uses occurring on different land types in PNG namely forest, grassland, cropland, wetlands and settlements, with 78% of land under cover. According to FAO (2015), PNG has around 33.6 million hectares of forested land covering 72.5% of the total land area, with 8.8 million ha designated as production forest. Almost the full extent of the forested area is defined as primary or otherwise naturally regenerated forest, and PNG has about 62 000 hectares of forest plantations. Despite the high forest cover, PNG's forests are still facing significant threats leading to deforestation and forest degradation. Deforestation rates are somewhat contentious, but usually range between 0.5 and 2.5 percent over the years.

PNG's forest are undergoing constant changes given the rapid increase in population and development activities. In rural communities, most deforestation happens because of shifting cultivation and fire associated with humans.

Figure 2.26 shows that population has a big influence of forest cover change, where population density is proportional to land-use patterns. According to GoPNG (2018c), more than three-quarter of it is primary has not been disturbed by human activities, 11.9% is disturbed by large-scale logging and 0.2% is disturbed by small scale logging using portable sawmill. Small scale shifting cultivation gardening cause 7.9% of forest disturbance.

The other consequence of degrading PNG's natural forest and asset is to increase PNG's greenhouse (GHG) emissions. PNGs forests store a significant amount of carbon dioxide (CO2) - The clearance of all 4 million hectares of Special Agriculture Business License (SABL) designated areas for instance, would result in emissions of 1.2 $GtCO_2e$-, equivalent to around 30 years of emissions at current levels; and, if the expansion of the agriculture sectors were to take place as outlined above, PNG's GHG emissions would conservatively increase by an additional 220 million tCO_2 over a 15-year period - a 50% increase in current emissions from commercial agriculture (UNDP, in press)

Figure 2.27 shows the percentage of land-use by different activities, and logging seem to be the main land-use compared to fire and other uses. Figure 2.28 shows under 250,000ha of forest in PNG have been degraded annually while Figure 2.29 indicates deforestation was under 25,000ha between 2000 and 2015, except in 2013 where it was about 50,000ha. This may be a result of increasing Sustainable Agriculture Business Leases (SABL) agriculture projects. Given the paradigm shift in economic, social and political landscape, different land-use patterns and uses can change the development, social and economic pattern of the country.

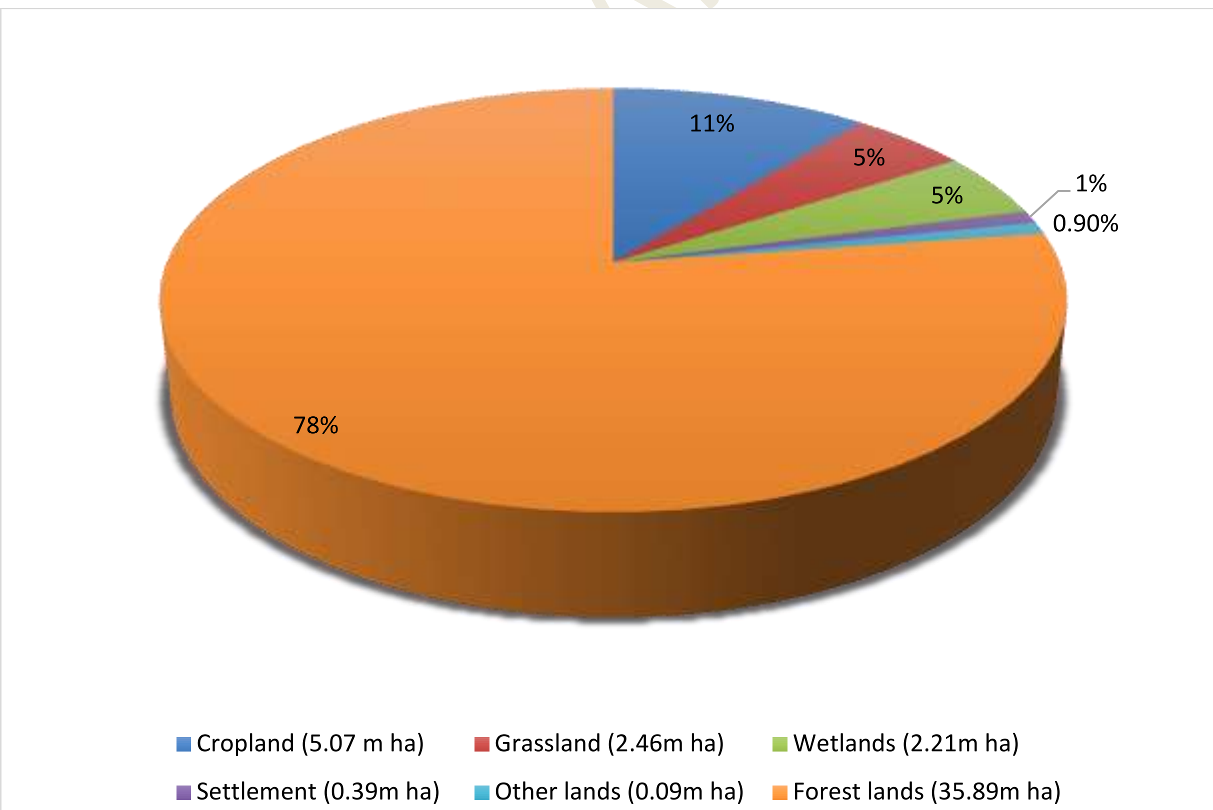


Figure 2.25: Different land use in Papua New Guinea (GoPNG, 2016).

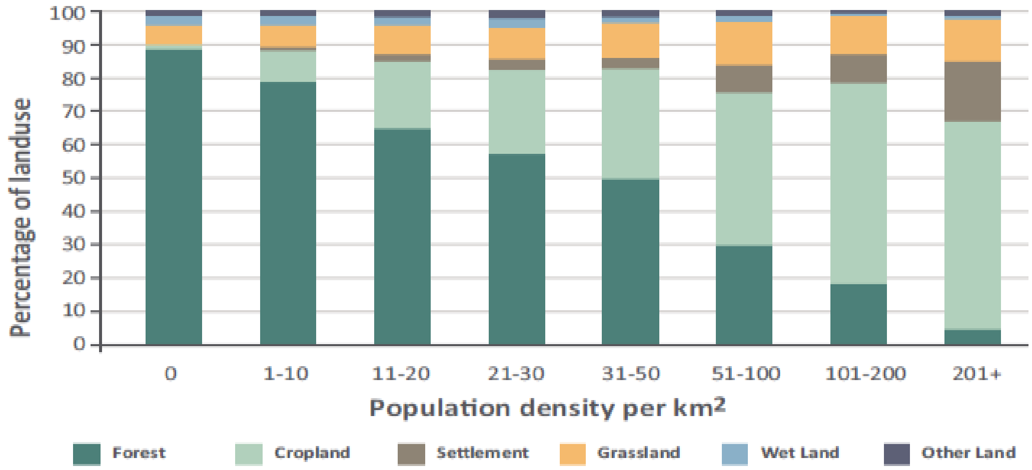


Figure 2.26: Trend in landuse and population density (GoPNG, 2018c)

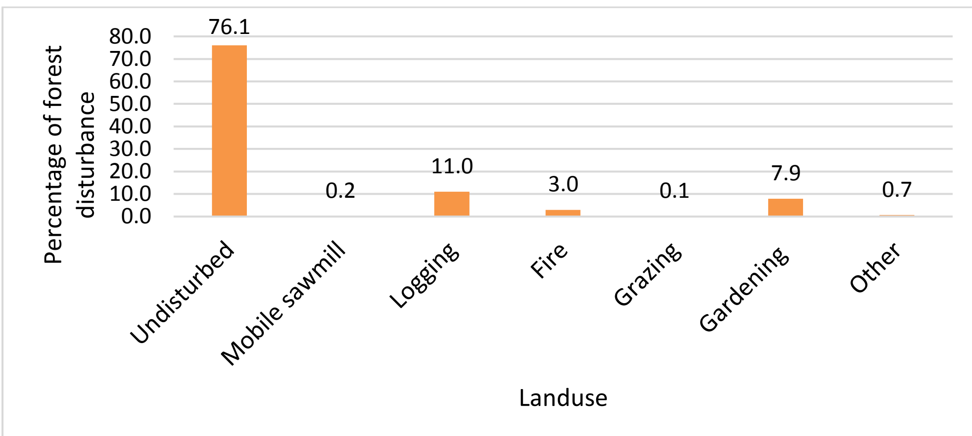


Figure 2.27: Percentage of different forest disturbances (GoPNG, 2017)

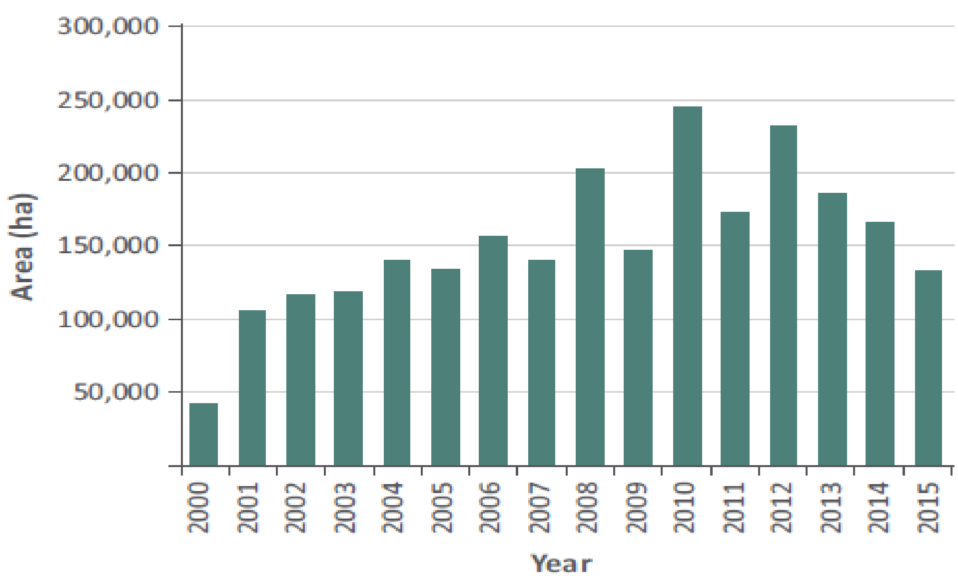


Figure 2.28: Forest Degradation 2000-2015 (GoPNG, 2018c)

Figure 2.29: Deforestation 2000-2015 (GoPNG, 2018c)

If the current rate of forest clearance through forestry and agriculture practices are unsustainable, the status and integrity of PNG's forest will be at stake. Unless the government takes drastic actions to manage the land and forest sustainable, forest clearance will continue at alarming rate. Given the less number of protected area to protect the forest and other environmental goods and services from depletion, increasing pressure by the rising population, logging or agriculture crop demand will continue, hence forest cleared forest will continue, resulting in loss of soil fertility, species, integrity and ecological functions.

Therefore, proper national land-use plan, monitoring and compliance and governance of activities must be adapted as earliest to govern all activities in forestry, mining, agriculture and other land-uses.

II. Commercial logging

PNG forest industry is one of the major income earner to the government coffers. Second in the agriculture segment to the palm oil industry in export value, the forestry sector continues to expand because of strong regional demand.

The growth in the forestry sector has increase over time since 1960s. Annual export volumes increased gradually during the 1970s and 1980s, expanded rapidly in the 1990s to a peak of 3million m^3, then dropped to an average of 2 million m^3 a year in the late 1990s and early 2000s, before increasing again over the past decade.

The clearing and degradation of native forests to scale-up forestry and commercial and family agriculture does not just impact the natural environment and biodiversity. Soil erosion and runoff associated with land clearing, and chemical (pesticides) and nitrogen (fertiliser) pollution associated with increased agriculture can then readily enter streams, then flow into rivers, and finally into the sea – this pollution will damage PNG's marine ecosystems (e.g. coral reefs) and therefore commercial and subsistence fisheries.

The clearing of coastal wetlands and mangrove forests (fish habit) can also impact fisheries and expose coastal communities and land-based industry (e.g. ports) to sea-level rise and storm surge events – both of which are increasing due to climate change. Keeping these coastal ecosystems intact can buffer against these negative impacts. Moreover, sustainable land management practices could aid in enhancing natural capital derived economic outputs. For example, the National Fisheries Authority (NFA) estimates PNG's 350 to K400 million market value of fish catch could be increased significantly through better land and sea management and development programs.

In recent times, the government has allocated large swaths of land for agricultural development which has allowed companies to fell increasing amounts of valuable tropical hardwoods for export. Production and exports hit an all-time high in 2011 as a surge of new special agriculture and business leases (SABLs) opened up large tracts of private land for development. This has propelled the country to its current status as the second-largest exporter of tropical timber in the world after Malaysia. However, issues ensued in 2012 over the validity of many of the SABLs, which led to a freeze on development (Oxford Business Group, 2015).

According to Oxford Business Group (2015), the forest industry earns around PGK1bn ($378.4m). In 2014 forestry product shipments hit a high of PGK962.1m ($364.1m), eclipsing the record of PGK768.3m ($290.7m) set in 2011 with a 32% increase over the 2013 total of PGK729.7m ($276.1m), and one-third greater than the PGK627.1m ($237.3m) registered in 2012. The majority of these exports consisted of raw logs, which accounted for PGK950.3m ($359.6m), or some 99% of the annual total. The forest industry produced about 4.1 million m^3 of logs in 2015 (ITTO, 2018).

Figure 2.30 shows almost 89% of the logs were exported as roundwood while the remaining was used domestically. From the plywood produced, 90% were used domestically and 10% was exported while an additional 10% was imported. From the total veneer produced, 95% were used domestically while 5% was exported. Moreover, for sawnwood, almost 83% was used domestically, 17% was exported while1% was imported. Table 2.6 shows the major wood products produced and used domestically or for export. Moreover, from the majority of timber products domestically produced, most have been exported, with a small portion wrere imported product.

Figure 2.31 shows PNG's forest industry predominantly export round logs to overseas markets, mainly to China. The other destination markets remain important for the exports of processed wood products, such as sawn wood. Figure 2.31 also shows the major importers of PNG's timber and log products. By 2020, the national government plans to ban round log export and promote downstream processing. However, investment into downstream processing and business is a big challenge.

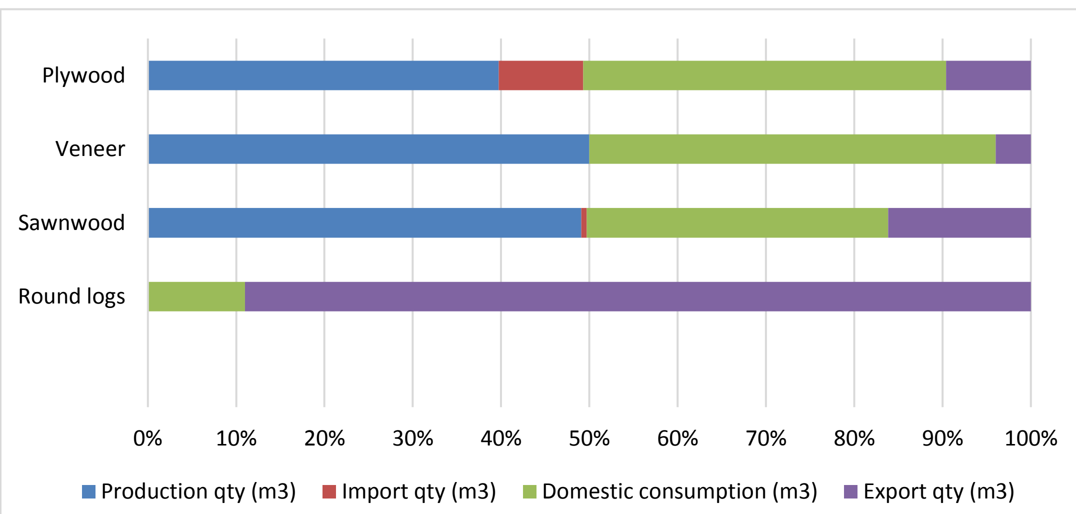


Figure 2.30: Percentage of wood products and their uses for domestic, and export market, including importation in 2015 (ITTO 2018).

Table 2.6: Major timber products for domestic, and export, including import in 2015 (ITTO, 2018)

Product	Production qty (m^3)	Import qty (m^3)	Domestic consumption (m^3)	Export qty (m^3)
Round logs	4 100 000	0	451,000	3,649,000
Sawnwood	82,000	1000	57,000	27,000
Venner	63,000	0	58,000	5,000
Plywood	29,000	7000	30,000	7,000

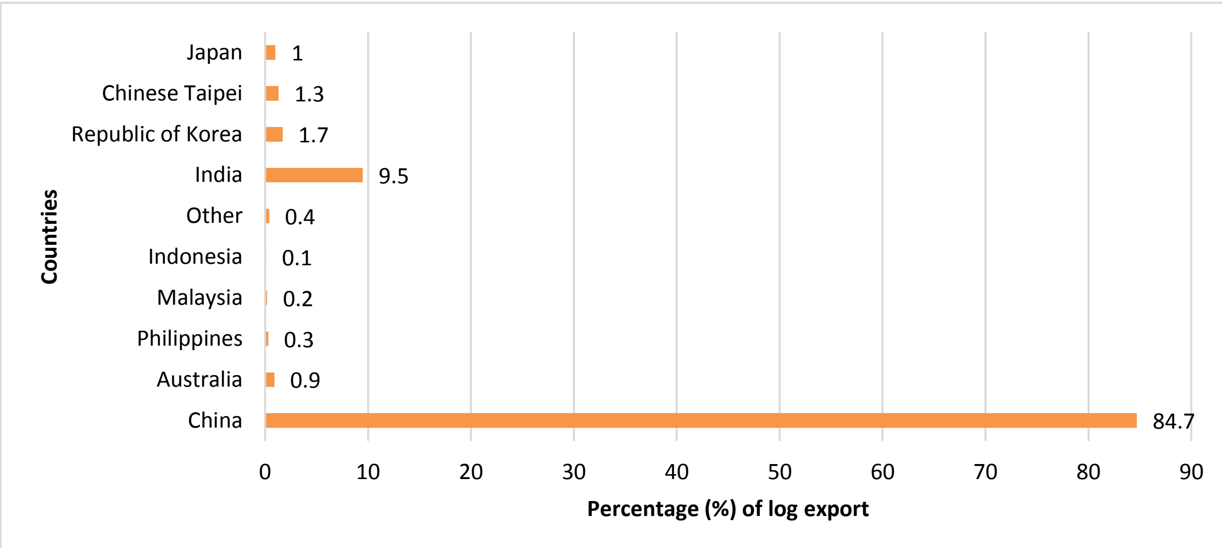


Figure 2.31: Major importers of PNG forest products in 2015 (ITTO, 2018.)

It is widely recognized that commercial logging is the biggest driver of forest change and degradation. Commercial logging account for almost 48.2% of forest change and biodiversity loss in PNG (Sherman et al., 2008; Bryan et al., 2015). Tallowin et al. (2017) argue that many of the terrestrial biota are found in forest, hence the destruction, loss and fragmentation to forest habitats can cause species loss.

Figure 2.32 shows the percentage of logging concession across the four regions of PNG with the highest concessions found in the Southern while the lowest in the Highlands Region(due to ruggedness and mountain terrains). This will most likely change given the increase in additional 5 million hectares awarded to SABL projects. In addition, some forest resources in many of those concession areas were already exhausted in terms of their resource base or the concessions had already expired or will come to their end. There are some being recently renewed.

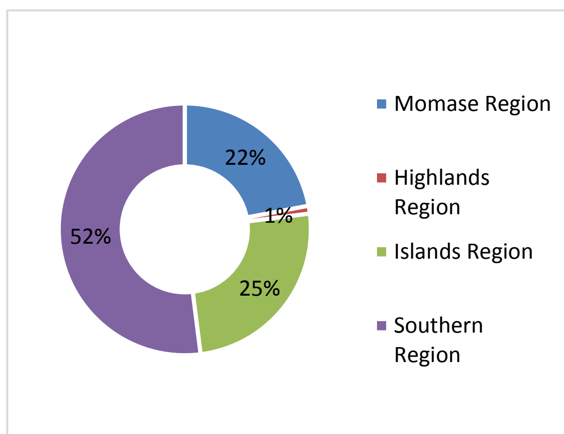


Figure 2.32: Logging concessions by region (FAO, 2009)

Though these concessions played an important role of acting as "vehicles" for immediate development, mostly in rural areas, it comes at an opportunity costs. Issues of corruption, governance, sustainability, environment damage, landowner issues, social and economic problems and lack of monitoring are often tossed about as hinderance to achieving sustainable forestry in PNG. Thus, many forests have been destroyed and their ecosystem values and well-being of local people have been compromised.

III. Commercial Agriculture

PNG has been an agriculture nation before western civilisation and during early colonisation. It has continued to do so post-independence. During the 1970s when there were no mining and oil and gas, the national government budget was mainly supported through renewable resources until Panguna mine came into operations in mid-1970 and Ok Tedi Mine in the mid-1980s.

Thus, the agricultural sector is the mainstay of economic growth and poverty reduction in PNG. The sector has contributed between 25 to 40% GDP over the past 40 years and around 85% of the population are dependent on agriculture for their livelihoods (Bito and Petit, 2016). PNG government policies mainly the Vision 2050, DSP, MTDS and StaRS have ambitious plans to increase agriculture production based on increased productivity by 60% and increase land under cultivation by 180%, depending on the major commodities needs. The emerging policy direction is leaning towards a stronger and more sustainable agricultural sector.

Developments within the cocoa and coffee sectors are focused on improvements in productivity while the palm oil sector is focused on increasing production through expansion of the area under cultivation. The Palm oil sector, the country's biggest agricultural export earning close to Kina 1 Billion per annum, is expected to have the largest impact on forest cover in the short to medium term. Oil palm is expected to increase in sizes for up to 200, 000ha across the country while the existing 150,000 ha is currently established and operated by New Britain Palm Oil Limited (NBPOL) and Hargy Oil Palm (HOPL) Limited and new mills entering into operations (Bito and Petit, 2016).

The area under cultivation is likely to double in the short term based on expansion of existing projects and increase by 10-fold to 1.5 million ha by 2030. In the 1970s, forest clearance for plantation was an important development where most lowland fertile land were converted to agricultural land, especially in West New Britain and Milne Bay provinces where 3.2 % and 1.1% were cleared for palm oil (Shearman et al. 2008).

Figure 2.33 shows the export values of agriculture commodities between 2005 and 2014. Palm oil is the best export commodity earning an average of K872m per annum followed by coffee with 491m and cocoa with K263m. Copra oil is the forth best export earning K97m, followed by copra with K29m, and rubber with K26m. Tea is the least earner yet it earned an average of K16m per annum.

Some palm oil operations are not in line with some internationally recognized sustainability standards currently applied by palm oil producers within the country. Currently, the global industry is moving towards internationally recognized standards where companies responsible for 90% of global palm oil trade have committed to zero net deforestation and sustainable products to be achieved by 2020 within their supply chains as spelled out under the Amsterdam Declaration. Some new developments operating under SABLs may have serious repercussion on the reputation of PNG's palm oil industry and this could impact export to countries like the European Union who is the major palm oil importer of PNG's certified palm oil products.

The coffee and cocoa sector represent the second and third most significant agriculture crops in terms of their economic importance to PNG. Coffee and cocoa exports when combined earned over K650 million per year. The current government policies are looking at the targets for increased production focusing on improvements in productivity of existing producing areas and rehabilitation of existing blocks or plantations. Significant sectoral support provide by the Productive Partnerships in Agriculture Project (PAPP) through the World Bank and there is potential for increase certification above existing levels (currently approximately 10%). The potential for coffee/cocoa certification in PNG is much higher than its current level of production, currently below 10% for each commodity (Petit and Bito, 2016).

With the Government's policy to upscale the agriculture sector, agriculture intensification means soil fertility will be lost. Hence, commercial plantations and agricultural crops need better techniques and technology to produce high quality and in quantity to supply its export demands. Consequently, this sometimes leads to widespread uses of nitrogen and phosphorus fertilizers and herbicides. Banabas (2007) mentioned in his PhD dissertation that the palm oil industry uses over 12,000 tonnes of fertilizer annually to offset nitrogen deficiency in oil palm plantations. He argued that oil palm strips out between 160-200kg/Nha-1yr-1 from the soil.probably because of massive rooting systems the plant has that demand more nutrients.

High rainfall incidence also causes leaching and runoff, and dentrification processes are taking its toll, accounting for almost 50% of nitrogen loss. Nitrogen fertilizer accounts for between 40-70% of the cost of production. Moreover, the use of herbicides may also leached into the the aquatic system and may cause euthorphication and loss of biodiversity as well (GoPNG, 2015).

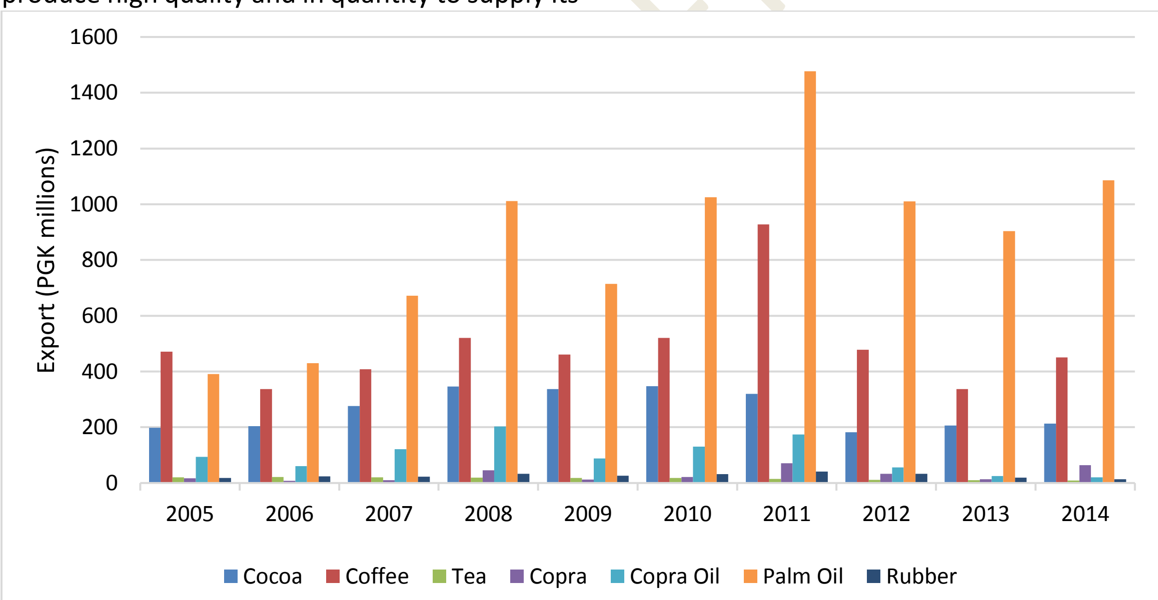


Figure 2.33: Export earnings by different commodities between 2005-2014 (Oxford Business Week, 2015)

IV. Subsistence Agriculture

Almost 80 percent of Papua New Guineans live in rural areas and depend much on their land, sea and forests for their sustenance. Shifting cultivation is one activity where majority of these people do for their livelihood and account for almost 45.6% of forest change compared to industrial logging which has 48.2% (Shearman et al. 2008). Thus shifting cultivation was identified as the second most significant driver of deforestation and forest degradation in PNG that impact on biodiversity and habitats (Shearman et al., 2008; Bryan et al., 2015). For generations the people have practiced swidden or fallow agricultural system, and planting crops on rotational basis and returning back to the same land after 10-15 years.

Consequently, over time, the forest begins to rescind, coupled with increasing population and poor economic growth, and pressure to use the same land continuously was discouraged as soil fertility drops.

In areas that are densely populated, particularly in the highlands and villages closer to urban areas, there is intensive gardening to meet local and industrial-demand for food and cash. This exerts ore pressure on the land and forest thus impacting the soil and its conditions. In logged-over areas, road access has enabled locals to move into concession areas to make gardens hence, further burning or clearing the forest. Most subsistence gardening can also lead to anthropogenic bush fires which often burn new forest thus turning them into anthropogenic grassland. This is often sever during dry season.

V. Mining

The mining sector has been the major revenue earner and driver of economic development PNG after oil and gas, followed by agriculture sector, fisheries and forestry. It contributes about three-quarter of export revenue and 17% of GDP (GoPNG, 2015). According to Business Week (2015) production data reported to the mining regulator, the Mineral Resources Authority (MRA), indicates copper exports in 2014 totaled K1.11bn ($421.5m), roughly on par with 2013. Since 2007 the country's average annual copper volume export index (1994 = 100) has declined from 96.2 to 46.3 through the first three quarters of 2014, almost the average shipping volume.

On the other hand, gold exports have remained more stable, with export revenues declined from K6.4bn ($2.4bn) in 2010 to K5.3bn ($2bn) in 2012 before rebounding to K5.4bn ($2.04bn) in 2013. Oxford Business Week (2015) also reported that the export of alluvial gold was at a record high in 2014 at K373m ($141m), with exports through September 2014 remained below the pace set in 2013, with PGK3.8bn ($1.4bn) in gold shipped through the first nine months of the year. All in all, the average annual production index for gold remained above 100 through 2010, when it registered 110.2 before dropping into double digits in subsequent years, averaging 93, 83.9, 98.6 and 90.3, from 2011 to 2014.

Moreover, total mineral export receipt was K5,765.2 mil in the March quarter of 2018, compared to K5,875.5 mil in the corresponding quarter of 2017. The decline was due to lower export volume of gold, copper, crude oil, condensate and lower value of LNG (BPNG, 2018). Figure 2.34 shows metal prices are fluctuating since 2012 to the lowest in 2015/2016 but picked up growth thereafter.

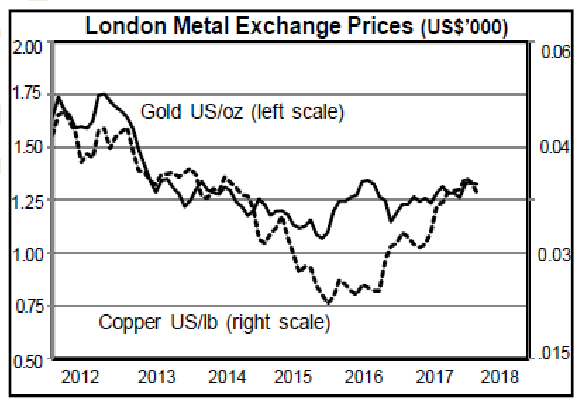


Figure 2.34: Mineral Export between 2012 and 2018 (BPNG, March 2018).

The Bank of PNG that the volume of nickel exported was 9.0 thousand tonnes compared to 7.4 thousand tonnes in the corresponding quarter of 2017 (BPNG, 2018). In addition, the volume of cobalt exports was 0.9 thousand tonnes in March 2018 compared to 0.7 thousand tonnes in March 2017. The increase stems from higher production and shipment by the Ramu Nickel/Cobalt mine, reflecting improved operational performances, and partly in response to higher international prices and growth in stainless steel sectors and car batteries producers. This resulted in combined increase in export price and volume resulted in higher export receipts of K229.1 million March 2018, compared to K99.2 million in March of 2017 (BPNG QEB, 2015).

PNG's mining sector is not immune to the local conditions (e.g. natural disaster and landowner issues) and global economic shocks that continues to have impact on the industry. Slack demand for base metal products and decreased access to cash for junior operators has curtailed exploration and development worldwide, delaying a number of PNG operations in the process. The low commodity prices of metals has impact operations of larger operations in Ok Tedi, Porgera, Ramu, Lihir and Hidden Valley. This saw decline in profitability which have in turn led to lower export receipts and less revenue for the government, especially taxes, royalties and other levy fees.

In addition, new projects were also affected because of issues faced as a result of local administrative and logistical hurdles, which delay these companies from entering into later development and production phases. While none of these next-generation projects have come on-line yet, parent companies continue to show resolve in bringing them to fruition with ongoing developmental expenditures, which should in time bring new and profitable projects to the market as the older legacy mines wind down their operations. Mining is very important to the government coffers, hence new deposit discoveries are high in government priority.

Despite the beneficial impact and contribution mining has to the nation, extensive indirect cross-boundary impacts are eminent, especially pollution and run off from tailings. For instance, huge toxic waste, pollutants and silts have been discharged into the river systems and the environment. Most mines are located near major water catchment, and high conservation value forest areas. In addition, mining also contribute to huge clearance land and forest thus having impact on the food change and biodiversity (GoPNG, 2015). More recently, an underwater mine was under development in the Bismarck Sea, off the coast of New Island and East New Britain provinces. This may pose concern on the marine environment, including people.

VI. Fire

There is a general belief that destructive wildfires are not common in moist tropical forests. In recent years, wildfires has become a norm because of accumulation of dry litter or fuel brought about by prolong droughts. In 1997-1998, the drought instigate a massive fire disaster that burnt across Western province claiming 150,829 ha of forest (Shearman et al. 2008). Right around the country, forest have been burnt either intentionally for gardening or indiscriminately resulting widespread fire disasters.

Opening of forest by logging, roads and commercial agriculture also enable people to make gardens or burn bushes. For instance, logging enable locals to have easy access to the forest and is severe in logged forests (Shearman et al. 2008). This behavior has led to forest destruction and change thus resulting in change in habitat or forest structures, species composition, thus new species emerged such as grass. Between 1972-2002 the spatial analysis indicates that almost 347,079 ha of forest were lost accounting to 4.4% of the PNG landmass, with the 1997-1998 *El Nino* being responsible for 160,000ha of forest loss (Shearman et al. 2008). In higher altitudes, 13% of upper montane forest was lost between 1972 and 2002.

VI. Urbanisation

Papua New Guinea has seen rapid change where urban development is taking prominence as PNG's economy is growing and expanding. Infrastructures such as roads, buildings, urban expansion and settlements are developing rapidly. Because of rising urbanization, the footprints are also increasing rapidly, especially wastes from industries, domestic and solid waste. Construction of buildings and earthworks also contribute to increasing run-off that causes drainage blockage and flooding.

Over the years, modern urban planning were not done by local municipalities. Figure 2.35 shows the growth of cities and urbanization across the globe in different regions, with the highest growth in North America, followed by Latin America and the Caribbean, Europe, Oceania, Asia and Africa. The Oceania region, which PNG is part of is the fourth faster region in terms of urban growth.

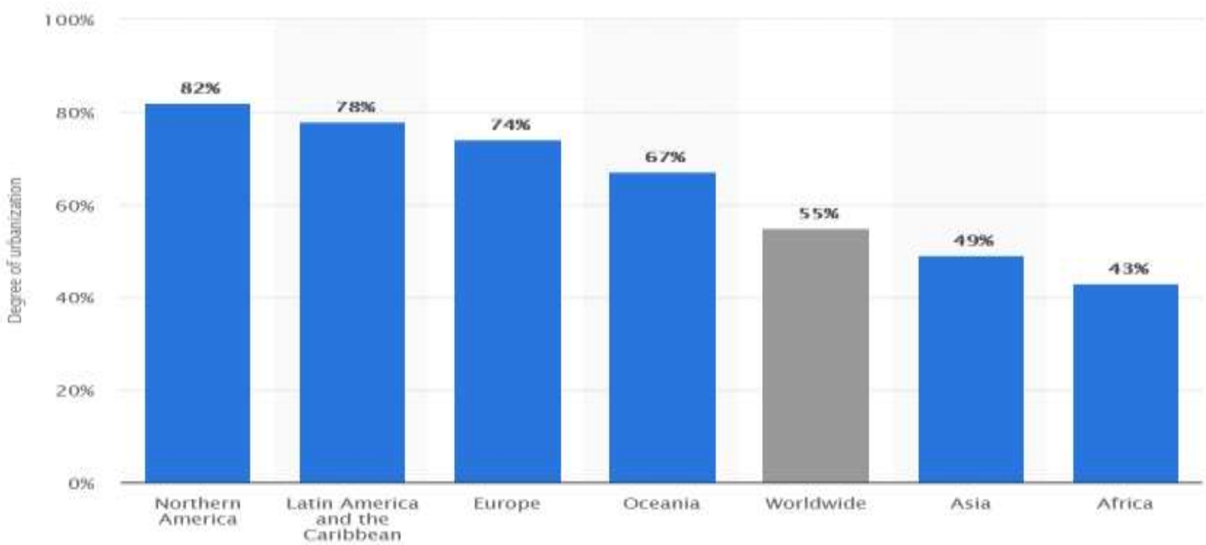


Figure 2.35: Percentage of Urban growth per region compared to the world (https://www.statista.com/statistics/270860/urbanization-by-continent/)

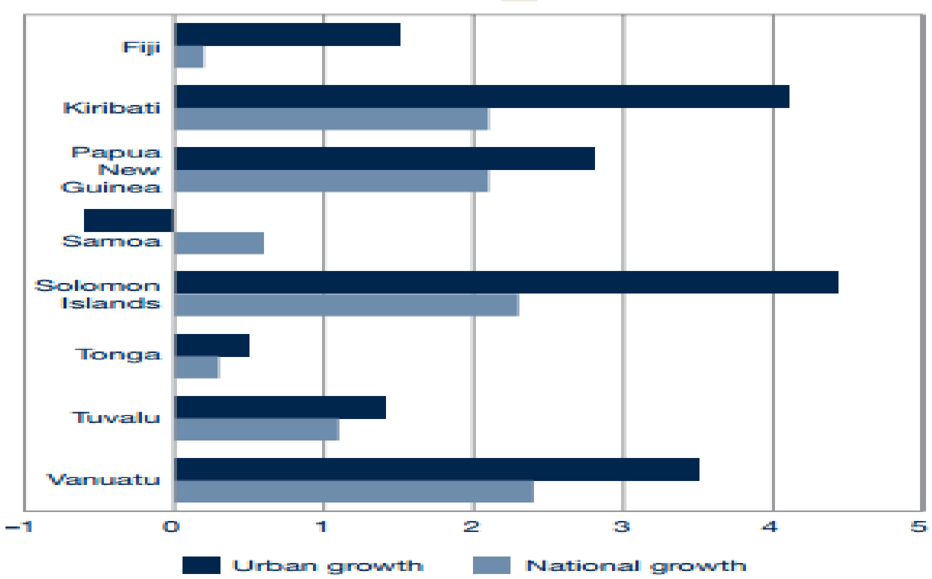


Figure 2.36. Urban and national population growth for pacific Islands Country (SPC, 2015).

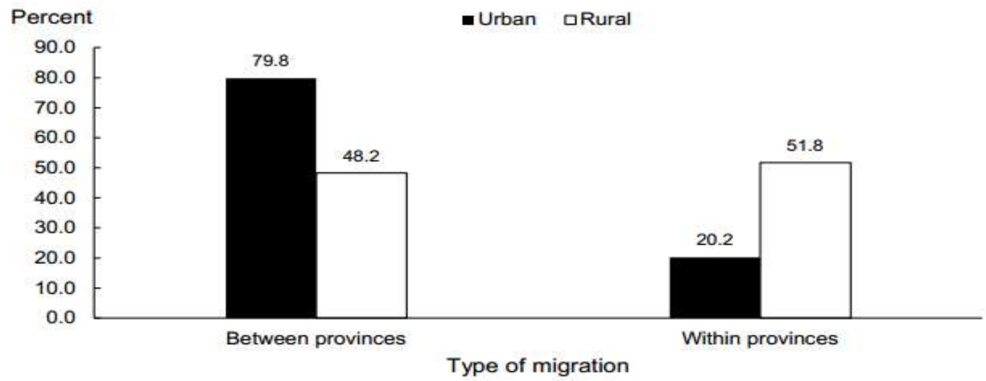


Figure 2.37: Migration of citizens in PNG (NSO, 2011).

Figure 2.36 shows PNG's urban growth in the Pacific is among the fourth highest in the region after Solomon Island, Kiribati and Vanuatu. Pacific island countries are rapidly urbanising. In nearly every country in the South Pacific, the urban growth rate exceeds the national population growth rate. Papua New Guinea (PNG) faces similar pressures; its urban population is expected to double by 2030 (GoPNG, 2010). Figure 2.37 shows that migration was higher in urban areas as expected than rural areas and between provinces than within provinces (NSO, 2011). It was also higher for rural areas within provinces than between provinces.

As cities grow, so too the diverse services, because more than 50% of GDP is generated from urban areas, as growth in transport information technology and small to medium enterprises increase open up (ADB, 2012). Partnership with government and private sector, financial institutions and education also flourish. A study by a post graduate student of the University of Papua New Guinea shows that majority of people coming to urban areas for a reason. Many people come to urban areas to seek opportunities, for services, family, market, retrenchment and tribal fight (Steven, 2016). Though the sample is low, it still shows the main reasons people migrate to urban areas in PNG. Figure 2.38 shows the incentives for people migrating to cities like Port Moresby.

As more people are migrating to urban areas, the demand for improvement in services and infrastructure also escalates. This also puts a lot of stain on resources which indirectly contribute to other issues faced in the city such as increase in loitering of soil and fluid wastes, excessive fuel and energy consumption, urban sprawling and increase in social and economic problems, scarcity of land and other issues.

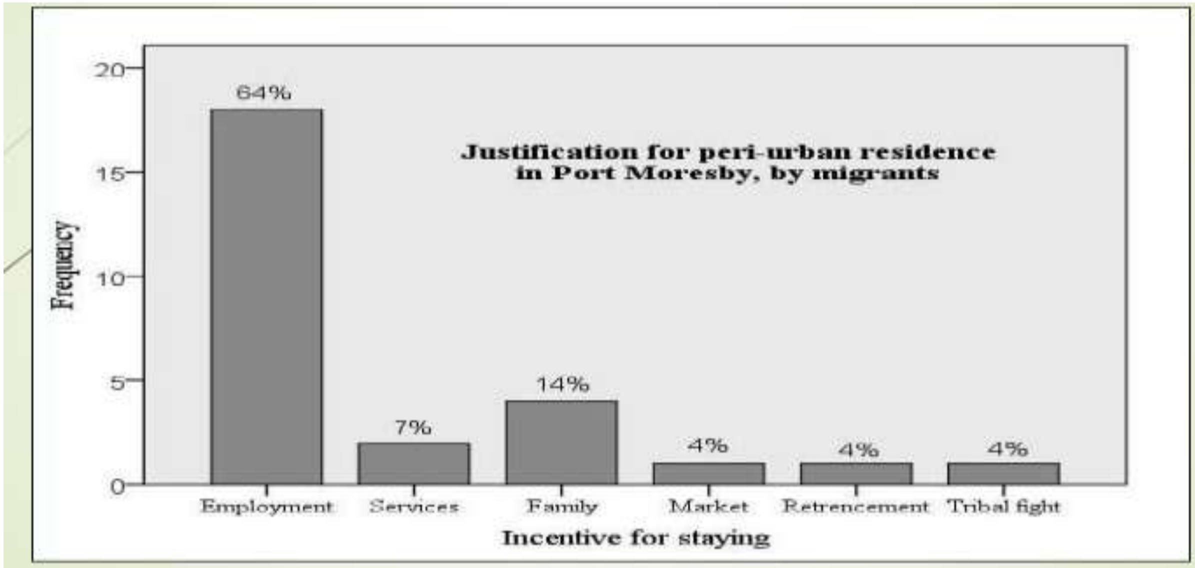


Figure 2.38. Incentives for staying in the city of Port Moresby (Steven, 2016)

6.1.7. Invasive or Exotic species

Invasive or exotic species are not native to a habitat or area but are introduced by vectors such as human, natural source or and other sources such as transport. Generally, most exotic species have no boundaries and can be easily be transported either intentionally or not intentionally by humans, different transport modes and animals. In PNG, most quarantine services are provided by the National Agriculture Quarantine Authority (NAQIA), mainly to safeguard agriculture commodities. There is not national body or partnership with other government agencies to look at the national level.

Some invasive species can be local species that could become a problem at its local habitat or elsewhere while others are not native to the local area but are introduced. Invasive species typically exhibit several traits that contribute to their successful establishment in new environments they inhabit. These include tolerance and adaptability to a broad range of environmental conditions, high reproductive capability, ability to successfully disperse, and low or negligible rates of predation (Allison and Fraser, 2018). They tend to compete with local species and may displace or become dominant. About 10% of invasive plants that change the character, condition, form, or nature of ecosystems over substantial areas may be termed 'transformers' (Richardson et al. 2000).

The economic costs of invasive species is staggering with estimates of USD 9.8 billion spent internationally on biodiversity conservation in 2013 and more recently, the New South Wales Government declared annual economic costs of managing invasive species at AUD 2.8 billion dollars((Waldron et al.,2013 and NSW Gov, 2018; cited in Allison and Fraser, 2018). The recent coffee Berry Borer which invaded the Highlands provinces of PNG in 2018 cost about K30 million to eradicate completely. Only % mil was spent by Coffee Industry Corporate to mange its spred and contain the pest.

A pathway for invasive plant species in the rainforest is through the opening of the canopy by logging and access tracks. Theses species can be introduced by machinery that has not been inspected before entry into an area of operation. There are at least 39 invasive species in rainforest (Kiapranis & Banka n.d.), however the amount of change that these have caused in the rainforest ecology is not known.

A review by GoPNG (2015) records among the invasive species in PNG, are cane toad, 5 species of birds and 4 mammals being common. Feral cows can become invasive in some areas. It was also reported that 22 exotic fish species were introduced. For plants, around 250 species may become problematic, depending on where they occur. Various reports shows varying numbers in different localities that have between 54-90 species of weeds of concern.

A tentative list (2019) from NAQIA shows there are 1 star fish, 28 fish, 16 insects, 3 snails, 1 bacteria, 1 fungus and 429 exotic plants species of major concern. For insects, the number of pest could be between 50-100 species whereas for pathogens, fungi and bacteria, between 50-100 species (*pers. comm Warea Orapa*). Figure 2.39 shows major taxa group of invasive species that are of concern in PNG, where invasive plants are the biggest threat to the country's natural assets and economy.

Introduced, alien or exotic plants and animals, including bacteria and viruses are regarded as one of the major cause of biodiversity loss. When exotic species are not managed or handled swiftly, it may also cost huge economic loss for a country. It can also cause environment costs affecting the marine, coastal and terrestrial environments, livelihood, and species. For instance, several frog species have been extinct around the world because of the deadly effects of the parasitic Chytrd fungi (*Batrachochytrium* spp) on vulnerable species (Bower et al. 2017; Bower et al. 2019). If this parasite reached PNG, it will cause a massive extinction of species that are confined especially to higher altitude of above 600m. Table 2.7 shows predicted loss of frog species in PNG, which most species occuring in higher altitudes are likely to be affected.

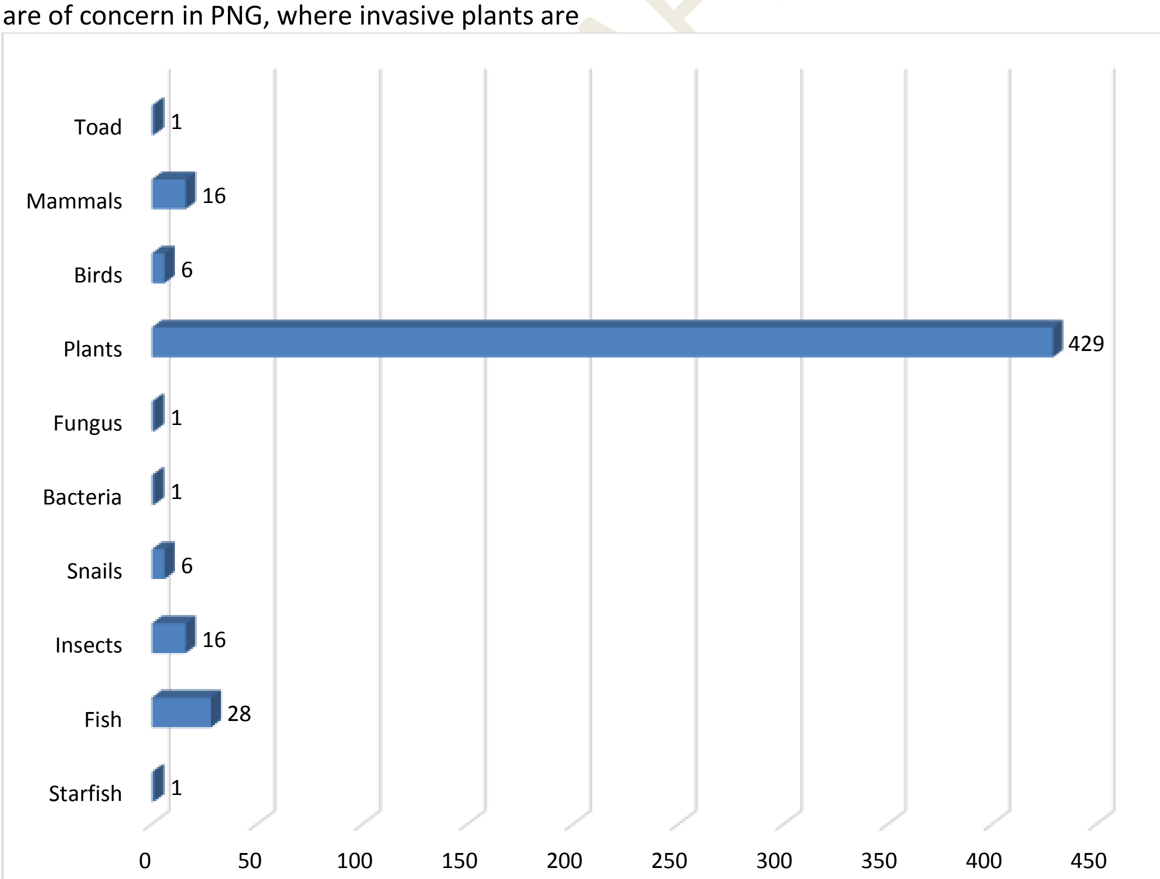


Figure2.39. Major taxa of invasive species in PNG (Warea Orapa, NAQIA)

Table 2.7: Expected frog extinction in PNG (Bower et al., 2019).

Family	No. spp. in PNG	Predicted to lose
Ceratobatrachidae	44	8
Dicroglossidae	2	1
Limnodynastidae	4	1
Microhylidae	212	38
Myobatrachidae	4	1
Pelodryadidae	102	22
Ranidae	12	2
Total	380	**73**

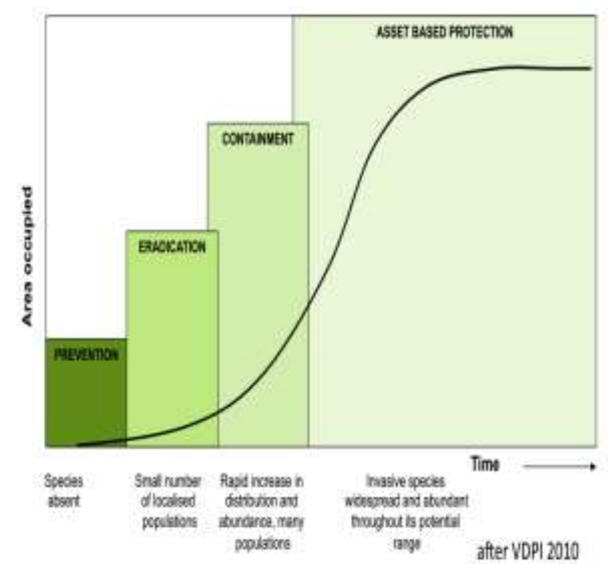


Figure 2.40: Strategy hypothesis and approach to address invasive species (Grice et al., 2010)

The strategic options to manage invasive to have minimal or no impact on the national assets or biodiversity are prevention, eradication at local level, containment (partial or total), protecting the asset (impact reduction, suppression or control). It needs profound decision making to address invasive if they are newly introduced or when they have already become establish in an area of concern. Figure 2.40 shows the general invasion strategy hypothesis and approach to address invasive species.

6.1.8. Extractive industries

The extractive industry, comprising of the mining and petroleum, is a major economic contributor of revenue to Papua New Guinea. PNG's extractive industry sector is currently based around five commodities-gold, copper, oil, gas and nickel and cobalt.

In recent times, there is so much booming in the extractive industries. While the current resources boom has underpinned the nation's growth and development experience, there is widespread perception within the country that this extractive –based form of development has not been inclusive or reached as many Papua New Guineans as it could and should have been over the years (UNDP, 2014).

Despite the resource boom, there are widespread environmental costs that offshoot inadvertently or by chance, causing damaging impacts on the freshwater and coastal ecosystems. The huge infrastructure and production facilities associated with mining and oil and gas operations also degrade land, watershed, and causing deforestation and displacement of species to some extent. In addition, these operations can permanently alter landscapes and habitats, and potentially detracting from the human development opportunities of people who reside in and beyond the footprint areas of operation sites.

The form of environmental impact from the extractive sector is both point-specific and linear. The latter tend to be focused along river systems while the former largely focused on discharge into an island or valley system. The environmental impacts arising from mining are largely irreversible.

Nonetherless, PNG has a strong sustainability story to tell impact investors. Its forests and other ecosystems (much of which are ecologically intact) are a significant contributor to climate change mitigation, it harbours a rich array of biodiversity, and, its people maintain strong cultural connections UNDP (in press. Conventional business models that destroy natural ecosystems are now being phased out.

The mineral and oil and gas sector contributes substantially to government's coffers. Figure 43 shows the export value received from the mineral sector, coming from gold, silver, nickel, cobalt, chromite and copper was highest for gold followed by copper and nickel. Figure 2.41 shows the exiting operating mines, mines under development and potential mines in PNG. Figure 2.42 shows the new mine tenements almost coming into production. Since 2012, there were 168 mining exploration licenses being issued to various Title Holders where some of them had already expired and or renewed.

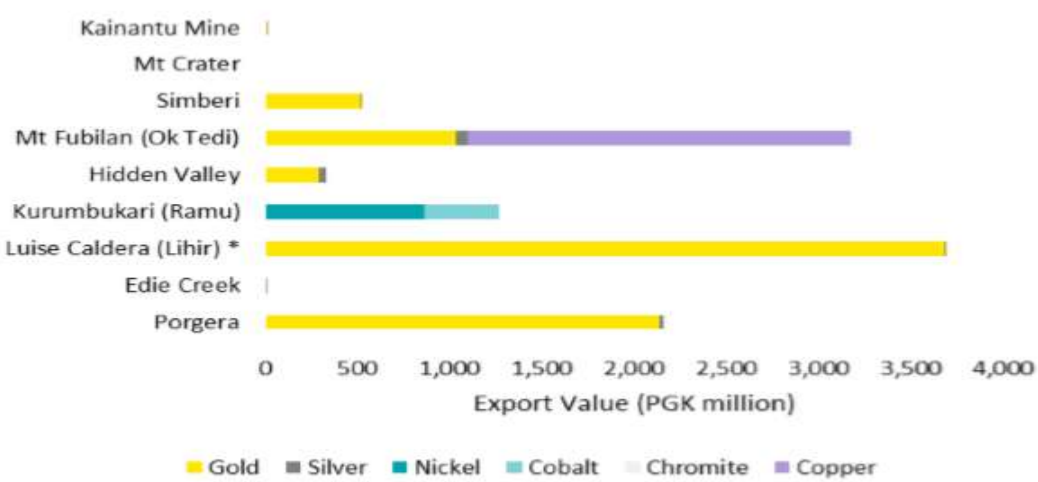


Figure 2.41: Export Value of minerals (MRA, cited in PNG EITI 2018)

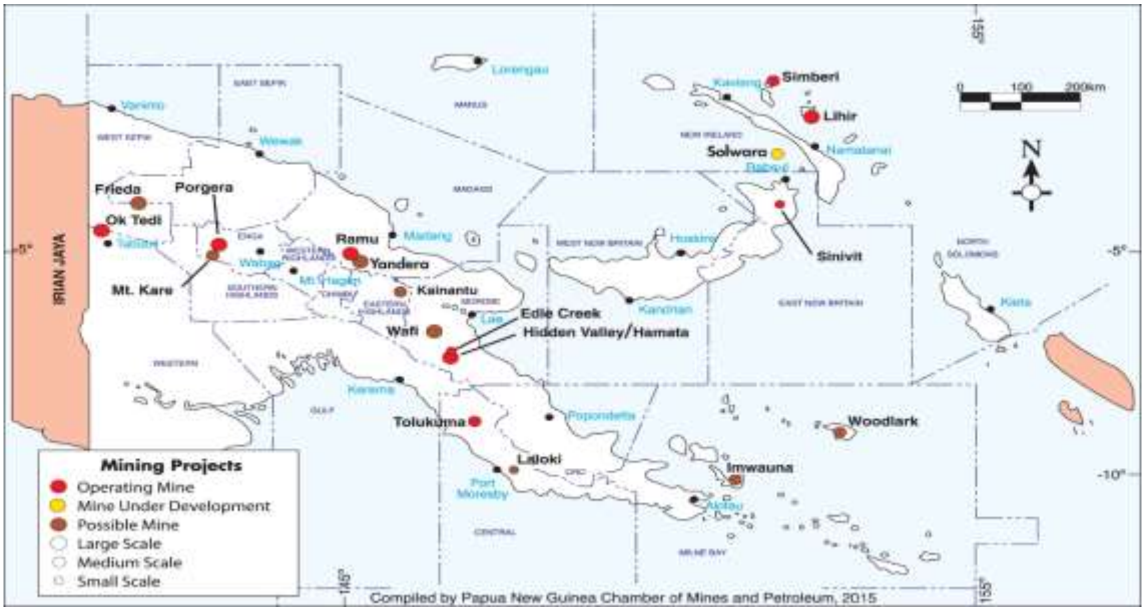


Figure 2.42: Operating, mine under development and possible mines in Papua New Guinea. (PNG Chamber of Mines and Petroleum (http://pngchamberminpet.com.pg)

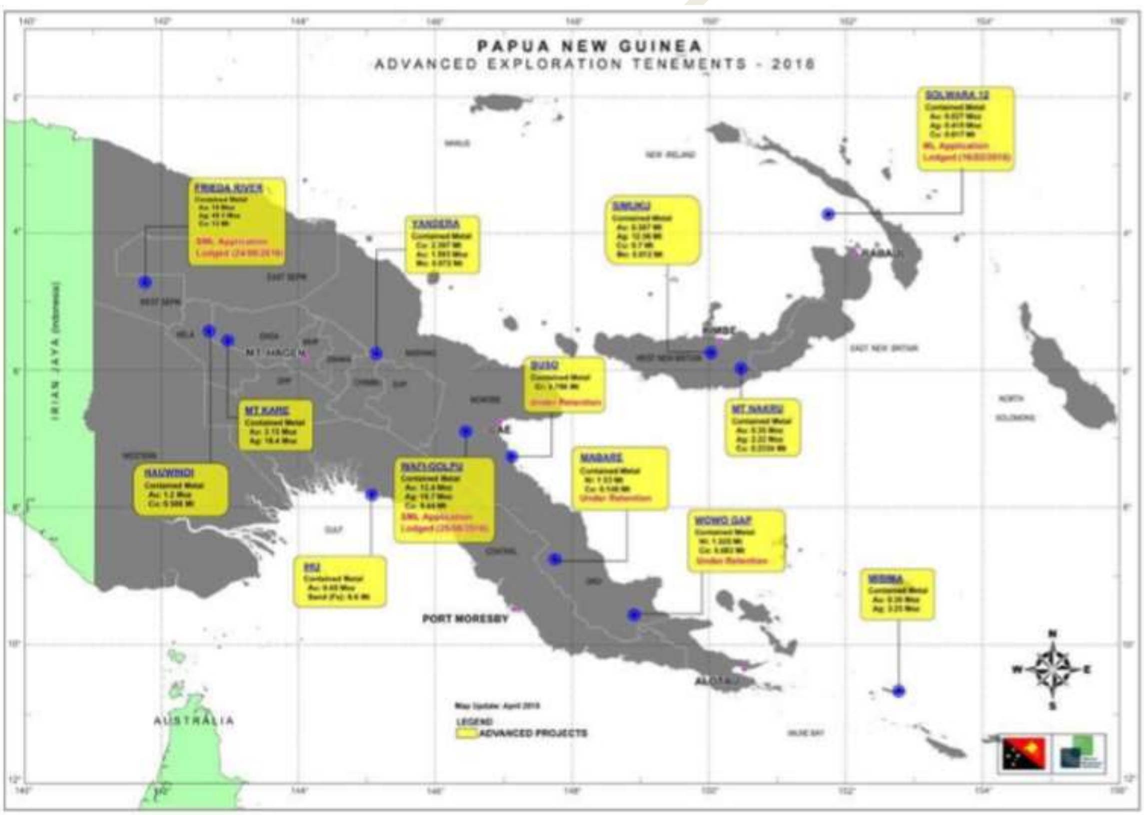


Figure 2.43: Advance tenement (PNGEITI, 2018)

Apart from mining activities, oil and gas also contribute significantly to the national economy. The commissioning of the US$20billion PNG LNG project in 2012 is projected to increase the country's GDP growth to more than 20% (ADB, 2014). With such giant leap in growth, PNG has an opportunity to leverage significant sustainable and equitable improvements by developing its health, education, income and other sectors of broad-based development. However, this growth has not being realized in the recent years because of external and internal debt servicing, falling commodity prices, global economic down turn, reduce in oil prices, misuse or mismanagement of public fund and other setbacks such as natural disasters.

Figure 2.44 shows the operating oil and gas field in the country while Figure 2.45 shows the oil and gas production for oil since 1992 and for LNG gas since 2014. The picture shows that oil production is declining but there is an increase in LNG production. Several new oil and gas exploration are currently underway in PNG.

The setbacks from oil and gas field is the alteration of local climate by way of gas flaring and emission of access gas from the earth into the atmosphere. Both the oil and gas file also allow permanent changes in the landscape and opening of corridors thus making introduction of invasive species and secondary disturbance and threats from humans becoming more of a concern as well to local habitats and species.

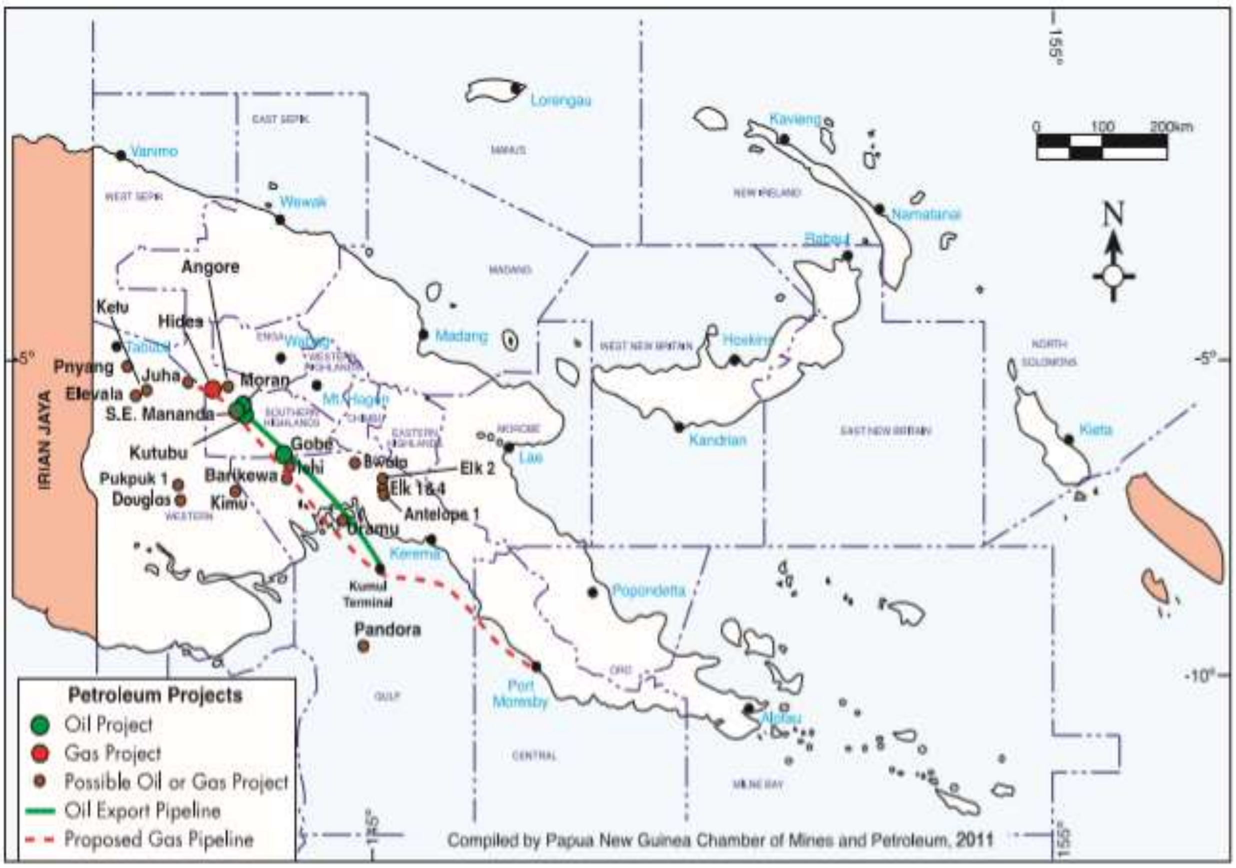


Figure 2.44: Operating, oil and gas field under development and possible oil and gas fields in PNG (Chamber of Mines and Petroleum)

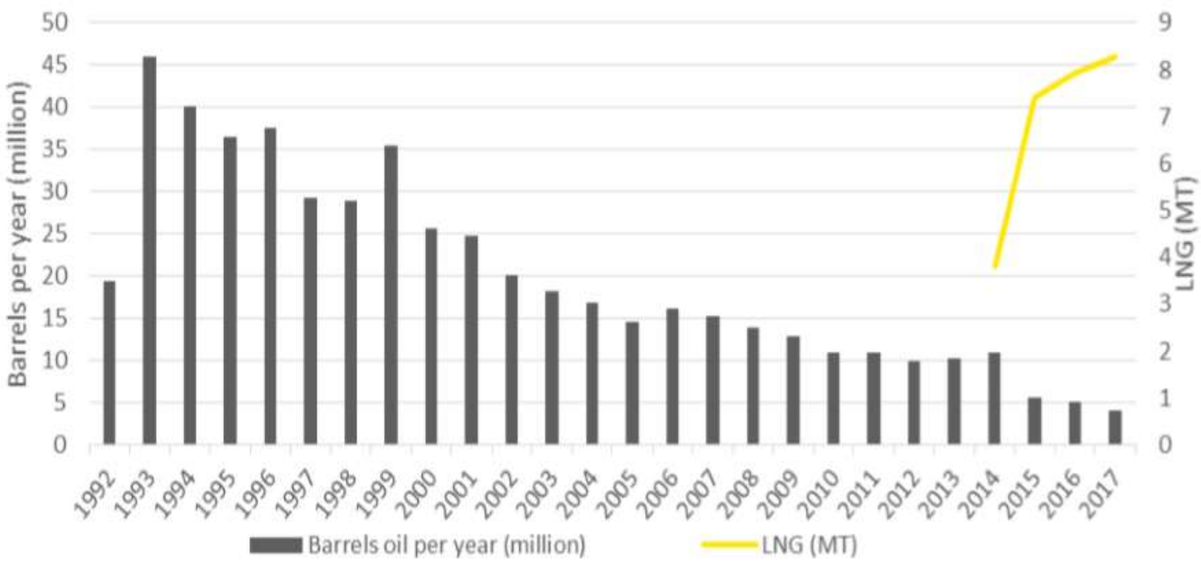


Figure 2.45: PNG Oil and LNG Production (1992-2017). Source United States Energy Information Administration. https://www.indexmundi.com/energy/?country=pg&product=oil&graph=consumption (PNGEITI, 2017).

6.1.9. Climate change and variability

The main climate drivers for PNG are the *El Niño* - Southern Oscillation (ENSO), the West Pacific Monsoon and to a lesser extent the position of the South Pacific Convergence Zone (SPCZ). The influence of ENSO on rainfall is stronger in the Southern and Mainland than the Northern regions. Thus the impacts of *El Niño* and *La Niña* are more evident in these two regions - the main impact of El Niño is a late start to the monsoon season. The positioning of the SPCZ also influences the climate of the Southern region (GoPNG, 2014b).

Since PNG is in the tropics, there is very little variation in the maximum and minimum temperatures. Rainfall patterns also varies and basically influenced by topography, ocean and altitude. In PNG three distinct patterns are known for the Momase and New Guinea Islands, Highlands and Southern Region Temperatures showed warming trends in both the maximum and minimum temperatures across the regions with higher increases in the night time temperatures.

Figure 2.46 shows the annual maximum variation for temperature in Port Moresby (Southern Region) between 1970 and 2006. Figure 2.47 shows the temperature pattern for Kavieng (Islands region) between 1973 and 2009 also shows slight difference to that of Port Moresby with increasing temperature for Port Moresby compared to Kavieng .Kavieng receives much rainfall than Port Moresby which is much dry. Figures 2.48 and Figure 2.49 also shows the annual rainfall variability for Port Moresby (1945-2009) and Kavieng (1917-2009). These differences are included by ocean wind trade and the ENSO patterns. In recent times, dry season has been more pronounced in the Port Moresby area and the country. Also rainfall are also changing across the country.

PNG's economy and population are highly exposed to the effects of climate change. At the same time, lack of technical, physical, and financial capacity to plan for and cope with severe weather events exacerbates corresponding risks. Vulnerability to climatic events is uniquely pronounced for PNG's 800,000 coastal villagers, due to their reliance on small ports for the timely delivery of perishable food. In the hinterlands, sudden massive floods have now cause havoc to properties and lives for both animals and man, thereby threatening infrastructures, food security and health among other concerns. It also has serious repercussions on the economy, especially agriculture and mining.

The 6th National Report to the Convention on Biodiversity 2019 (in press) states that in farmers' subsistence gardens, the diversity of foods crops is being lost at an alarming rate. The intense droughts that are occurring in the country are causing 'genetic erosion' to food crop diversity in the subsistence sector. Farmers are able to maintain only the crop varieties that are hardier and can withstand dry spells, such as the triploid ABB cultivars/landraces of bananas are hardier than diploid AA cultivars. Following drought there are often extended periods of La Niña with many months of rain, conditions which favour other cultivars, whilst drought tolerant varieties may decrease in these conditions. Consequently, genetic diversity is lost, not only under *in situ* conditions, but also under *ex situ* establishments due to effects of climate change, inadequate resources, and in the latter case ongoing inconsistent funding.

PNG is far from becoming more climate resilient because of lack of early warning systems. The Building Resilience to Climate Change in PNG Project is currently strengthening the capacity of communities, government agencies, and civil society to plan for and respond to the effects of climate change. The project is (i) increasing access to adaptation financing; (ii) fostering a better understanding of climate change vulnerability and adaptation options; (iii) increasing adaptive capacity at the sectorial, national, district, and community levels; and (iv) enabling further investments in climate-resilient maritime infrastructure for coastal villages (ADB, 2018).

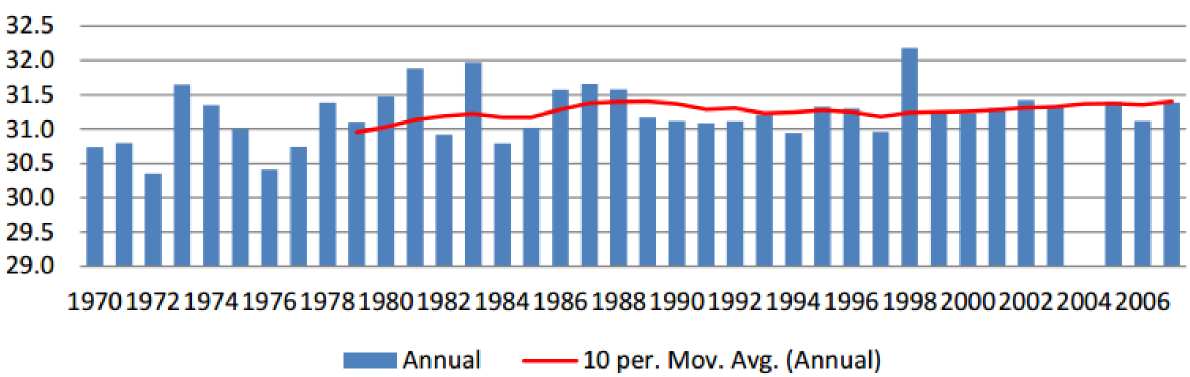


Figure 2.46: Annual maximum variation for temperature in Port Moresby (Southern Region) between 1970 and 2006 (GoPNG, 2014b)

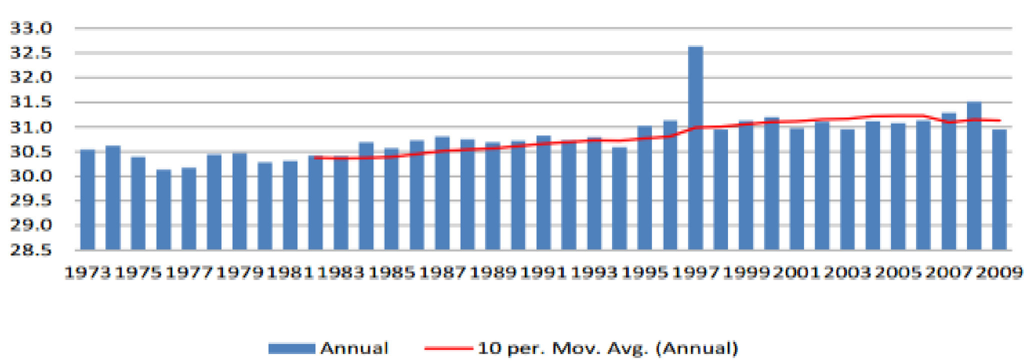


Figure 2.47. Temperature patterns of Kavieng between 1973 and 2009 (GoPNG, 2014b)

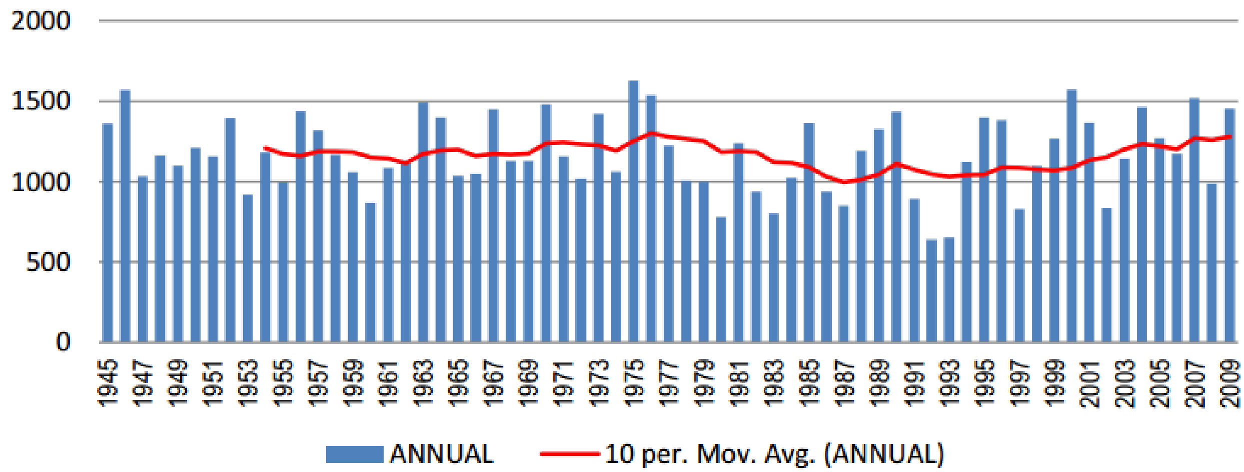


Figure 2.48: Annual Rainfall Variability for Port Moresby between 1945-2009 (GoPNG, 2014b)

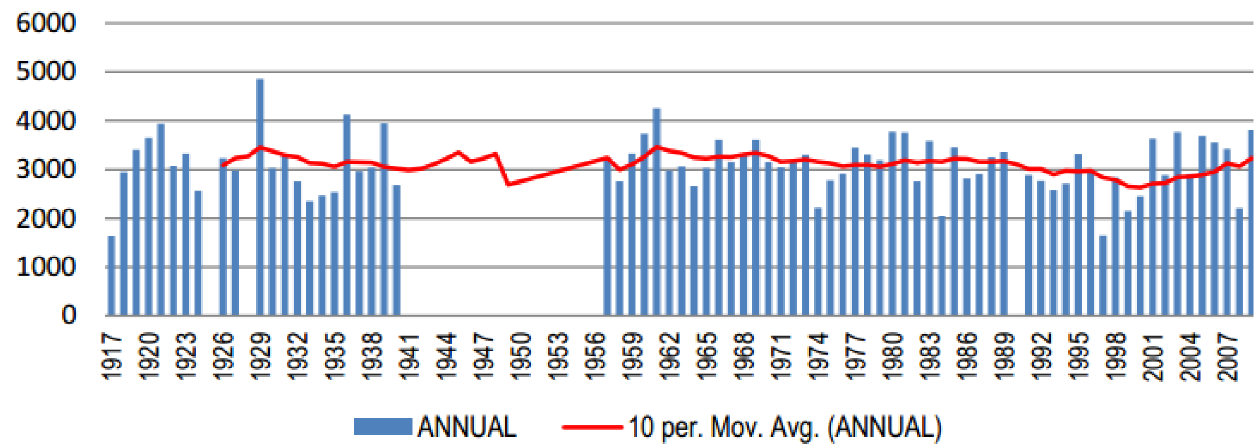


Figure 2.49: Annual Rainfall Variability for Kavieng between 1917-2009 (GoPNG, 2014b)

6.1.10. Pollution

Pollution is a term used when a substance entered or is present in the environment that causes harmful or poisonous effects that affects the natural state. This word is synonymous to contamination and impurity. There are many causes of pollution that comes from solid and chemical wastes caused by human activities, such as household wastes, factories, mining, forestry, agriculture, combustions, transport, fuel usage and so on. Pollution from greenhouse Gas emissions are also escalating since the industrial revolution.

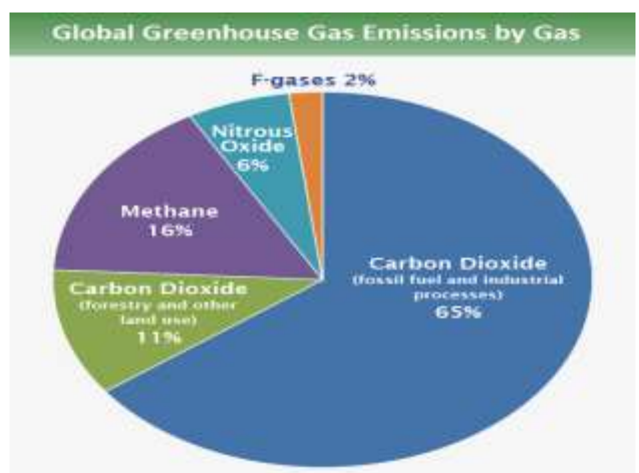


Figure 2.50: Global GHG emissions by gas (IPCC, 2015)

Figure 2.50 shows the Global GHG emissions by gas. Carbon dioxide (CO_2)from fossil fuel and industrial processes contibutes 65%, Mehtane (CH_4) with16%; CO_2 from forestry and other land with 11%, nitroxide (N_2O) with 6% and F-gases 2% (IPCC, 2015). Despite whatever energy require, Figure 2.51 depicts different economic sectors GHG emission produced. Electricity and heat production emits 25% of global GHG, agriculture, forestry and other land with 24%, tndustry with 21%, transportation with 14%, buildings with 6% and other energy with 10% (IPCC, 2015).

The graphs depicts the global average concentrations of all the major long-lived greenhouse gases will continue to rise in the atmosphere, with CO_2 concentrations rising above 400 ppm since 2016 and the CO_2 equivalent of all gases reaching 500 ppm in 2017 (CSIRO, 2018). Emissions from burning fossil fuels is continuing to increase and is the dominant contributor to the observed growth in atmospheric CO_2.

A number of threats may arise from intense shipping activities, including oil spills, pollution from ports, ballast or bilge discharge, as well a garbage disposal. Impacts arising from groundings and anchor-damage, leading to the direct destruction of coral reef formations. Increase usage of dinghies and boats measure most pristine sites have now becoming vulnerable.

Fish, sharks and turtles in the ocean and estuaries feed on plastics which has proven fatal while coastal towns lagoons and seas water quality are degrading. Waste from oil palm development along PNG's coastal provinces of West New Britain, New Ireland, Milne Bay, and Oro to name a few, poses grave long-term implications for PNG's species that are world renowned for rich coral reef ecosystems.

Pollution from large-scale mining activities are also a growing concern with numerous studies (Mudd and Roche 2014; Mudd 2012; Storey et al. 2009; Bolton 2008; Brewer et al. 2007;McKinnon, 2002; Swales et al.1998) directly attributing pollution of coastal ecosystems and changes in habitats and species composition due to discharges from mine waste streams (GoPNG, 2015).

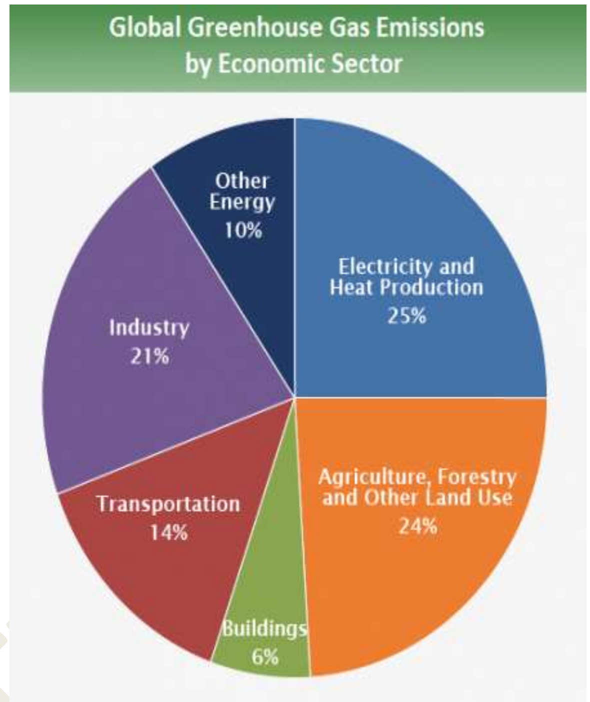


Figure 2.51: Global GHG Emission by economic sector (IPCC, 2015)

Mines tailings disposal in PNG

In 2014 PNG was one of 18 countries to impact coastal areas with mine tailings disposal. This raises concern of heavy metal contamination in the environment and food chains. The following is a list of past, current and potential riverine or marine deep-sea disposal of mine waste in Papua New Guinea.

Below are some data from the 6th National Report to Conservation on Biological Diversity 2019 (GoPNG, in press). It shows the amount of waste discharged as mine waste in metric tonnes into riverine sysetms by Panguna, Pogera, Ok Tedi and Tolokuma mines. PAguna mine has the largets discharged followed by Ok Tedi, Pogera and Tolokuma Mines. Discharges into the marine system was also provided in that report and are shown below, with Lihir Gold Mine, Misima Mine and Kurumbukari mine at Basamuk Bay having the highest ischarge than the other mines which are yet to resume operations. These figures are shown below.

1. Riverine

Panguna	500 Mt (million tonnes) 1972-1989.
OkTedi	>22 Mt since 1984- (tailings dam collapse reduced fish >1600km^2 forest flooded
Porgera	> 5 Mt
Tolukuma	>160,000 t 1995-2018 liquidated

2. Marine

Misima	90 Mt 1989-2004
Wapolu	n.a. circa 1989
Lihir	>5 Mt since 1997
Simberi	>1 Mt Since 2008
Basamuk	>5 Mt
Woodlark	DSTP (Deep Sea Tailings Placement) preferred option EIA
Wafi-Golpu	DSTP preferred option (2018 Feasibility Study) 28 years

Porgera runoff (top) and Panguna (Bottom) (Earthworks Mining Watch 2012)

Most of this tailings waste ends up in the sea through the multiple natural processes of saltation, sedimentation and solution. Consequently, the interface of pollution and the sea is changing. This is also a likely entry point of pollutants into the food chain that has potential consequences of affecting both marine lives and humans that feed on the fisheries species.

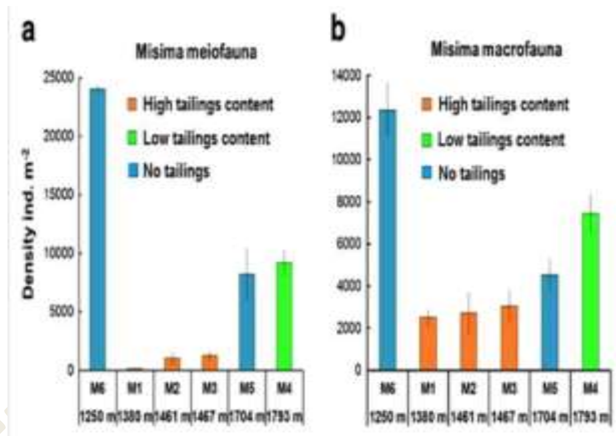


Figure 2.52: Abundance of metazoans (> 250 µm) at stations around Misima (Hughes et al., 2015)

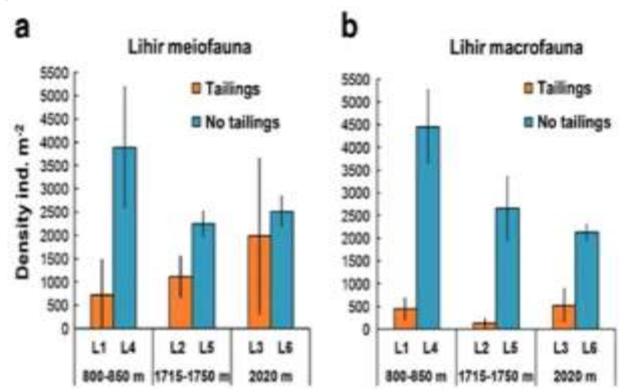


Figure 2.53: Abundance of metazoans (> 250 µm) at stations around Lihir (Hughes et al., 2015)

Impacts on meio and macrofauna were see at the Misima and Lihir mines. At Misima, Deep Sea Tailings Disposal (DSTD) took place for 15 years and ceased with its operation in 2004 (Fig 2.52). Sediment samples shown in the graphs above in 2007 show sever impacts on deep sea faunal communities at a broad taxonomic scale. Figure 2.53 dhows Lihir initiated the DSTD in 1997 and is projected to continue out to 2030 but results indicate impact of this currently active disposal.

For these mines, Acid Rock Drainage (ARD) where it occurs poses a potential long-term environmental hazard that could adversely impact the local ecology without preventative measures.

Mercury

There is extensive alluvial mining in PNG with some use of Mercury which requires regulation. The volume of its use and escape into the local environment is not known of monitored. PNG has not taken steps to determine whether to ratify the Minamata Convention.

Agro Industry

Oil palm estates across PNG use a fertilizer regime to maximize productivity from the palms. Within this they attempt to minimize leakage into the surrounding environment and hence minimize this cost. Companies which are RSPO certified maintain or reestablish vegetated buffers on rivers, the coast and settled areas, guided by the *Logging Code of Practice* (1996). Effluent that is generated from palm oil processing at mills is passed through a series of settling ponds before water overflow into the surrounding environment. Regular stream monitoring is a requirement of CEPA under the *Conservation Act* 2000.

Marine

The dumping of waste at sea by fishing fleets has been recorded by on-board observers. These incidents have been plotted and the nature of the waste recorded as per the below graphs.

6.1.11 Development access corridor

Transport systems may also have massive impact on the environment, particularly road and sea transports. Coastal shipping, which cater for almost 65% of PNG's poor population, will be safer and more efficient, and passenger capacity will increase as improvement is provided (ADB, 2018). Poor road infrastructures and shipping and aviation services are the major setbacks to many coastal and inland provinces.

PNG is still facing major hurdles to deliver safer, compatible and more efficient transport system (given climate impacts are prominent) that are conducive for rural areas and urban centers that meets international standards. The downside of the transport sector are noise pollution that shy away animals, emissions of GHG into the atmosphere, fauna kill, and other indirect effects such as habitat destructions and increasing waste and energy consumption. Figure 2.54 shows a total of 2436.2 Gg CO2e- GHG emission was emitted using different fuel types in 2000, with the major fuel type used is the LPG followed by gasoline and gas/diesel oil (GoPNG, 2014b). These fuel are mainly used by the transport sector with the bunker fuels GHG estimate for year 2000 for aviation and marine industry is 144.5 Gg CO_2e-.

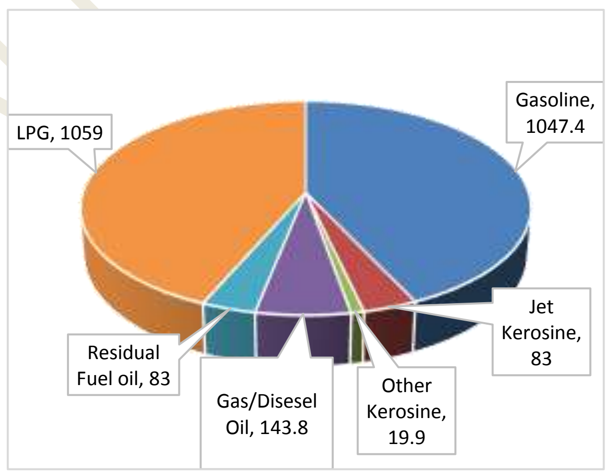


Figure 2.54: Type of fuel GHG emission from combustion of various fuel types in 2000 (GoPNG, 2014b)

Development of accessibility to goods and services and markets would bring in tremendous changes of both good and bad to the country. Better transport systems and network will bring much needed development to the people of this country.

However, these changes too comes at a cost. Untouched and once pristine environment may succumb to problems of pollution, invasive species, loss of habitat, GHG emissions among many other social and environmental issues. Below are some massive government investment that may become drivers of environment changes.

Road infrastructure

The road transport infrastructure in PNG is inadequate both in terms of maintenance and nationwide connectivity. Furthermore, the rapid rise in trade and prosperity envisaged in the PNG DSP will require considerable growth in the coverage and quality of the national road network. A comprehensive program of rehabilitation and construction is advocated that will expand PNG's national road network that is in good condition to 25,000 kilometers by 2030.

Under the DSP 2010-2030, the government plans to improve its road network by building or maintaining 8460km of national roads (total network 30,000km). Additionally, some funds were allocated to build or rehabilitate 27 bridges. In recent times, between 2012 and 2018, almost K3.3bil has been spent of alleviating growing pressures from aging bridges and road infrastructures.

PNG has one of the lowest road densities in the world. The road transport network is the lifeline of most rural communities providing people with access to markets and services. 28.7% (2512km) of road are in good condition and by 2030, the government plans to improve the road 100% because thousands of kilometres of roads have not been maintained. Figure 2.55 shows the government's plan to improve road conditions to good and better by 2030. The government terms new road development as missing link.

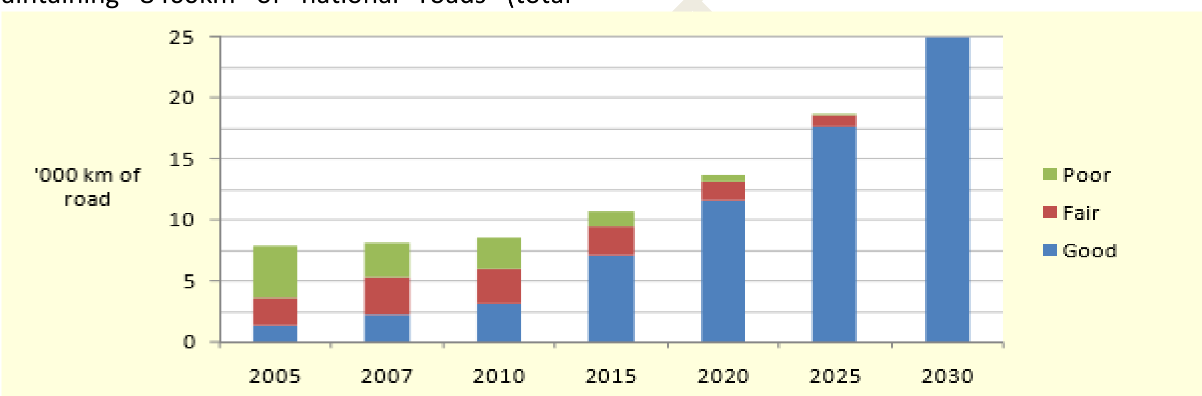


Figure 2.55: PNG Government's road construction plan (ADB, 2017)

The Highlands region and PNG's hinterland are a major contributor to the PNG economy through its agricultural and mineral exports. The Highlands region is also home to 40% of the country's population, who rely almost entirely on the road network for movement of people and goods (ADB, 2018). PNG's subnational network of provincial and district and artillery roads totals about 20,000 km and serves 85% of the rural population. However, rural roads often receive fewer financial and technical resources than national roads, and many are deteriorating due to neglect and lack of maintenance over the years.

Realizing the state of the road networks and its importance to development and service delivery, the government and its development partners such as ADB, World Bank and China AID have invested significantly in improving those road networks, especially from Morobe province and the Highlands region. However, a lack of regular maintenance has led to an overall degradation of the Highlands core road network. This resulted in increase high maintenance costs. In the early

1980s, the Department of Works was fully funded and maintains the road periodically. Similar road developments are taking place elsewhere in PNG facing similar dilemma such as the Highlands Highway. Some areas of the country are still inaccessible and given the government's economic corridor plans, more areas will be opened up to the outside world and markets. Consequently, this may also allow the spread of invasive species, loss of biodiversity, settlement expansion, forest degradation and other environment impacts.

The infrastructure growth is allowing PNG for economic development, and improve communication, increase trade, employment, tourism, and increase access to vital government services. Total funding costs from ADB and government counterpart funding for all road, bridges, maritime and aviation costs to date is roughly $735.52m. That is, 346km or roads and 600km of maintained costing $337.39m, $ 83.75 for bridges for rural areas and $314.45 covering1200km highlands highway, including 1800km regional and feeder roads and 430km of (ADB, 2018).

To finance the expansion and maintenance of a nation-wide network of roads, the Government will engage the private sector through the public-private partnership scheme. Currently, the government has acquired a loan from the Asian Development Bank (ADB) and is committed to the construction of quality roads that do not deteriorate quickly, especially the Highlands Highway. This multi-tranche financing facility (MFF) is envisaged to be financed through loans not exceeding $625 million from ADB's ordinary capital resources (OCR) and $70 million from ADB's concessional ordinary resources lending (COL) to help finance the Investment Program (ADB, 2017). It is envisaged that the MFF will consist of three tranches, subject to the government's submission of elated periodic financing requests (PFRs), execution of the related loan agreement for each tranche, and fulfilment of terms and conditions and undertakings set forth in the framework financing agreement (FFA).

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In 2008, ADB approved the financing of Highlands Region Road Improvement Investment Program (HRRIIP) which is focused on the Highlands core road network (HCRN) of 2,500 kilometers (km) particularly the major national and some provincial roads. To date, through three approved tranches, HRRIIP has successfully improved about 350 km of the roads of the HCRN, which all lead from the hinterlands into the main road of the region and the nation, the Highlands Highway. In addition, HRRIP has provided technical assistance to support the Department of Transport (DOT) to prepare a new National Transport Strategy (NTS) for 2014–2030, which provides a framework of policies and strategies for a sustainable road system in PNG.

The Highlands region of PNG is a major contributor to the fragile nation state's economy, through its agricultural and mineral exports. It is also home to approximately 40% of the country's population, who rely almost exclusively on the road network for movement of people and goods, and thus livelihood opportunities as well as access to health, education, and social facilities. The road network is vulnerable because of the mountainous terrain, the fragile geological conditions, and the climate. The Government of PNG and its development partners have invested significantly in improving the road network, but a lack of strategically planned and consistently implemented periodic and routine maintenance has left the network in such a poor condition that a significant amount of appropriated funding is annually expended on emergency works.

The government's road corridor spelled out in the DSP 2010-2030 implies that the government will be opening up new roads to give people give to new frontiers. Road corridor often construction results in the direct and immediate loss of habitat (Bennett et al., 2011). They are a major contributing factor to habitat fragmentation that causes edge effects, isolation of species thus causing speciation, inbreeding and extinction, introduction of alien species, decrease in average patch sizes, and further exploitation by settlers or villagers (Laurance et al. 2009). In the neighbourhood, across the border, issues of opening up road may affect conservation areas, create land issues, forest loss and forest degradation, all because of development aspiration of the government (Sloan et al. 2019).

Road corridors can also reduce the quality of the immediate surrounding habitat through habitat degradation (air and dust emissions, sediment mobilization, chemical runoff, and potentially impact on the quality of habitats further afield (e.g. downstream). Noise pollution and artificial lighting generated by passing vehicles or during construction can scare away animals and disrupt their activity patterns near road corridors or reduction in species density during day and night (Laurance et al. 2009; GoPNG, 2014b). Also the incidence of road kill can also increase thus putting the lives of animals at risks.

Conversely, there are also beneficial values of road corridors for some wildlife that favours other species to forage and look for prey. For humans, it linked provinces, districts and urban centres and markets.

Landslides are also a familiar sight along the sides of the roads and when rain comes, the land is disstabilised because of the steep slopes and lack of vegetation in some areas. Missing embankment protection and revetment in a few areas, and ineffective gabion protection that will not help stabilize the slope are the main set-backs because the high rainfall the country experience. (ADB, 2017).

Water transport

There are fourteen Maritime Provinces in PNG where the sizes of the population per provinces indicate that at least 60 per cent of the country's population depends on water transportation. Many of the coastal communities and the public in those provinces do not have ready access to road or air, hence rely on water transportation, and for the delivery of goods and services. Figure 2.56 shows there is a growing demand for water transport in PNG being forecasted. The ports of Lae, Port Moresby, Wewak, Madang and Kimbe are the country's busiest sea ports, accounting for 80 per cent of the country's cargo throughput in 2008. Lae and Port Moresby has a handling time of 3 days and the plan is to reduce it to 1 day because the throughput are increasing rapidly, rising from 28 per cent from 2004 to 2008. Similarly, rapid growth is occurring at other ports of PNG including Rabaul, Madang, Wewak, Vanimo and Buka (GoPNG, 2010).

A cargo vessel towed by a tug boat (Photo by P. Alloy)

Water transport services provide the highways for communities who live on islands and in remote coastal and river locations. The water transport system is inadequate and requires more vessels, more transport routes, more frequent services on existing routes and better ports and jetties. It is projected that cargo throughput at all of PNG's ports will increase five-fold. Therefore, the government is planning to triple number of routes serviced and number of vessels, and upgrade ports. This may also bring other impacts on the marine waterways and sea quality. Figure 2.57 shows the projected throughput of the port in terms of growth in capacity and productivity from 2006 to 2030.

Development partners such as ADB and EU are funding infrastructures, including safety equipment in the Maritime Provinces. The domestic benefits of coastal shipping may include greater access to goods, services, and economic opportunity, while the region will benefit from safer, more efficient trade. The negative impact would include:

- increase transportation of alien or invasive species across boundaries;
- discharge of ballistic waster and oil in PNG waters and ports; and
- Disturbance to deep sea marine wildlife such as whales, dolphins and sharks.

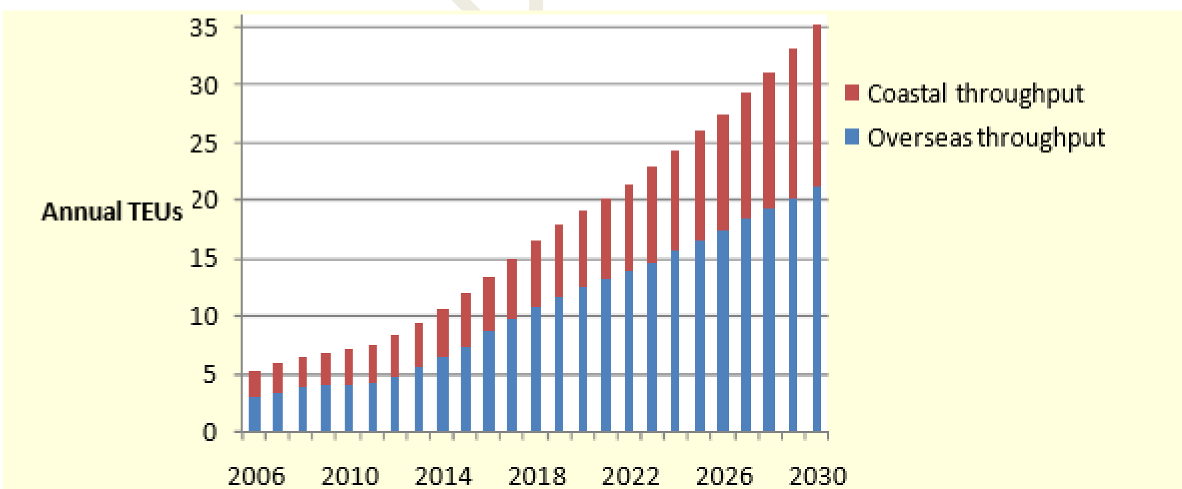

Figure 2.56: Growth in demand for marine transport, 2006 to 2030 Forecast container throughput for coastal and overseas marine transport (GoPNG, 2010)

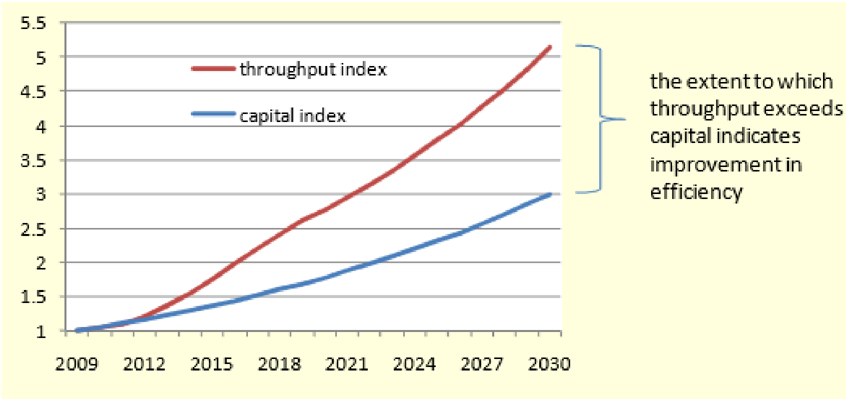

Figure 2.57: Index of growth in capacity and productivity of marine transport 2009 to 2030 (GoPNG, 2010)

Air Transport

The aviation industry plays a vital role in the changing economic, political and social development and life of the country as alternative forms of transport are often not available. Currently, there are 21 National airports which services the bulk of international and domestic passenger and freight traffic throughout the country. Ten are located along coastal provinces, 6 in the Highlands and 5 are in the New Guinea islands Region. In PNG, most of the major airports and terminal facilities are owned and operated by the Government through the PNG National Airport Corporation (NAC).

In the aviation sector, new airstrips and airports airdromes and facilities are currently undergoing upgrading. The PNG's aviation industry provides essential support for tourism, business, trade, and social cohesion. However, deteriorating infrastructure and constrained institutional capacity threaten the certification of many of PNG's airports (ADB, 2018). The Civil Aviation Authority's development plan provides a framework for addressing existing gaps within the agency. The agency requires technical and financial support to implement them successfully. Development partners such as ADB and JICA are supporting development of airport infrastructures countrywide.

Given the complexity of PNG's topography and terrain, air transport for many remote parts of PNG will continue to be the only possible means to link to the main centres of the country. However, the condition of the 22 airports (14 jet airports and 8 non-jet airports) has deteriorated over the years to an unacceptable state, thus breaching the international compliance requirements for safety and security of the airports (GoPNG 2013). Remedial action is needed to reverse the current situation and avoid accumulated cost implications.

Consequently, the government, under the Civil Aviation Development Investment Program (CADIP) in partnership with ADB under MFF, at a tune of approximately $480 million is currently upgrading 21 airport sites around the country within existing airport boundary (ADB, 2017).

The aim of the CADIP project is to ensure safety standards is improve by 70% where the airports can handle larger planes and increasing passenger numbers. Those airstrips in rural areas will be rehabilitated to improve their economic viability. In essence, it is envisaged that improved airport facilities will increase mobility and accessibility of people to markets and natural resources, thus increasing productivity and other spin-off benefits such as tourism.

Figure 2.58 shows the domestic air travel by region. The liberalisation of PNG's air space and the promotion of a competitive airline market is vital for reducing the cost of travel and for improving service on domestic flights. However, as airplane numbers increases so too GHG emissions and noise issues that may have impact one way or the other.

Though not much impact would come from the aviation industry because no new areas will be cleared. However, GHG emissions and other issues brought in due to increase tourism, movement of people, invasive species and other problems cannot be overlooked.

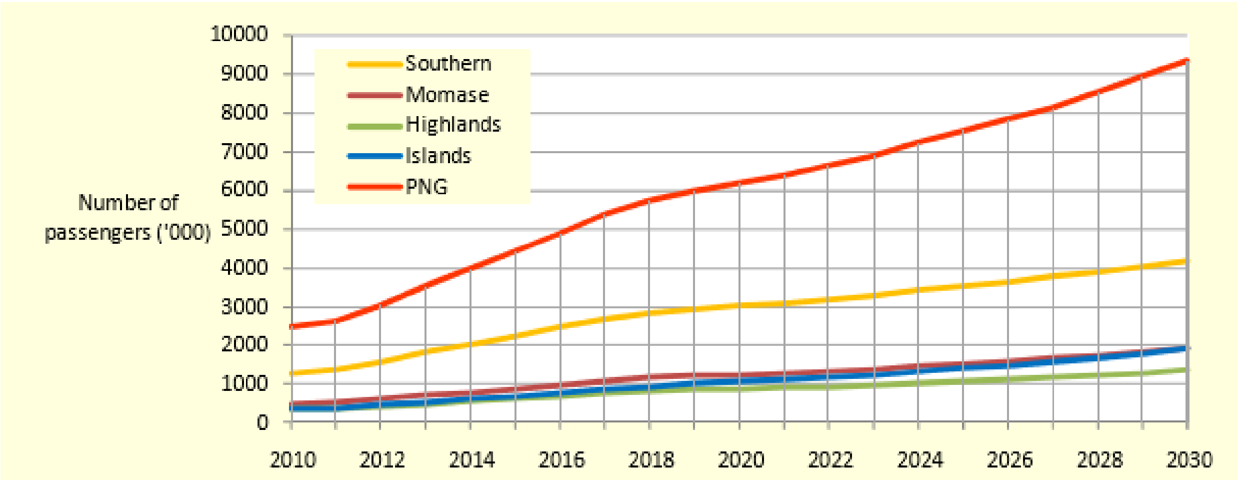

Figure 2.58: Projected domestic travel by regions by passengers (GoPNG, 2010)

7.0 WHAT ENVIRONMENT PRESSURES ARE THE DRIVERS CREATING?

This section highlights the key pressures on the PNG's environment and society created by the overarching drivers identified in the previous section. Pressure indicators present data about the main human activities that could adversely affect the environment, and each indicator is linked to at least one of the drivers. Pressure indicators are organised using three classifications: land development, resource extraction, and consumption and waste, indicated in Table 2.8. Some pressures will be covered in the 'State of the Environment' Section 3. The pressures on the environment fall into three categories for the SoE Report:

- Land Development (urban development, agriculture and Roads and infrastructure);
- Resource Extraction (logging, Over hunting and fishing and illegal trade); and
- Consumption and Waste (energy consumption, and solid and liquid waste generation).

Most pressures on environment in PNG are increasing simultaneously in tandem with population growth, government's development priorities, the nature of export driven economy to increase production and export requirement in order to support its budgetary and development aspirations, and poor environment governance in terms of monitoring and enforcement.

State of the art sewerage treatment plan in Port Moresby funded through the Japanese International Cooperation Agency (JICA, 2018)

Table 2.8: Key environmental pressures in PNG

Pressures	Land Development	Resource Extraction	Consumption and Waste
Key Indicators	Urban Development	Logging	Energy consumption
	Agriculture	Over hunting and fishing	Solid and liquid waste Generation
	Roads and infrastructure	Illegal trade	

7.1 LAND DEVELOPMENT

7.1.1: Urban Development

PNG has undergone rapid changes since independence in 1975, propelled by development, population growth, and the demand for natural resource, land and services. All these come at an opportunity cost, thus exerting pressure on the environment. This result in removal or exploitation of sensitive habitats and ecosystems may promote other direct or indirect impact to the environment. Other push and pull factors may lure people to cities for instance, the tribal fights. In the highlands of PNG, a region that is very densely populated, often faced tribal fueds that resulted in emigration to the urban centers, especially coastal towns in Lae and Port Moresby. Also, immigration of people into urban areas to look for jobs and better government services has increased rapidly. Consequently, this exerted more pressure on the goods and services in the urban areas that result in increased waste discharge, in particular sewage and solid waste and use of energy. In major cities such as Lae and Port Moresby, increase waste output has caused blockages and overflow in the sewerage system because the sewage pipes were old, small and were installed back in the 1980s that need replacement. The same could be true for all centres, except places like Daru where buckets have been used for toilets.

In addition, pressure on land also increase with most development and infrastructures occurring in urban areas, thus discharging tonnes of sediments into drains and streams,and into the ocean and reef, during heavy rains and floods. Shifting cultivation near urban areas and settlement or urban expansion has taken its toll on the environment as well. Most engineering designs cannot contain the sudden changes on the environment such as the sanitation system being not sufficient to cater for the overload.

More recently, the Japanese government through it development arm, the Japanese International Corporation Agency (JICA) has funded a massive sewage system and solid waste burial system for Port Moresby to address the issue for wastes and sanitation. In other centers, both water and sanitation has been promoted by both government and development partners.

Figure 2.55 portrays the number of migrants into urban areas has increased since 2000 but declined in 2011. Most of the migrants migrated to the National Capital District. The provinces that are losing their population are mainly Chimbu and Central provinces. On another hand, main provinces gaining rural migrants are Central and Western highlands provinces. The reason for the latter is because many people migrated from their provinces to settle in those two provinces in Port Moresby or Mt Hagen. Those in from Central living in NCD also go back to Central province because NCD is within the Central province (NSO, 2011).
As the population grows, and the economic divide between urban and rural economies widens, the appeal of jobs and a better standard of living drives more people to urban settlements. Many settlements have limited access to sanitation, electricity and water. There is also a pattern of residents of urban settlements moving to the outskirts of the town areas, due to overcrowding in town areas.

With increasing urban settlements and city development activities, tremendous pressure has being exerted on the urban environment, particularly in regard to habitat destruction such as mangroves, waste pollution and burning, and reduction in water quality. Figure 2.56 shows an example of pressure on reef and mangrove habitats due to urban development. Soil aggregates were eroded and washed into the sea as mud, covering reefs.

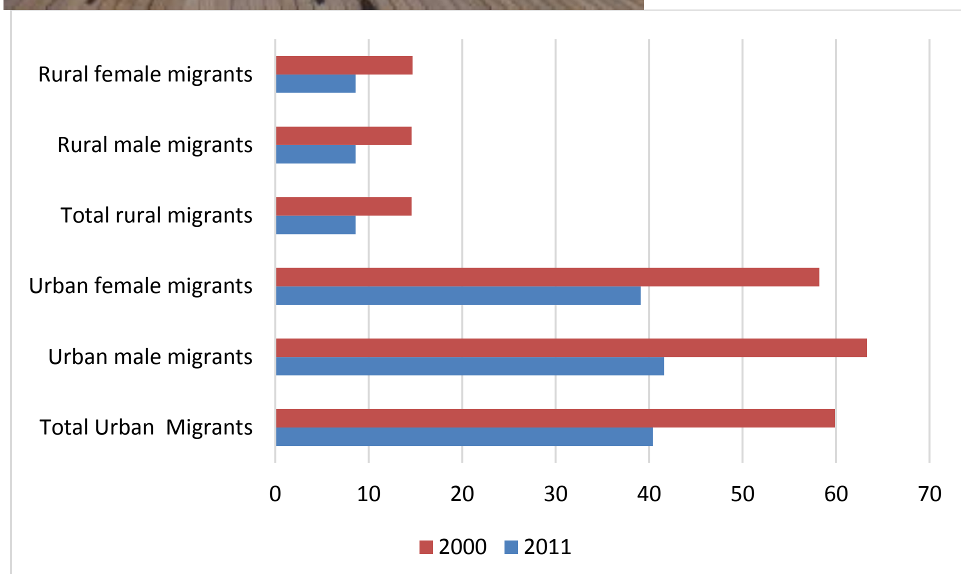

Figure 2.55: Percentage of total and gender urban and rural migrants between 2000 and 2011 (Source: National Statistics Office, 2011 National Report).

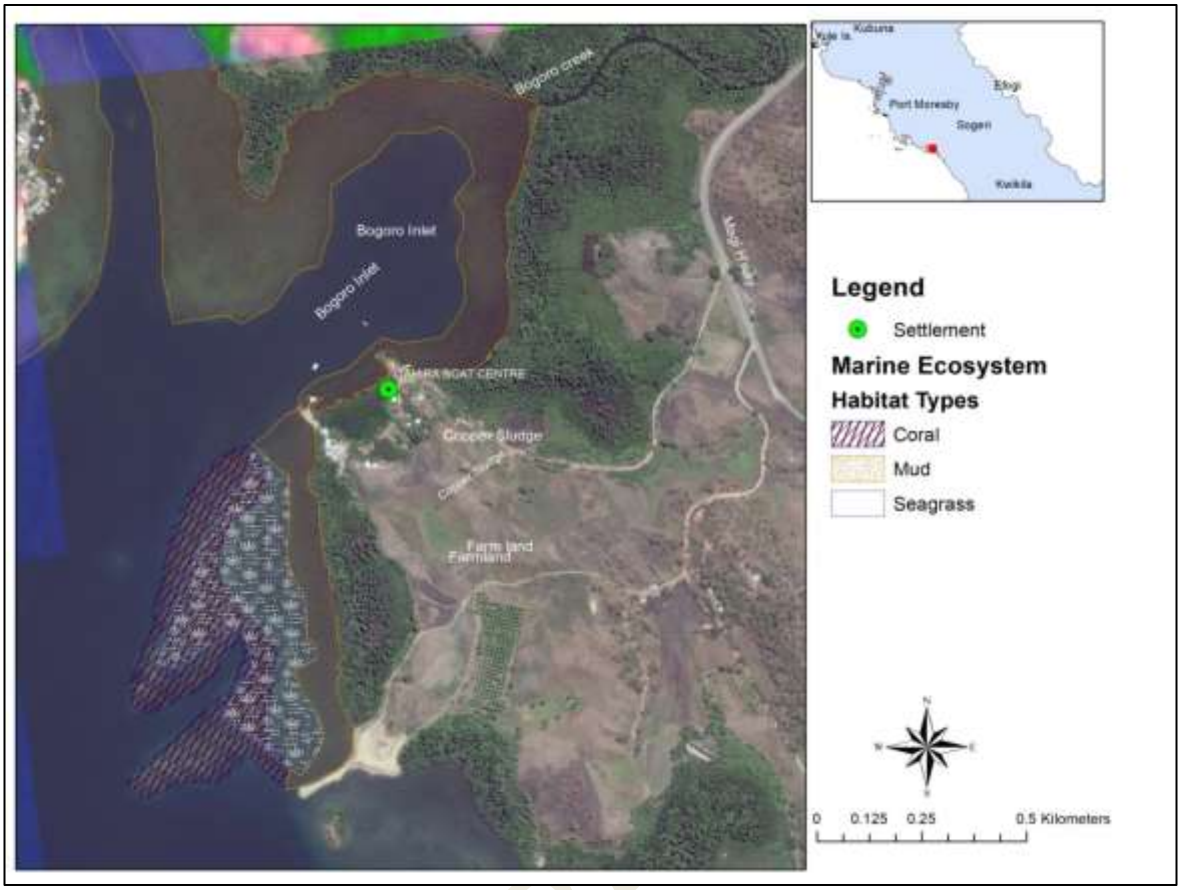

Figure 2.56: Sediment and mud aggregates covering reef and seagrasses in Bootless Bay as a result of urban development and sediment loss from urban development (P. Piskaut, UPNG)

7.1.2: Agriculture

A greater part of this topic was discussed in the drivers but here it is expanded further as one of the pressure on land and forest.PNG has one of the most significant areas of tropical forest in the world. These forests are, however, under threat from commercial logging, clearing of land for agricultural commodities, mining or the expansion of small-scale agriculture to meet the livelihood needs of the country's largely rural population. PNG economy is small and is primarily export-oriented where it is heavily reliant on export of commodity products. The minerals constitute roughly 75% of total exports, agriculture (including fisheries) products 20%, and forestry products 5%.

While overshadowed by energy and mining investments, PNG's agricultural sector is a key earner of foreign currency and employer. The Department of Agriculture and Livestock (DAL) estimates that around 85% of the population, who are mainly rural based, are dependent on agriculture. The country's fertile land makes the sector the most viable option for absorbing its growing workforce, while continuing to provide potential for the economy in the long term (Oxford Business Group, 2015).

Agriculture has contributed between 25 to 40% GDP over the past 40 years. Agricultural commodities such as palm oil, coffee, cocoa, and coconut provide the key sources of agricultural export revenue and employment. Nonetheless, over the years, the sector remains relatively underproductive and not a major force in the global commodities markets.

Consequently, the government is making significant plans to boost investment in the sector in the years to come through intervention using new policy framework discussed earlier. There are ambitious expansion plans for palm oil, coffee, cocoa, copra, spices and rice as key part of the government long-term strategy to develop by 2030 a "*world-class agricultural sector that is responsive to international and domestic markets for a diverse range of products and provides the best available income and job opportunities*". Increase in agricultural production is expected to be derived from a 180% increase in the use of land by agriculture and from a 60% improvement in agricultural productivity (Bito and Petit, 2016).

Traditional subsistence agriculture plots in the highlands of PNG (Photo by S. Gigmai)

Though there may not be expansion for other commodities, the palm oil sector is focused on increasing production through expansion of the area under cultivation, and represents the most significant threat to levels of forest cover. Indeed, the area under cultivation estimated at 150,000 ha is already set to more than double in the short-term based on expansion of existing projects thereby to increase by 10-fold to 1.5 million ha by 2030 (Bito and Petiti, 2016).

Oil palm also has important opportunity costs: (i) it reduces the diversity of crops in the oil palm area, as it does not allow for companion planting and encourages wide scale land clearing; (ii) the land clearing introduces soil erosion and siltation of rivers; and (iii) several forms of chemical pollutants are introduced, most notably fertilisers, which cause serious water pollution (Anderson, 2006).

Increasing global demand for agricultural commodities, palm oil in particular, has seen deforestation rate rise, with over 4 million hectares of forest land cleared under Special Agriculture and Business Lease (SABL) agreements between 2003 and 2010. Such rapid increases in forest clearance for agriculture are also likely to continue in a country with population growth of over 2%, increasing global demand for agricultural commodities and only 4% of land area currently dedicated to agriculture when an estimated 30% is considered suitable for agriculture (Bito and Petit, 2016).

Kokopo market is reknoun for its diversified agriculture produces (Photo by: Unknown)

Agriculture is a mainstay of the PNG economy and thus represents an important area for economic growth and stability. As such there is a need to ensure that continued agricultural development not only supports economic growth and poverty alleviation, but is also socially and environmentally sustainable. This is particularly important if the country is to meet its objectives under the Vision 2050 development strategy, including that of becoming carbon neutral by 2050 (Bito and Petit, 2016). In 2014 there was 38,242 Km^2 of rainforest inside Special Agriculture and Business Leases (SABLs). The terms of these leases potentially allow for their future deforestation for industrial agricultural developments (Shearman et al., 2015).

In order to develop the agriculture sector, there needs to be appropriate coordination and regulations to drive the agriculture industry forward. However, there is a lack of coordination between government departments when it comes to agricultural commodities between for instance, DAL, Commodity Boards, CEPA, Lands department, and Forestry. Each department operates in isolation rather than through multi-sectoral approaches, and overlapping roles exists. There is also a lack of dialogue and transparency between the different actors engaged in agricultural commodities namely the private sector, civil society, landowners, and the government. Opposite views on what should be done for the future is hampering their stand and as a result there is a lack of trust between the key actors (Bito and Petit, 2016).

There is low capacity in government departments to work on enforcement of existing legislation. The necessary legal framework is in place and the intentions are good but these are not adequately enforced. The agriculture budget represents less than 2% of public spending.

This palm oil expansion is not in line with the same internationally recognized sustainability standards currently applied by palm oil producers within the country. Thus, presents a potential reputational risk to the entire PNG palm oil sector. The global industry is under significant public scrutiny and is moving increasingly towards internationally recognized standards practices. Most companies responsible for 90% of global palm oil trade have already being committed to zero net deforestation within their supply chains by 2020. The Netherlands, UK and Germany, the largest purchasers of palm oil products from PNG have also recently signed the Amsterdam Declaration to ensure that by 2020, 100% of palm oil entering their countries is from sustainable sources (Bito and Petit, 2016).

A report by UNDP states that investors are now requiring new finance criteria be met to mitigate the downside legal, market and reputational risks associated with goods and services that degrade environmental assets e.g. conventional forestry (UNDP in press). The report iterates that this is increasingly being reflected in assessments by Credit Rating Agencies (e.g. Moody's and S&P), statements by regulators, powerful investor disclosure initiatives (e.g. CDP), and ultimately, in higher insurance premiums. This change in investor sentiment is nudging producers and supply-chain managers to seek alternative business models that improve environmental and social conditions, and that address consumer concerns e.g. chemicals in food, deforestation and waste.

In terms of subsistence agriculture at village level, population explosion has resulted in more forests undergoing clearance. It was a normal practice where locals normally implement the bush fallow or swidden agriculture system, but this is not the case anymore. The fallow time has been reduces and so too the land productivity and fertility thus driving locals to cut down more forests. Previous analyses of deforestation and forest degradation have highlighted the role of agriculture as a key driver.

Deforestation has occurred through the conversion of degraded forest land into commercial plantations or smallholder farming plots (many also containing cash crops). For example, subsistence agriculture is estimated to have resulted in over 3.6 million hectares of deforestation over the 30 years prior to 2002 (Shearman et al., 2008).

7.1.3. Roads and infrastructures

A great deal of road infrastructure was discussed above but it is better to expand as roads more on the topic. Road infrastructure facilitates economic and social development. It provides market access for timber and agricultural products. It also lower the costs of land clearing and development, labour, and transportation to rural and urban areas. In PNG, most road project developments are through the government's economic corridor policy, logging and large commercial agriculture projects.

However, these road projects can propel increase deforestation and biodiversity loss. That is, roads opens up places never access by humans and invasive species, thus creating competition and ecological imbalance in the ecosystem. Some species may also face edge effects due to changes in micro environment conditions *in situ*. In essence, road are major causes of habitat loss, road mortality, edge effects and barrier effects and fragmentation (Laurence et al, 2009). Some threats of roads are discussed below.

Firstly, habitat loss is the initial and most obvious impact of roads, powerlines, and gas lines. These can alter or destroy scarce natural habitats and also facilitate further clearings by humans. For instance, in the 1980's, Brazil's road network doubled from 87,000 to 161,500 km. Now 1 million km of road is estimated to be established within the Amazon (Laurance et al., 2009). Consequently, it leads to increasing deforestation rate which increased dramatically with the expanding networks of infrastructure development.

Secondly, road mortality causes significant population sink for animals that can be easily killed due to features of susceptible wildlife namely mobility, ecology and behaviour. That is, slow-moving, arboreal, terrestrial or flying, nocturnal or crepuscular species may see roads as an as small opening and try to cross but when crossing, they are easily killed by moving vehicles. In parts of PNG, some animals cross the road to acquire heat or to look for food on the other forest patch but faced their fate, and get killed by moving vehicles. In Australia, many wallabies and wildlife have been killed by moving vehicles on the roads, when trying to cross the road.

Species that are mostly attracted to roads or roadsides are amphibians, reptiles, herbivores and frugivores, carrion feeders and predators (Laurance et al., 2009). Some species that get killed easily are those from nearby habitat such as wetlands, grassy vegetation and fruit eating species, including other species with large-area requirements.

A road network in Simbu province (Photo by: I Kolima)

Moreover, species faced mortality because some road features also contribute to increase mortality rates. For instance road width, traffic speed and volume, roadside vegetation and adjacent habitat are major contributors to road mortality (Laurance et al., 2009). Apparently, significant population sinks can occur for rare and endangered species as well, due to road openings and corridors. Figure 2.57 depicts road width increase so too is the death toll increases, with amphibians' deaths higher. As road width increases, mortality also decreases. This shows that bigger roads are like oceans that are hard to cross so mortality is less, whereas, mortality is high for amphibians because there were attracted to it for food and heat.

Moreover, opening of roads also provide accessibility to areas for local hunters to hunt for game animals. Figure 2.58 shows hunting pressures declines as distance from the road side increases because distance near the road is easily accessible by hunters.

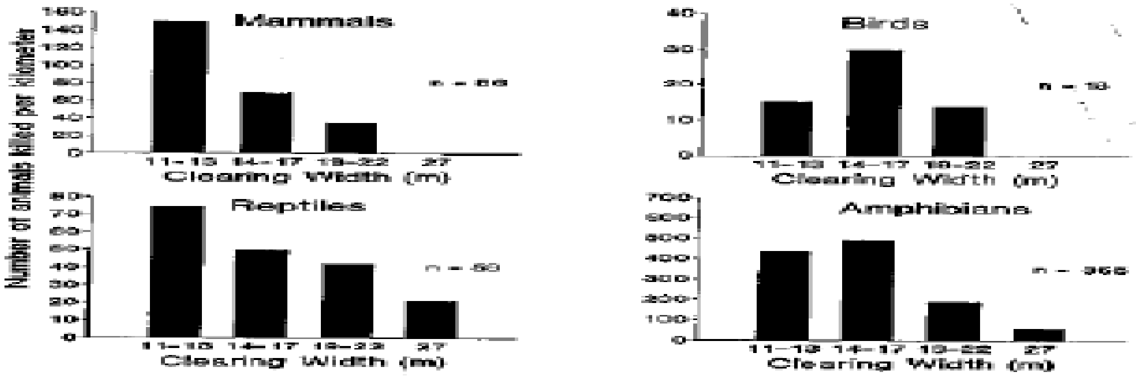

Figure 2.57: Road kill due to road opening by width (Laurance et al. 2009)

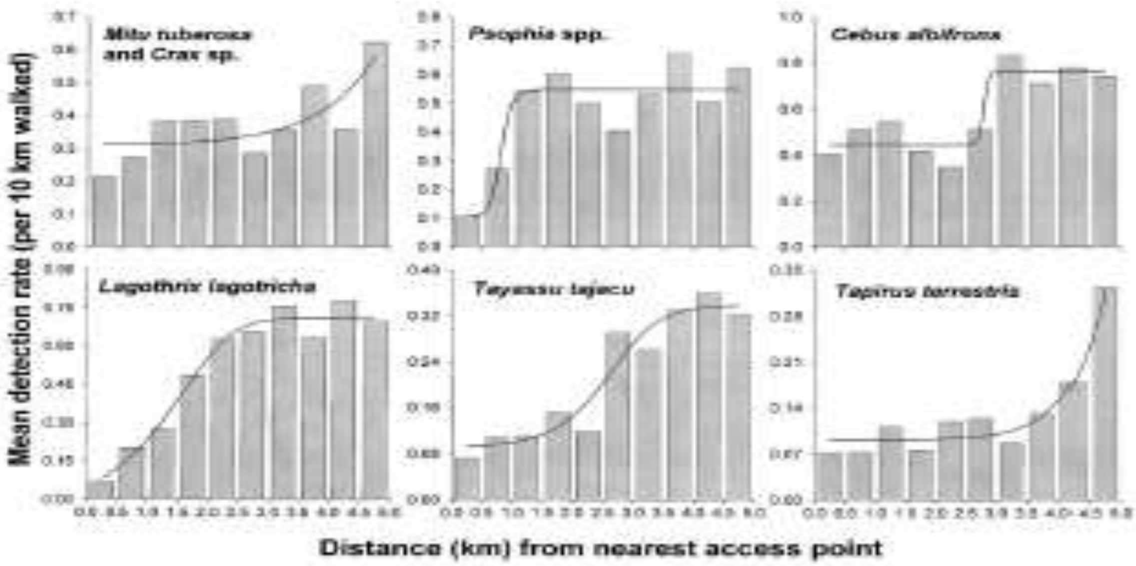

Figure 2.58: Hunting pressure on fauna population (Laurance et al., 2009)

Thirdly, edge effects can be seen along road corridors and can cause physical, chemical, structural, environmental and biological impacts on the adjacent habitat. For instance, cut and fill soils can impede water flows when no proper drainages systems are build. Vehicles moving in the area can also contribute to emission of chemicals that may lead to pollution of air, soil and water adjacent to roads. Energy emissions in the form of noise, headlights, vibrations and movements may disturb sensitive wildlife as well (Laurance et al. 2009).

Moreover, changing microclimatic conditions such as humidity, light, temperature; wind speed and turbulence may propelled increase tree damage and death and increased tree dynamics -turnover, resulting in changing species composition. Road corridors may also cause changes in stream ecology caused by soil erosion, sedimentation, altered flow patterns and subsequently causing impacts on aquatic and stream bank life. Other causes of edge effect is the movement of species. Some species are confirmed to gaps, edges and canopy near the edges, while others are confined to the interior.

This may influence the behaviour of nest predators and parasites on different species movement and can cause population calamity. Roads also provide avenue for invasive species and diseases to enter the area.

Fourthly, the barrier effect is another concern as well for road. Linear clearings can divide up habitats and possibly wildlife populations. Smaller partially isolated populations may be at greater risk of extinction due to deterministic processes, such as limiting a critical resource- food, shelter or space or random demographic or environmental changes (Laurance et al. 2009). Roads can act as barriers to gene flow leading to genetic differentiation among populations.

There are some features that influence the permeability of linear clearings: Clearing characteristics -width, traffic volume and speed, adjacent vegetation, and road cuttings; and Species characteristics –behaviour, mobility, habitat specificity (generalist vs specialist). For instance, the movement of birds and their response can be determined by their behaviour patterns (Laurance et al., 2009). When trying to cross the road, most birds must do some passive observation first.

One group of birds will not cross the road because they have behavioural mechanisms that deter them to do so. Generally these group of birds avoid gaps and clearings due to predators, forest interior conditions, or habitat use and territory establishment. On the contrary, the other group of birds would cross the road after passive observation. These birds are forced to cross the road because the local movements have been disrupted. They are now experimenting translocation.

A study in the Amazon forest shows that Movements of edge/gap and frugivores unaffected at all sites. It is intermediate to tall regrowth sites where it facilitated the movement of some guilds across roads. However, the movements of understory solitary species were affected at all sites (Laurance et al. 2009). The study concluded that small rainforest road clearing (30-40 m) had surprisingly significant effects on movement patterns of rainforest birds. Only 2 guilds were unaffected. Overtime, regrowth vegetation improved the permeability of roads. This experimental translocation demonstrate that road clearings of 30 –75 m inhibits local movements of birds, however populations are probably isolated by clearings ca. 250 m.

In summary, dispersal of species of fauna is a principle factor determining wildlife survival in a fragmented landscape. Birds inhibited by 35-40m but were isolated by 250m. Consequently, populations could become isolated by particular clearings before wide-spread fragmentation has occurred. Therefore roads are crucial for biodiversity conservation. Road that are unplanned will lead to loss of species. Thus in order to increase permeability of roads, there is an onus to:

1) Decrease road widths, and allow regrowth and canopy connections;
2) Extend bridges of watercourses to include terrestrial vegetation –allow movement;
3) Reduce road speeds (windy roads better) in protected areas;
4) Limit or stop night time driving;
5) Prohibit hunting; and
6) Build canopy bridges, overpasses and underpasses.

Pristine rainforest along the world's famous Kokoda Track (Photo by: F Alkam)

7.2 RESOURCE EXTRACTION

7.2.1 Logging

Logging has been discussed in the drivers but it is better to discuss the stress it is having on the environment and forest ecosystem. Forests have significant values to PNG in terms of its ecological and economic values. PNG has one of the most significant areas of largely-intact tropical forest in the world, although these forests appear to be facing acute and imminent threats. Forests are also a vital resource for the local population, particularly in the remote rural areas of PNG, providing food, fibre, building materials, and support a variety of wildlife and ecosystem services.

The PNG Forest Authority (PNGFA) estimates approximately 60% of the total area of the country is covered by natural forests, of which 52% are considered production forests (for timber and other products), and 48% are for conservation (not for timber extraction due to inaccessibility or ecological constraints).

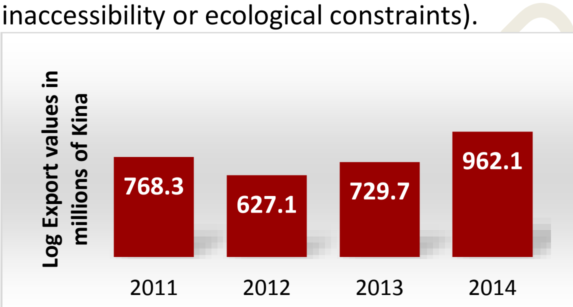

Figure 2.59: Value of log export between 2011-2014 (Oxford Business Week, 2015)

Logging has played a significant role in the development of the country, and is a big industry in PNG and contributes about K950.3m to the government coffers from log export per annum (Oxford Business Week, 2015). Figure 2.59 shows the export value of PNG logs between 2011 and 2014 has increased from K768m in 2011 to K962m in 2014. The government plans to ban the export of round logs by 2020 and if that happens, the scenario might change but it is still unpredictable at this stage.

A logging ship offshore (Photo by: Unknown)

Generally logging may cause forest structural damage (10-80%) of canopy loss during selective harvesting of selected timber species. At the same time, other collateral damage can be done to other plants thus causing fragmentation of understorey vegetation and this is something that can never be avoided.

Consequently, disturbances alters the microclimate and microclimatic factors in the forest. Forest clearance also causes soil damage and also increased vulnerability to fire, declines of disturbance sensitive species, proliferation of disturbance-loving plants, exotic species and pathogens. Logging also facilitates forest invasion by human activities, logging roads, fires, hunting of wildlife and deforesttion.

In 2014 there were 278,767 km^2 of closed canopy rainforests in PNG, where 13% or 36,269.71 km^2 had been logged at least once since 1972. Since 2002, 4.1% or 1,149.447 km^2 of forest was cleared or logged. A total of 3,752 km^2 of rainforest was deforested and 7705 km^2 of previously unlogged forest was degraded through logging. Overall PNG's forests were being cleared or degraded at a rate of 0.49 % per year in 2014, a deceleration compared to the 1972-2002 period.

Figure 2.60 shows the size of different forest parameters described here in percentage. Those forests accessible to the logging industry underwent much greater change. Between 2002 and 2014, 7.3% of commercially accessible forests were logged or cleared – much greater than the 4.1% that was cleared or logged overall (Bryan et al., 2015).

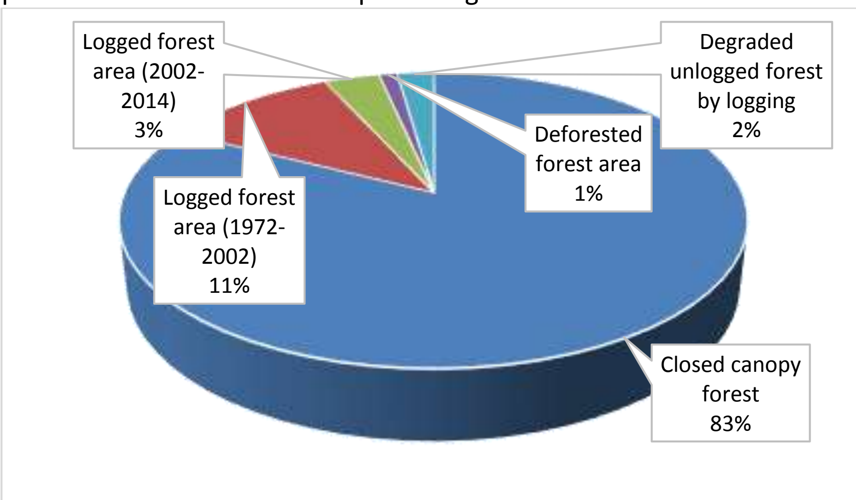

Figure 2.60: Percentage of forest change between 1972-2014 (Bryan et al., 2015)

Overall in PNG, the island provinces has the greatest proportion of forest change between 2002 and 2014, with Manus having 9.1% of its forests logged or cleared, New Ireland 7.6% and West New Britain 7.5%. By far the greatest extent of logging occurred in the lowland forests of West Sepik, Gulf and Western provinces. During those periods, substantial changes to the mainland lowland forests also occurred. In Gulf and West Sepik provinces, 7.7% and 6.3% of forests were cleared or logged since 2002 (Bryan et al., 2015).

In addition in 2014, 14.9 million hectares of rainforest occurred inside logging concessions. Out of 228 logging concessions where active logging occurred over the period 1972-2014, 72 had more than 80% of their commercially accessible forests logged by 2014 (Bryan et al., 2015). Moreover, in 2014, there was 38,242 km^2 of rainforest inside Special Agriculture and Business Leases (SABLs). The terms of these leases potentially allow for future deforestation for industrial agricultural developments. Between 2002 and 2014, 2047 km^2 of forest within SABLs was cleared or logged.

By far the biggest cause of forest change in SABLs was industrial logging and most of this logging was not followed by clearance to allow for the development of agricultural plantations. That is, substantial oil palm plantations were established in four SABLs, suggesting this trend may change in future. A key priority for forest management in PNG is immediately excluding logged forests from re-entry logging in very short a time period to allow recovery.

A study by Simon Saulei on clearfell logged over forest in the Gogol valley in Madang Province shows forest regeneration reached an equlibirum after 30 years (S. Saulei, pers comm). Most commercial species were able to attain maximum diameter at breast height of between 40-60 cm dbh, depending on individual species growth rate. This indicates that with right local micro and macro-environment conditions (eg. more rain rain, no human disturbances and less fire and good edaphic factors) and condusive ecological factors may aid such feat to happen (Witmore eds. 1990; Begon and Townssend eds. 2012).

7.2.2. Illegal trade

International trade in flora and fauna is currently one of the many threats to biodiversity. PNG is a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1975 and as such all international trade in protected or CITES-listed species are regulated under permits issued by CEPA. Despite all non-CITES and CITES II-listed species being regulated by CEPA, there are still widespread illegal, unreported and unregulated trade in plants and other wildlife across PNG remote borders. In 2017 alone, about 181 Export Permits were issued for CITES Appendix II species by CEPA for personal effects, commercial, cultural and research. Figure 2.61 indicates the number of CITES Appendix II species that were given Export Permit by CEPA. Reptiles are the biggest permited species comprising of crocodiles (69), monitor Lizard (20) and snakes (12). The mollusca comprises of 2 species.

Illegal trade in PNG occurs throughout the country though largely unreported for both fauna and flora. Examples of floras exploited include sandlewood, ebony, eaglewood, agarwood, and Massoy barks. For terrestrial fauna species most likely traded are birds, wallaby, and others. For marine species, species such as Saratoga fingerlings, turtle shells, Giant Clams, sea horses, beech-der-mer, shark fins, live reef fish (e.g. Humphead Wrasse) are traded.

Much of PNG's illegal export in plants and wildlife is destined for East Asia where population growth and burgeoning affluence has led to rising demand for exotic and luxury products, including wildlife products (Traffic, 2008). In PNG, more illegal trades are common in coastal boarder provinces and outer islands in Western, West Sepik, Milne Bay, AROB, New Ireland and Manus provinces.

Continuous sourcing of the fauna and flora from the wild without control can lead to extinction. Freshwater turtle has experienced far reaching population declines and extinction because of demand to supply the lucrative international pet trade, which is vibrant across the border in Papua, Indonesia (*pers. Obs. B. Bito*). Trade in freshwater turtles, reptiles, birds and fishes at present appear to be restricted to the international exotic pet trade, and there appears to be significant illegal trade along the southern PNG-Indonesian border. Actual export statistics of all species are essentially several times greater than those reported by Indonesian authorities (Samedi and Iskandar, 2000). The consumption of shark fins is driven by its delicacy, wealth, social status and traditional beliefs

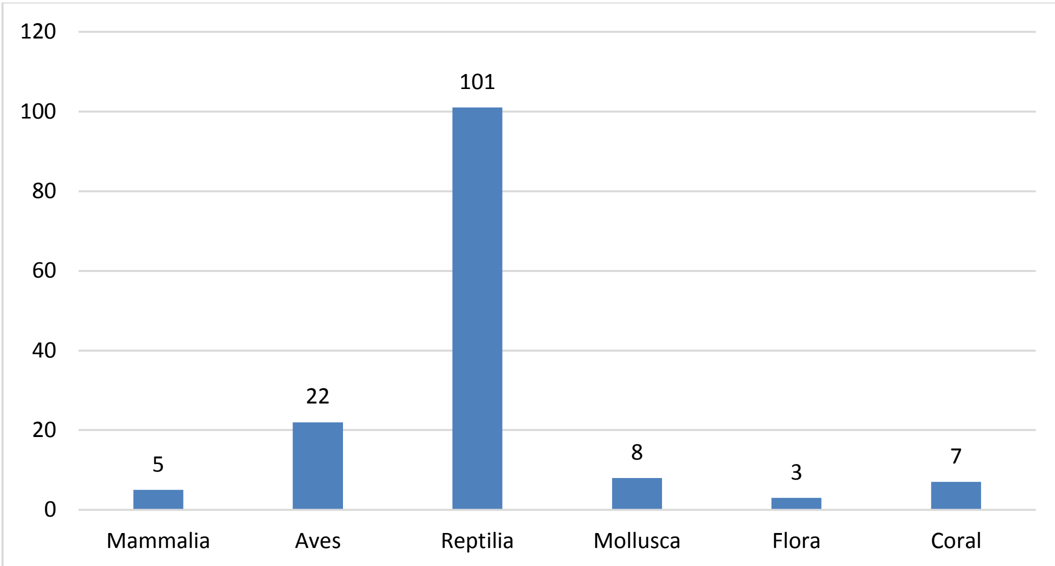

Figure 2.16: Number of Permit given by CEPA for flora and fauna in 2017 (CEPA internal database)

7.2.3 Over hunting and fishing

Understanding the risks of extinction affecting single populations is important in both pure and applied ecology, for the formulation of effective conservation plans for threatened and endangered species (Lande, 1993). Johnson (2009) hypothesized that many megafauna such as Diptrodon, Procoptodon, Meiolania, Megalania, Dromomis and Genyormis, on major continents of the world went into extinct following a stable climate conditions 4000 years ago, that coincide with the arrival of humans. He discounted glacial cycle were responsible for their extinction. Evidence of increase fire activities were also known following human arrivals, coupled with overkilling, were deduced to be the main causes of extinction. There was a large marsupial species (Diptrodon) from New Guinea that roamed the island was hunted to extinction (Flannery, eds. 1995).

A man with a prime catch, the pig nose turtle, in the Fly River area, Western Province (Photo by W. Mondu)

The best evidence of human kill is the Moa bird of New Zealand when humans arrived on the island in 1260 AD. Steadman (1995) recorded recent extinctions to be related to human arrival and hunting pressures. For instance, in Hawaii, 60 species of land birds extinct after first human arrival and 20-25 more were lost in the last 200 years. In New Zealand, 34 species of land birds extinct between Maori settlement and European arrival. The Punakaiti karst region of South Island had 50 land bird species and now 27 are gone (Duncan et al., 2002).

Moreover, the disappearance of large seabird colonies also occurred (but little seabird extinction). Previously the number of seabirds nesting on Huahine (Society Islands) was used to be 15 but now 4. Also Easter Island had 30 breeding seabird species but this has reduced down to 1. In Fiji, extinction of frogs (Fiji's mega-frogs), lizards, some invertebrates and plants all coincide with human arrivals (Duncan et al., 2002).

Over hunting

The staggering examples above depicts human beings are responsible for the extinction of species and declining population caused by over hunting and fishing, habitat destruction and introduction of pests and diseases. These effects are compounded by climate change effects. The reason why those species extinct was because of their high value and removal rates, and their characteristics to become vulnerable to hunting and fishing (e.g. low replacement rate or growth rate and easily accessible by humans). A recent extinction of a large species happened when the last Stella's sea cow was killed in 1768, as a result of decades of overexploitation and uses (Turney and Risley, 2006).

Over hunting and fishing using modern effective techniques and technologies, and other destructive methods such as dynamite fishing (often not selective) can cause species to decline in population and reach critical limit of carrying capacity before becoming extinct. In coastal waters of PNG, good transport modes have now enable people to go to places never fished before and this may result in over fishing and disturbance.

Currently, there are instances of extinction and overharvesting for fisheries worldwide, including bushmeat harvest. This is more alarming in Central and West Africa, thus causing the 'bushmeat crisis' where apes and other forest animals were harveted unsustainably (Walsh et al., 2003). This happened because local-scale harvest of forest mammals, for protein and cash in poor societies is common. This can be sustainable for small fast-reproducing and abundant species (e.g rodents, small antelope) but not for large, scarce, and slow-breeding primates as seen in the megafauna cases.

In PNG, direct exploitation of resources is one of the major drivers of biodiversity loss in terrestrial and marine environments, mainly subsistence hunting and artisanal fishing. Subsistence harvesting of game animals continues to be the mainstay of many rural population in PNG, to meet their traditional practice requirements or dietary requirement (GoPNG, 2016). More recently, it is the cash economy that is driving the increase in hunting of game animals mostly bird, mammals and others such as crocodiles.

Despite many communities have been hunting the animals over millennia, some practices have become unsustainable. Mack (2005) studied the cassowaries and concluded that exploitation and habitat destruction are both causing decline in population of wild meat hunting. This wildlife exploitation is further widespread with the use of illegal firearms, motorised transport and increase hunting efficiency (GoPNG, 2016). Since PNG does not have large game animals, a variety of species are hunted for food, mainly mammals, reptiles, birds (Mack and Write 1998; Mack 2005; Mack and West, 2005; Kagl et al. 2015; cited in GoPNG 2016).

A post-graduate student concluded a recent study on endemic bird plumes trade in the Highlands of PNG in the last 30 years and found that harvesting of bird species increased because of the need for traditional regalia, cash and school fees (Supuma 2018*).* Figure 2.62 shows there are various reasons for increase trade of bird plumes and carcase. Supuma also found that increase in trade in individual species that are valuable has seen increase in trade of that species as well.

Figure 2.63 shows the trade of endemic birds traded in the Central Highlands of PNG over 50 years has increased due to their values and needs. Figure 2.64 shows specific bird species traded in Port Moresby where there is a reduction in species diversity traded after 40 years as new species are constantly entering the local market. Thus, Sala et al. (2000) and Millennium Ecosystem Assessment (2005) confirmed that direct exploitation of resources has been the major driver of species loss and declining in population of both terrestrial and marine species.

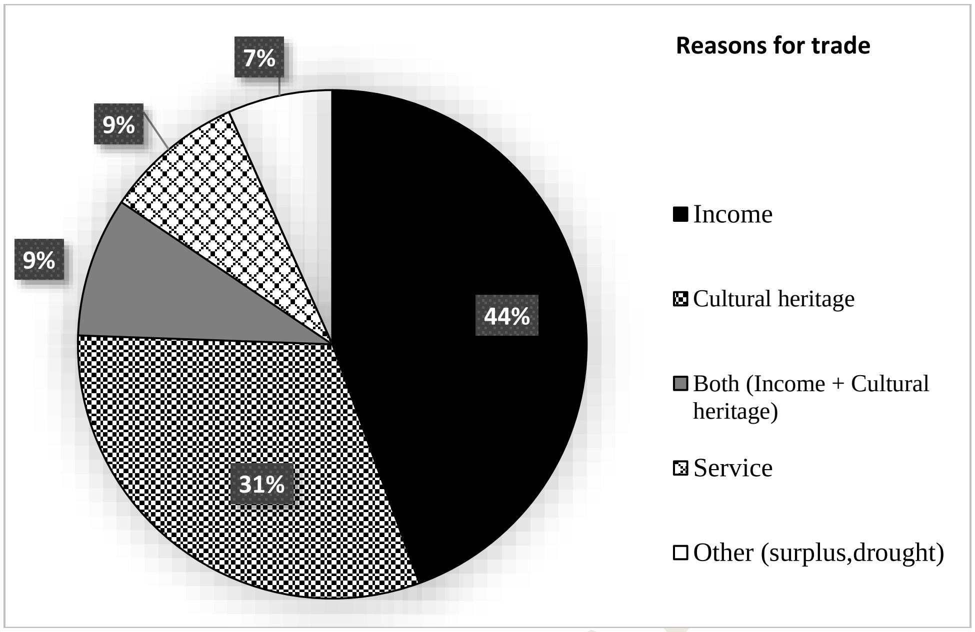

Figure 2.62: Reason for harvesting and trade of endemic bird plumes (Supuma, 2018)

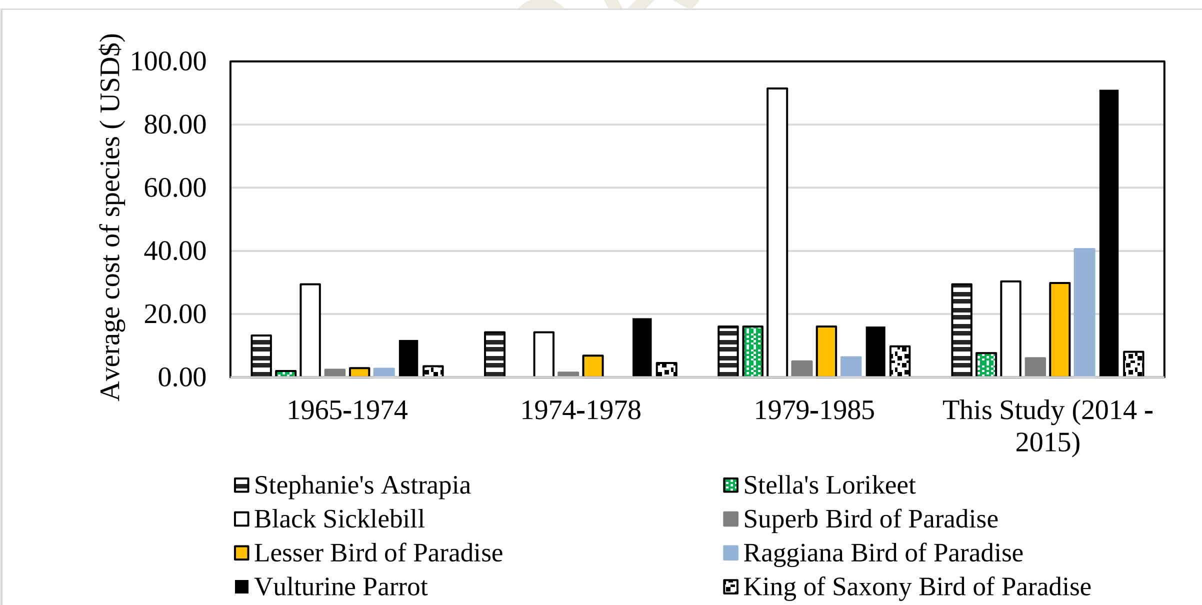

Figure 2.63: Trade of endemic birds of Central Highlands over 50 years (Supuma, 2018)

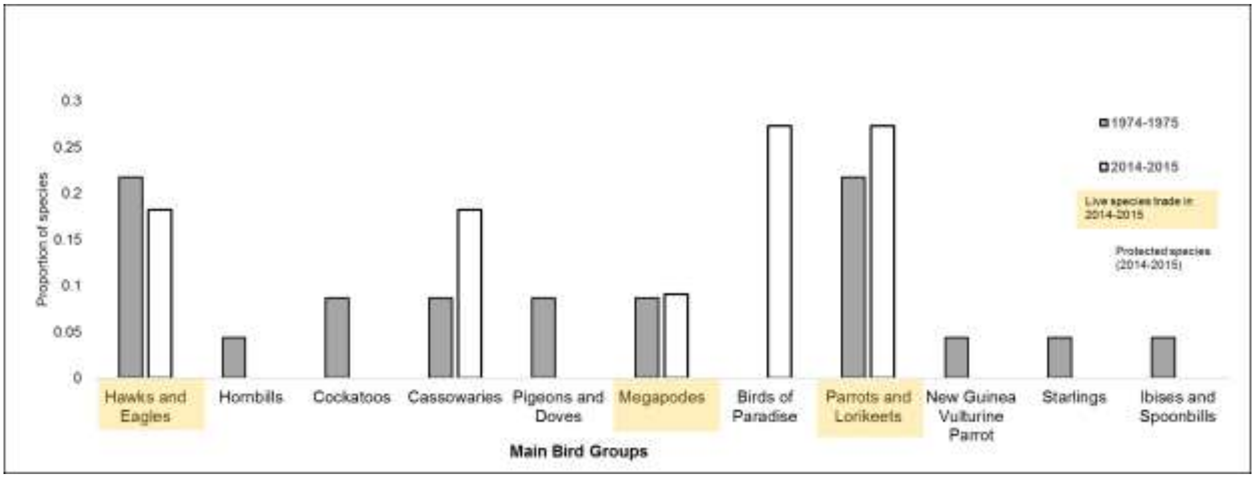

Figure 2.64: Bird Trade in National Capital District (Supuma, 2018)

Overfishing

Overfishing is one of major contributing driver of biodiversity change. It has been estimated that about 25% of the world's commercial marine fisheries are overexploited and a further 50% are fully exploited (Millennium Ecosystem Assessment, 2005). In PNG, direct exploitation and unsustainable harvesting of marine resources is causing biodiversity loss for species such as tuna, prawn and sea cucumber (GoPNG, 2016). Increasing by-catch in purse-seine and prawn fishery is now having an impact on other species as well. Pressure on fisheries has been increasingly intense due to improved market access and high prices, increased accessibility to remote areas by use of boats, poverty coupled with income generating aspiration, increased incentives to fish even when population density densities are extremely low. Some species such as beche-de-mer and shark fins are continually exploited and exported illegally, as communities and exporters seek to continue their income generation and profit making ambitions.

With increasing population and resource use, the fisheries stocks are also in demand. This result in stocks being overfished, with all activities performed outside the law, beyond the control of PNG National Fisheries Authority (GoPNG (2016). The uses of destructive fishing methods such as using gill nets, derris roots, reef gleaning and by-catch can also cause harm to the marine environment and the fish population and individual species, hence prolonged or compounded the problem.

According to GoPNG (2016), the sea cucumber or beche-de-mer fishery is one of the highly sought after product in the Asian cuisine industry. It is the second most valuable capture-based fishery, that is not sustainably manage over the years. Hence, over a period of 7 years, between 2011 and 2018, a blanket ban was imposed by NFA because the carrying capacity of beche-de-mer declined drastically due to overharvesting. Despite a sustainable management plan for beche-de-mer fishery was developed by NFA since 2006, several issues such as unregulated practices, over harvesting and undersize harvesting by rural communities for cash or food were common, resulting in reduction in population and body size, thus harvesters moving offshore, targeting low valued species as well (Purcell et al . 2013; cited in GoPNG 2016).

Harvesting of aquatic wild meat has faced similar fate like the marine fishery. Crocodiles and their eggs, turtles, and dugongs have been harvested beyond their boundaries and sustainable harvestable rates. Consequently, this has led to poaching and illegal trade.

The above experience deduced that many of those local fishing threats are proportional to human population size, coupled with development pressure and environmental degradation. This is because majority of fisheries activities occur within the coast to <50km off the coast. A study by Drew et al. (2015) found species diversity for both fished and non-fished groups decreases as the size of the local population increases, and this relationship is stronger in species that are targeted (fished). GoPNG (2016) argued that this finding show that the reef fish communities of PNG experience multiple anthropogenic stressors and that even at low human population levels, targeted species experience population declines across both time and space.

7.3. CONSUMPTION AND WASTE

Papua New Guinea is not an industrialized nation but is a more of a consume-oriented of goods and services nation. This means not many off the products it produces onshore but most come from off-shore.

7.3.1. Energy consumption

PNG is well endowed with a wide ranges of resources and is climatically well positioned to exploit renewable energy opportunities. PNG enjoys abundant fossil fuel (oil and gas) and renewable energy (hydro, biomass, LPG gas, and geothermal) resources even while only 12% of its population has access to electricity. The PNG Power Limited, the national state owned utility, manages generation, transmission, and distribution over three main grids (Port Moresby, Ramu, and Gazelle), which serve the main urban canters, and 19 isolated independent power grids servicing provincial canters. PNG Power Limited installed capacity is approximately260 MW (66% hydro, 44% thermal) with independent power producers adding 50 MW of thermal capacity. Approximately 280 MW is generated by the mining industry as captive power for their own consumption (ADB, 2018).

However PNG's energy consumption is a one of the lowest compared to the OECD nations.
The Development Strategic Plan 2010–2030 identifies the government's priorities of a 70% electrification rate and carbon neutrality by 2030. The 2011 Electricity Industry Policy focuses on (i) encouraging private sector participation, (ii) upscaling rural electrification, (iii) enhancing technical regulations, and (iv) sector coordination at the national level (ADB, 2017).
In 2014, PNG Power Ltd. developed the Fifteen Year Power Development Plan, which provides a road map for priority power infrastructure. In May 2016, the government developed 15-year National Distribution Grid Expansion Plan under ADB's support, which covers the technical, financial, and economic aspects of distribution expansion in PNG Power Ltd. canters (ADB, 2018d).

Despite the abundant resources, PNG is still using diesel generators to for its energy demand in some provincial centers. In cities like Port Moresby and Lae, constant black out is prominent hence, many business communities resort to standby diesel generators for their energy and electricity need. More recently, a proposal by a company to use coal in Lae for its electricity need became a controversial proposition.

Transport fuel varies as well for different cars but is higher in urban areas like Port Moresby and Lae. Thus rate of fossil fuel consumption rates varies for all sectors. The end use consumption of commercial energy in 2000 was 364 ktoe, with Industry accounted for 60%, transport 17% and agriculture, residential, commercial use for 24% (GoPNG, 2014). Petroleum provided 40% of energy consumption and other energy forms (mainly electricity) sixty percent. In 1996, 2% of all households in PNG were surveyed and 12% had electricity while fewer than 9% had either a refrigerator or television. Over half of the households used inefficient kerosene lamps as the main source of light and a quarter relied on open fires. Nearly 90% cooked mainly with fuel wood and 3% each used liquid petroleum gas or electricity. For the Port Moresby area, 77% of households were electrified, 67% had refrigerators and 61% had television. Over 75% had electric lighting, 40% cooked with kerosene and nearly 30% reportedly cooked mainly with electricity. The results overstate the extent of electrification in Port Moresby, and probably nationwide, but are indicative of household energy use.

7.3.2. Solid and Liquid Waste Generation

Solid Waste

Little information exists on historical solid waste generation rates for PNG, until 2008. However, given the rising levels of household consumption and population growth over 30 years, it is probable that PNG has a bigger waste stream. PNG's per capita waste production is lower than most developed countries in terms of GDP per capita waste, yet it is highest in the Pacific given its big population size of 8 million plus people. Figure 2.65 indicate PNG has the highest GDP of waste per capita at when compare to other Pacific island nations at nearly US$19bil followed by Fiji at 3.8bil, Timor Leste at US$3.6 bil while Tuvalue has the least waste generation per capita GDP at US$39mil (World Bank data Catalog, 2019).

Figure 2.66 and Table 2.10 shows percentage of waste from different sources namely plastic, cardboard, metal, glass, organic food, rubber-leather and others. Vanuatu has the highest percentage of organic food disposal with the lowest being Palau, with PNG having 31%. PNG has no data for glass and metal but generally, glass waste and metal wastes in the Pacific is less than 6% and 14% respectively. Vanuatu produces the highest waste in glass and metal in the pacific. PNG produces the highest cardboard wast with 16% followed by Timor Leste, Tuvalua and Kiribati at 10.9% being the next biggest produces. In terms of Plastic, Solomon Islands has the highest number of plastic waste with 22% with PNG at 10%. For Rubber and leather, most pacific islands countries produced less than 4% wastes.

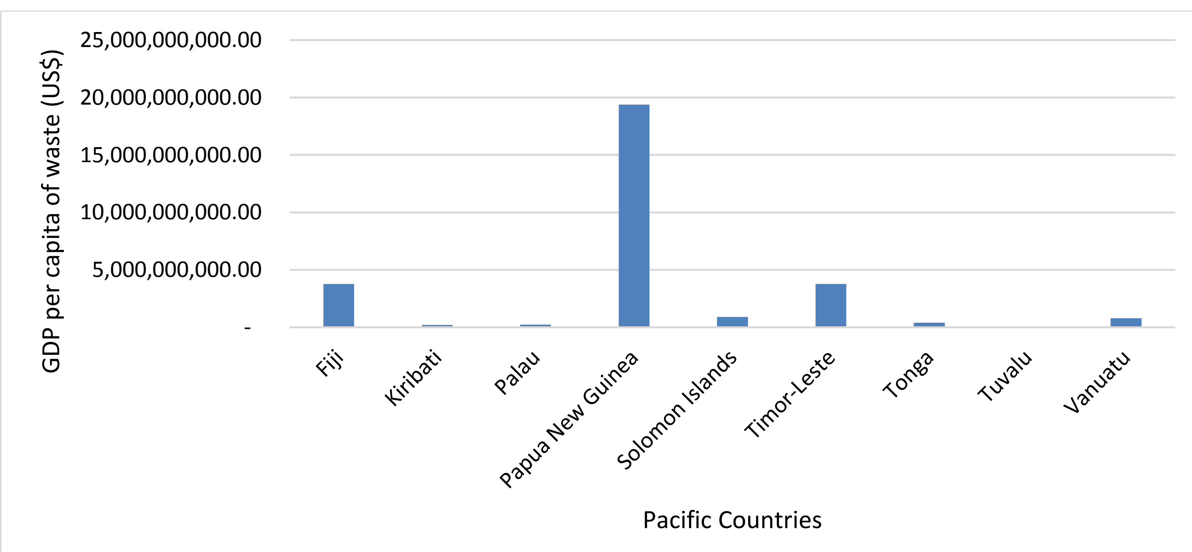

Figure 2.65: PNG's GDP capita per waste compared to other Pacific Islands countries (World Bank, 2019 data).

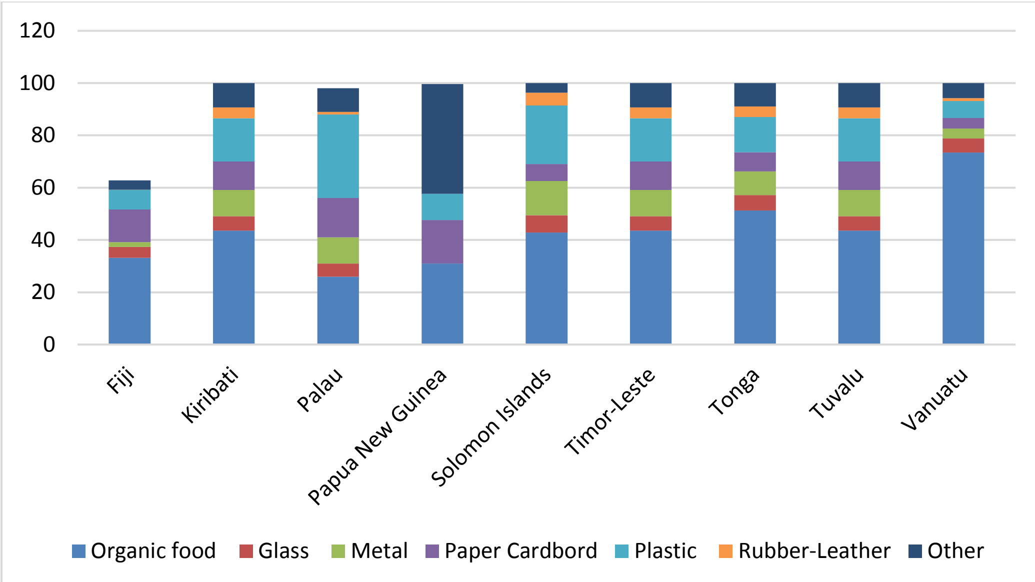

Figure 2.66: Percentage of waste from different sources ((World Bank data catalogue, 2018 data).

Table 2.10: Percentage of waste from different sources (World Bank data catalogue, 2018 data).

Country	Organic food	Glass	Metal	Paper Cardboard	Plastic	Rubber-Leather	Other
Fiji	33.2	4.1	1.9	12.5	7.5	0.1	3.5
Kiribati	43.6	5.5	10	10.9	16.5	4.2	9.3
Palau	26	5	10	15	32	1	9
Papua New Guinea	31	-	-	16.6	10	-	42
Solomon Islands	42.8	6.65	13.15	6.45	22.35	4.9	3.7
Timor-Leste	43.6	5.5	10	10.9	16.5	4.2	9.3
Tonga	51.3	5.9	9	7.4	13.4	4.1	8.9
Tuvalu	43.6	5.5	10	10.9	16.5	4.2	9.3
Vanuatu	73.4	5.4	3.8	4.05	6.45	1.2	5.7

The above figure for PNG may not be reliable for PNG. This is because not much data has been collected consistently and accurately. Reliable data is not available on the amount and composition of municipal solid waste (MSW) in PNG. However, going by the average for all Pacific island countries, it may be inferred that PNG's per capita household MSW generation rate could be about 0.45 kilograms (kg) per person per day. It varies in different parts of the country based on GDP, urbanization rate, and other factors. In Port Moresby, Lae, and other cities, MSW generation rates are likely higher, and probably considerably lower in rural areas.

CEPA had done a trial waste collection audit waste along the coastal villages in Port Moresby over a period of 6 months in 2018.

Figure 2.67 shows the mass of waste at the coastal village of Hanuabada in Port Moresby. PET, General Wastes and PSB are higher at 42kg, 32 kg and 13 kg respectively compared to other plastics, and packaging with 8Kg and kg respectively. This figure is a sample of PNG and could be more higher because the amount of non-recyled waste are high. There are illegal dumping sites as well, including continuous dumping of plastic bag everywhere in cities and towns.

Assuming this average Municipality Solid Waste (MSW) generation rate and the current population, the national household generation is over 3,000 tonness per day, or over one million tons per year. From 2012 until 2030, assuming nominal per capita generation and population growth, PNG is expected to generate in excess of 20 million tonnes of household MSW. On the composition of PNG's MSW, although national data is not available, information from other Pacific island countries indicates that it is likely to contain significant proportions of organic material (possibly up to 60%). Port Moresby likely generates about 135 tons per day of household MSW, equivalent to over 50,000 tons per year (ADB, 2018b).

Thus PNG is most likely to have the highest per capita waste generation, at 0.9 kg/person/day. While the generation of waste on PNG is growing, the percentage of waste disposed of properly, or recycled, remains much lower. The number of unauthorised dumpsites in PNG is not known. The low recycling rate and unauthorized dumps make it harder for PNG to manage and dispose of waste effectively and to reduce the potential adverse air, marine and freshwater impacts from landfills, garbage burning, littering and disposal of hazardous waste.

A total of 36 private contractors operate the MSW collection system of Port Moresby, under arrangements with the Waste Management Division of the National Capital District Commission (NCDC). The contractors include 11 for household waste; 11 for public markets; 8 for settlements; 3 for schools; and one each for commercial waste, for sanitary waste, and for MSW of medical institutions. MSW is collected twice a week on average, with contractors providing their own equipment and labour. Most contractors use small, open topped vehicles for the collection of wastes. Some contractors also collect commercial MSW, although many commercial generators either contract alternative private haulers or haul their MSW to the disposal facility themselves. The geographic area served by the system is large, but there are no transfer stations. Records of collection coverage and collection efficiencies are currently unavailable (ADB, 2018).

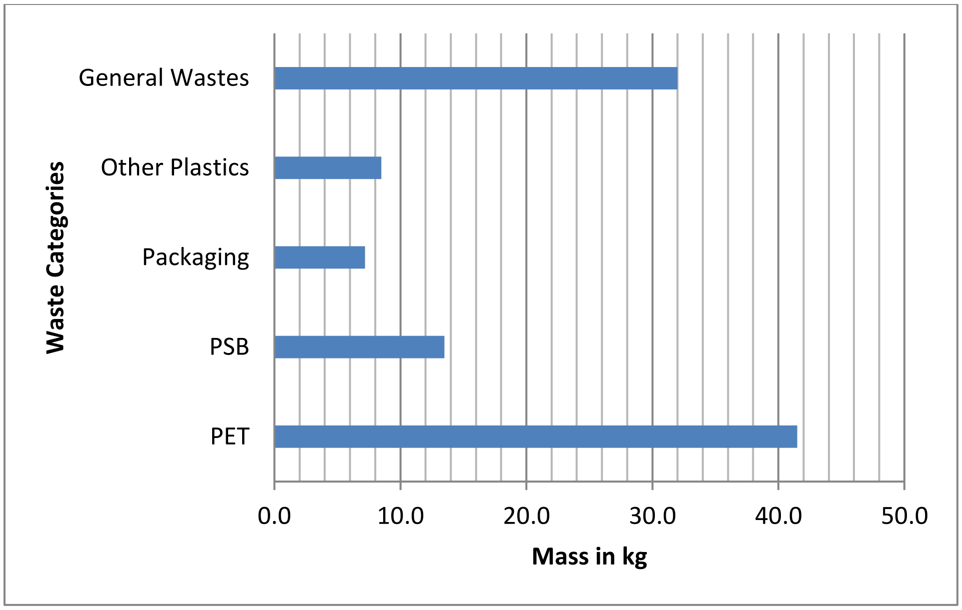

Figure 2.67. Waste Categories mass for Hanuabada village in kilogram (CEPA, 2018 data)

Regulations require household and commercial generators to provide suitable storage containers for their MSW. In reality, however, many containers are unsuitable. Many households place their MSW for collection on raised metal stands to isolate wastes from scavenging animals; but many of these stands are untidy, with waste scattered on the ground. Other common containers include oil drums that are frequently used in public areas. However, the containers are often left uncovered, exposing the wastes to vermin and the elements, and causing the bases of the drums to rust (ADB, 2018).

Wheelie bins have been provided to selected communities in the city, but are not widely used. There are legal provisions that prohibit illegal dumping, including the imposition of fines. Despite this, illegal dumping and burning of waste are common due to the lack of public awareness and education, adequate waste collection services in certain areas including the city's large informal settlement areas, and insufficient funding for adequate enforcement; and the relatively low level of fines imposed (ADB, 2018).

Marine debris/plastic/oil

The polluting of our ocean and marine life is a growing concern in the Pacific islands region. Plastic and marine debris has a negative impact on marine life and general health of the ocean, and places more pressure on fisheries resources. This is mainly due to illegal dumping of solid and hazardous waste on the coastal areas and marine environment. Figure 2.68 shows areas in the PNG EEZ and the pacific where there is reported illegal dumping of waste from local and foreign fishing vessels between 2013 and 1014 by observers (Blaha, 2016). These wastes include plastics, metals, waste oil, general garbage, chemicals, fuel oils and fishing gear.

The pollution incidents mapped by latitude and longitude positions were provided by observers stationed on fishing vessels and are overlaid on colourised map indication purse seine activity between Aril 2013 and March 2014, using FFA fishing vessel databases and automatic identification system (AIS) vessel track. The high number of incidents in the EZ of many pacific countries, especially PNG indicates the high activities of purse seine fishing grounds (Blaha, 2016)

Figure 2.69 shows 71% of all purse seine pollution incidents comes from wastes dumped overboard, 16% as oil spillages, and leakages, and 13% as abandoned, lost or dumped fishing gears When further analysis was done into sub categories of 'waste dumped', plastics makes up the largest proportion with 37% followed by metals with 15%, waste oil with 9%, general garbage with 8% and chemicals constituting 2%.

Moreover, Figure 2.70 also shows 70% of total pollution incident from 2003-2015 by purse seine observers aboard vessels from distant water fishing nations (DWFN). PNG flagged vessels constitute the largest percentage of pollution incidents with 18% where almost 85% of pollution occurred within PNG's EEZ. The next largest pollution incidents occurred on vessels flagged to Taiwan with 16%, followed by USA with 15%, Korea with 12%, the Philippines with 10%, Japan with 10% and China constituting the least with 8% (Blaha, 2016).

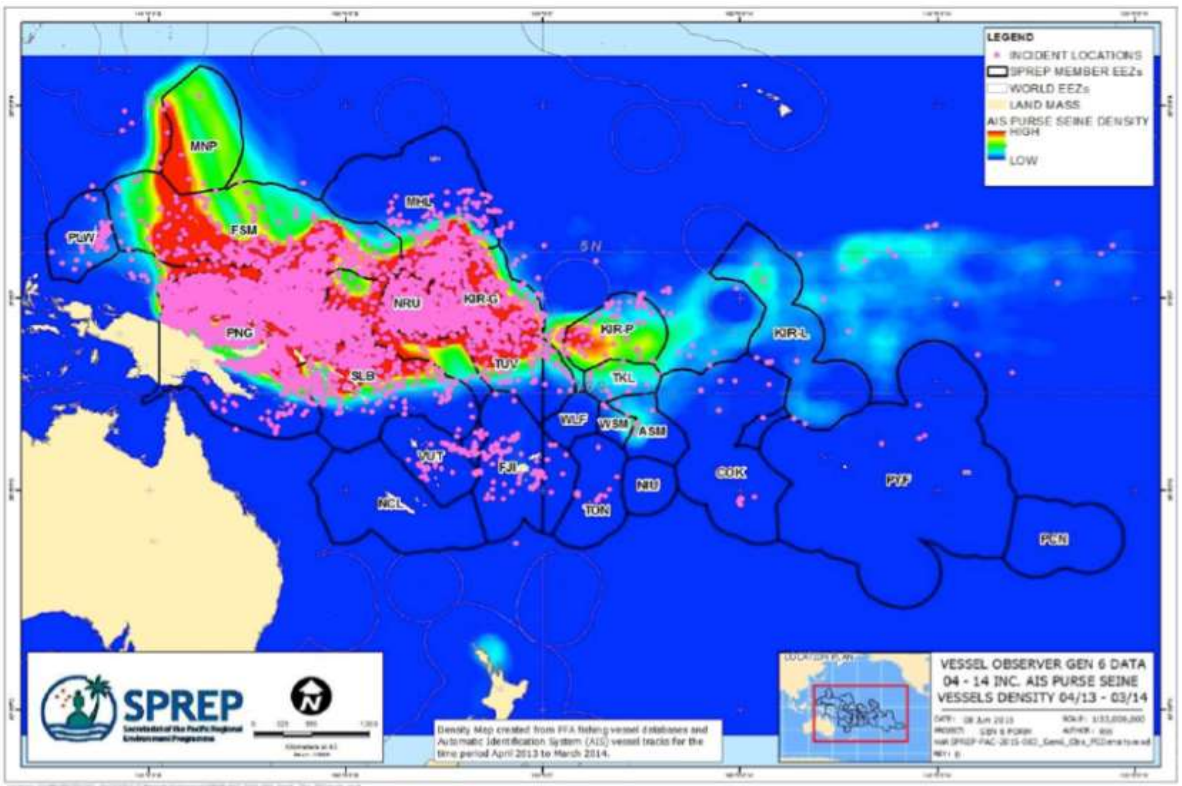

Figure 2.68: Purse Seine Pollution Incidents Mapped by Latitude and Longitude between 2013 and 14 (SPREP, 2016; cited in Blaha, 2016).

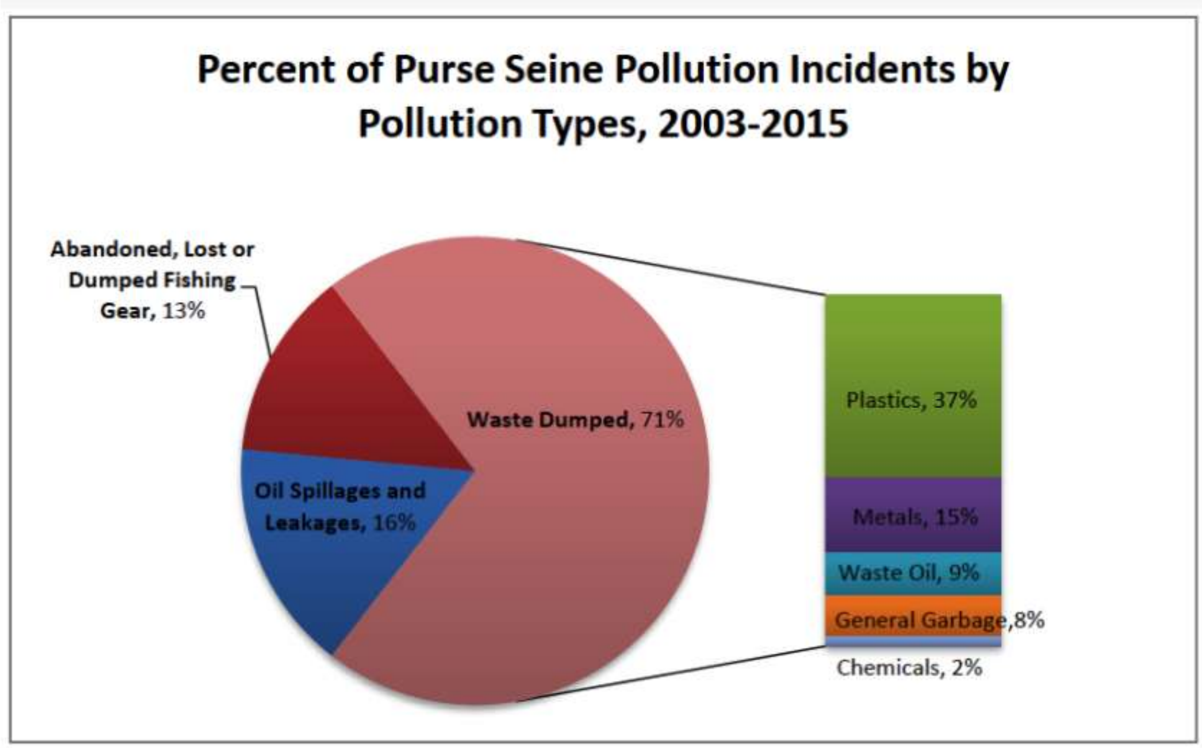

Figure 2.69: Percent of Purse Seine Pollution Incidents by Pollution Types, 2003-2015 (Blaha, 2016)

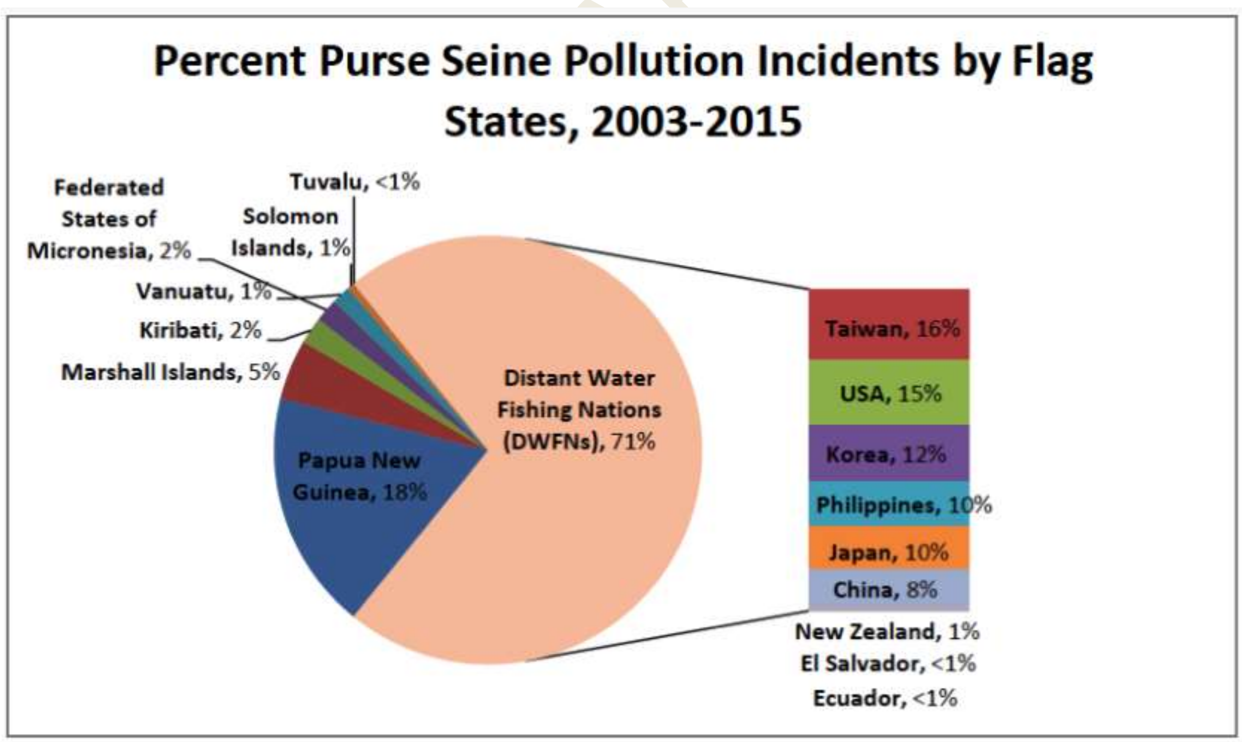

Figure 2.70: Percent Purse Seine Pollution Incidents by Flag States, 2003-2015 (Blaha, 2016)

7.4 CHALLENGES ON CONSERVATION AND DEVELOPMENT

The government of PNG sees a need to increase economic development and improve the livelihoods of its people. According to the National Statistics office, PNG's economy is largely supported by four sectors: agriculture, forestry and fishing (19%); mining (10%); extraction of crude oil and petroleum (12%); and wholesale retail and trade (11%), which combined contribute more than a half of GDP in PNG NSO, 2011a). When combined, agriculture, forestry and fishing industries are the largest sources of employment domestically, providing jobs to around 20% of the working population. These sectors maintain a strong cultural connection with the citizens of PNG, whom have developed the necessary skills and knowledge to work the land over centuries.

Thus, the urgent need now to raise the standard of living (PNG ranked 154 out of 187 countries on the Human Development Index in 2016) and meet the growing international demand for timber, food (which is set to double by 2050) and other natural-resource based commodities, unsurprisingly, the scaling-up of these industries is a priority for the Government of PNG (UNDP, in press).

With many challenges, drivers and pressures on PNG's environment, any environmental and socially sustainable and projects PNG is embarking on based on its policies is critical for PNG to attract international investment at reasonable scale that does not compromised the future of PNG. Perhaps the single most challenging aspect of accessing impact investing opportunities is to identify mitigation and consevation projects that can generate a financial return for PNG in the long run.

Currently PNG is facing challenges and some of them are identified in this Report and these challenges must be assessed before any pilot and large-scale projects must attract massive development prospect and at the same time must be environment sustainable. There are many reasons to take this stand because of current lack of capacity within the government agencies to assess projects, lack of understanding amongst landholders, security concerns for vinvestors visiting certain areas of the country where a project may be suitable, or political and bureaucratic red tapes and bottle-netcks exists.

Some projects also have high transaction costs and the economic environment and political conditions may not be attractive for investors. PNG is classified as one of the difficult places to do business (UNDP in press). For instance REDD+ has been championed by the PNG government, hence establishing pilot projects would be quite expansive and the the opportunity costs is high. While there are some exceptions, and the evidence base continues to build linking sustainable agriculture with improved land productivity, REDD+ is generally not a profit-making enterprise should not be discounted. UNDP iterates there are four main challenges to attracting private-sector investment in conservation and sustainable land management and they can be achievable only if a financial return is identified. That is:

1. **To generate an acceptable cashflow once the project commences**. In the case of sustainable agriculture and forestry, many projects only start generating cashflows after several years of investment. i.e; once commodities become available for sale (e.g. cocoa, carbon). Other projects produce benefits that are difficult to monetize e.g. the non-market economic gains from conserving biodiversity, boosting the incomes of local communities or mitigating risk associated with future losses such as invasive species, climate change and deforestation. For instance, restoring and conserving marine protected areas, ecosystems and habitats such as tidal marsh, cultural sites, barrier islands and shellfish reefs, can lead to reduction of

damages caused by storm to coastal infrastructure. This is where climate change adaptation come in and must be executed well. An added complexity is that when multiple parties benefit from a restoration project it can be difficult to get some parties to provide upfront capital.

Critically, sustainable land management focused investments are often relatively small compared to other private investment opportunities (e.g. energy), and therefore create a significant disincentive for fund managers to invest (UNDP in press). UNDP iterates that face-to-face interviews with several large multinational fund managers (including several operating in the Pacific) suggest that deals need to be in the realm of at least $50 million to $100 million to be worth considering. This is partly because transaction costs tend to cut significantly into small-scale investment opportunities. Associated with this challenge is that sustainable land management revenue streams are often considered less competitive compared to competing market opportunities (e.g. the conversion of forests or grassland for agriculture), at least in the short-to-medium term.

2. **The unpredictability and inherent complexity of ecological systems** - This can be problematic to predict conservation outcomes from managing an ecological system in a particular way, even with robust scientific knowledge. This is important as ecological systems impose changeability for business activities, such as providing food, water, medicine timber and fibre for the local population. Subsequently, cash flows from sustainable land management projects are often uncertain. When this uncertainty and complexity exists, following proper processes are sometimes compromised or ignored. Hence this must be debated and processes followed.

3. **Sustainable land and marine management projects are complex**. The complexity of good governance, marketability and defining objectives and policies of the government, often requires expertise in ecology, economics, project management, law and public policy. This can be a barrier as most sustainable land and marine management projects depend on defined uses for land and water – scarce natural resources that may be used in a variety of ways. UNDP (in press) iterates that promoting environmentally beneficial uses of resources can also be highly political and unpopular for government and may result in high opportunity cost, when exclusion of other socially beneficial uses for that land and marine environment, and therefore, lower profits compared to other land uses (e.g. mining).

4. **Sustainable land management projects (Including marine and aquatic projects) may also generate enhanced risks**. Risks such as potential conflicts of interest between multiple stakeholder groups, and regulatory risk often exisiting in decision making and sustainable resource management. The bottom line is, investors do not like uncertainty, especially where small projects are concerned; sustainable land and marine management projects inherently create a lot of risk in this respect (UNDP, in press). Also, project developers and investors can utilise various tools to improve a project's expected risk-adjusted returns. Management and operational risks, for instance, can be mitigated by assembling a team with all the necessary expertise in science, economics, business, policy, cultural affairs, and other areas.

The above challenges means a holistic approach must be taken to address resource, environment and conservation challenges. Some of the deicisons made would be tough because as a nation in this global community, PNG must not forgo its natural wealth in the name of development. Somewhere a balance between, politics, economics, social and environment should be met to ensure sustability is maintained.

Reduced Imissions from Deforestation and Degradation (REDD+) and plus (=+ conservation of forest carbon stock, sustainable forest management, and enhancement of forest carbon stocks (REDD+)

Currently there is limited capacity to determine the ecosystem services values of the environments across PNG that would give government and landowners alike a sense of the cost-benefits of development options.

For instance, the ecosystem service of localized water provision to communities by maintaining the environment of watersheds has been neglected. Even the role of water in maintaining ecosystems types is also poorly researched, understood, valued or promoted. Moreover, the ecosystem provisioning service of forest in maintaining the soil for current and future forest or agriculture, is also neglected and its true value is poorly researched and known.

A project that has potential to promote mitigation of climate change, deforestation and forest degradation, reafforestation and reforestation and biodiversity conservation is the REDD+. Under REDD+ there is opportunity from a PNG developed protocol and extensive field surveys to evaluate the value of the environment and ecosystems services in determining premiums additional to carbon values.

PNG is already at the forefront of spearheading REDD+ with the coaliation for Rainforest Alliance (CfRA) countries. The aim for REDD+ is for developing countries to conserve and manage their forest, at a global scaleto mitigate climate change as agreed under the United National Framework Convention on Climate Change (UNFCCC), which PNG is a signatory to.

The government of PNG (GoPNG) has prepared documents to implement REDD+, to address global climate change through the Paris Agreement. It is envisage this REDD+ will aid PNG reaching its vision of environmentally sustainable development pathway. Hence, the Government of PNG has shown leadership and commitment to contribute to the reduction of global GHG emissions by transitioning to a low carbon economy. These were captured in the relevant climate change legislation (*Climate Change Management Act* 2015 and *Paris Agreement Act 2016*), and in policies such as the *National Climate-Compatible Development Management Policy 2014* and the National *REDD+ Strategy* (NRS) 2018, and technical reports such as the National Communications Report to UNFCCC 2014, and the Biennial Update Report 2019.

The GoPNG has also enshrined the concept of "sustainable land development" in many of its other national plans and targets, and as a focus for some of its most important government committees (UNDP, in press). For example, the recent Medium-Term Development Plan 3 (MTDP3) reiterate the government's commitments to increasing the area under conservation and reducing rates of forest loss while continuing to support responsible and sustainable development particularly in rural areas. Hence, according to UNDP (in press), there are huge opportunities for PNG to tap into REDD+ because:

1. There are significant international climate finance opportunities available;
2. The private sector is showing enormous interest in sustainable agriculture and forestry investments;
3. International climate finance will unlock even larger amounts of private sector investment;
4. PNG has a strong sustainability story to tell that can impact investors; and
5. PNG's natural and social capital, and its geostrategic location, are its comparative advantages.

REDD+ projects must not compete with development activities, but instead strengthen national policies to reduce carbon emissions and forest degradation, in order to access benefits from climate change financing and REDD+ activities. However there are challenges REDD+ is facing. The question is what does PNG needs to do to position itself as an attractive climate finance and impact investment destination? UNDP (in press) states that PNG needs to:

- Establish strong systems of governance, and clear channels of responsibility;
- Build capacity in government agencies and the broader community;
- Develop a coordinated strategy for tapping into international climate finance flows, and further down the track, impact investment
- Identify and assist in the development of a pipeline of bankable projects;
- Mitigate risk to expand international climate finance and impact investment flows; and
- Embrace carbon as a commodity, promote PNG as an exporter of sustainable products

The challenge to make REDD+ work in PNG is capturing a share of these financing opportunities is far from guaranteed for PNG. Hence, PNG needs to be ready to capture these big finance opportunities, by addressing these barriers

Due to several key barriers highlighted above, much of this high-level commitment has failed thus far to increase the share of international public-sector climate finance and private sector impact investment flowing into PNG (UNDP, in press). Addressing these barriers is crucial if PNG is to position itself as an attractive climate finance and impact investment destination that has balanced the needs of developing a stronger economy while maintaining a healthy environment for its people, thus conserving some portions of the third largest rainforest in the world.

Curently only one REDD+ Voluntary Carbon Project under Voluntary Carbon Standard (VCS) (one of the first three projects in the World) was traded at the stock exchange. However, benefits were not forthcoming to landowners. The project expired in 2015 and is yet to be renewed. Discussions with local communities reveals that the project was hijacked an only few individuals are benfiting and not the real landowners. The other three pilot project identified by the PNG government are in Milne Bay (Forest management and logging), Eastern Highlands (reforestation and afforestation) and New Britain (natural forest management) but were never materialised.

An analysis currently underway by UNDP suggests approximately $200-300 million of core financing (an equivalent increase of 50% on existing government budgets) is required to help meet the targets for avoided deforestation and emissions under the NRS, and be invested into two critical components (UNDP, in press):

Component 1 – REDD+ Action Areas:

- Strengthen land use and development planning;
- Strengthen environmental management, protection and enforcement; and
- Enhance economic production and sustainable livelihoods

Component 2 – REDD+ Coordination and Reporting:

- Establish systems for coordinating and reporting on actions related to REDD+; and
- Summary of green goals.

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8.0. SECTION 3: STATE OF THE ENVIRONMENT

World War 2 memorial plaques along the Kokoda Track, Owen Stanley Range, Kokoda LLG, Oro Province (Photo by F Alkam)

8.1. THEME 1: ENVIRONMENT MONITORING AND GOVERNANCE

8.1.1 Overview

The Environment Act 2000 and Conservation and Environment Act (CEPA) Act 2014 has given CEPA as the mandated government's agency to monitor and regulate all environment and conservation activities in the country. There are also other government agencies such as National Fisheries Authority (NFA), PNG Forest Authority (PNGFA), Mineral Resource Authority (MRA), PNG Customs Commission, Department of Commerce and Industry (DCI), Department of Petroleum and Energy (DPE), Department of Works and Transport (DWT), and Department of Agriculture and Livestock (DAL), just to name a few, under their own Acts and regulations, that work in close collaboration with CEPA to manage the environment. All agencies have a purpose and that is to ensure sustainable development and environment management is achieved.

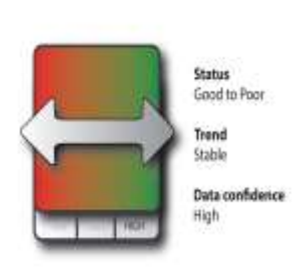
In retrospect, these government agencies have their own environment and monitoring divisions and officers who enforce and monitor projects at their own capacity but may report or collaborate with CEPA if needed. For instance, the National Policy for Transparancy and Accountability in the Extractive Sectors in PNG calls for transparency and accountability within the oil, gas and mining sectors, where processes have to be institutionalised. The policy sees the establishment of the PNG Extractive Industry Transparency Inititiatve (PNGEITI) as the body that promotes open and accountable management of revenue from natural resources for the benefit of Papua New Guineans. It seeks to strengthen government and company systems and policies, inform public debate, support anti-corrutption and investment promotion of government, and enhance trust. However, collaborative work has not be forthcoming because of lack of capacity and resources.

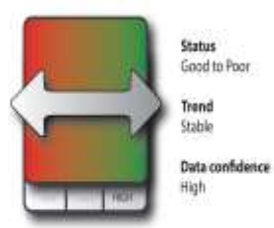
The Division of Non-renewable and Renewable within CEPA is responsible for all monitoring and enforcement of development projects, pertaining to waste management, compliance, and Permit conditions issues amongst others. Meanwhile, the Sustainable Environment Program Division is responsible for all conservation and species management work. However, other organisations listed above also work in partnership with CEPA in one way or the other.

At the international level, PNG is a member of the United Nations General Assembly, thus a signatory to several Multinational Environmental Agreements (MEAs) such as the Categana Protocol, Climate Change and Desertification (CCD), Convention on Biodiversity Diversity (CBD), and United National Framework Convention on Climate Change (UNFCCC) among others. CEPA is the focal point for at least 14 MEAs and together with the Department of National Planning and Monitoring (DNPM), reports on behalf of the Government of Papua New Guinea (GoPNG) to the UN General Assembly and the MEA secretariats. There are other MEAs administered by other government agencies such as climate change and Ocean, which are administered by CCDA and Office of the Attorney General respectively. The focal point for MEA reporting at CEPA is the Minister, Managing Director, Directors and technical officers.

According to CEPA's Administrative Framework on MEAs, the Ministers for Environment and Climate Change and the Foreign Affairs are the focal point that reports to directly to the Un General Assembly. The Managing Director and his deputy are the Operational Focal Point reporting to both the Minister and the Secretariats of the UN Conventions and MEAs. At the Conventional level, the Directors are the focal points reporting to the Managing Director. The subsidiary MEA focal points at the technical level are managers and designated officers who reports to the Directors. This Chapter looks at the Ministry of Environment budget allocation, Approved environment impact assessment for approval for development proposals and Environment cases prosecuted.

8.1.2 ENVIRONMENTAL MONITORING & GOVERNANCE HIGHLIGHTS

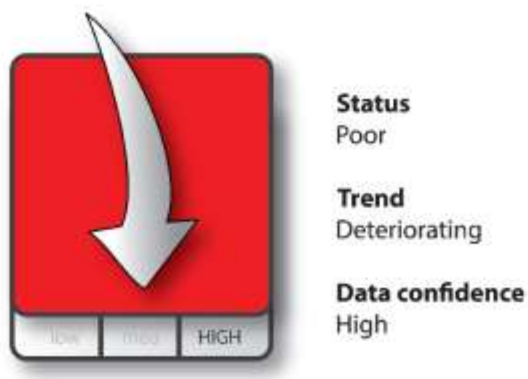
TOPIC	STATUS	KEY FINDINGS	RESPONSE AND RECOMMENDATIONS
Conservation and Environment Protection Authority (CEPA) budget allocation		Government budget allocation was at its highest in 2012 at K43 mil but reduced by 85% from K43 million in 2012 to K6mil in 2017.Funding has declined over the years since CEPA became an authority in 2014. In 2019 CEPA has to work within its mean to generate funds implement or sustain its activities.	Need to fully operate as an independent entity by implementing good business practices, built capacity, undertake major reforms in its operation structure. Also improve major function and revenue collection ability that would enable the organisation to manage its affairs in terms of financial sustainably and effective implementation of its core activities.
Approved EIAs for development proposals		The total number of documents received by CEPA decline over between 2015 and 2019, with 148 documents received in 2015, 70 documents in 2016, 24 in 2017, 29 in 2018 and 17 in 2019. The number of documents received for Environment Permit application has dropped from a high of 53 applications in 2015, 31 in 2016, 22 in 2017, 16 in 2018 and 17 in 2019. Only 5 damage complaints were received in 2015 but none in subsequent years. Overall, from 2014 to 2019 about 600 plus projects were given Environment Permit by CEPA of which 20% are renewable and 80% are now-renewable.	An Environment Council is to be appointed immediately to deliberate on EIA/EIS applications. Capacity building, resources and revenue generation are needed for effective monitoring and enforcement of laws. There is a need for quality output and scrutiny of data and staff capacity and resources are need in order to improve EIS/EIA scrutiny before Permits are issued.

MEA reporting requirements		Most reports are not done on time and reporting is poor So far only 6 national reports have been submitted since 2009, including 3 Action Plans. A total of 229 legislative have incorporated the MEAs.	Staff morals, incentives, capacity and training, resources, and collaboration with partners must improve in order to achieve timely reporting of the MEA targets and deadlines. In addition, a coordination desk for the MEAs must set up and the staff be given the right job description.
Environmental cases prosecuted		In the last 5 years, there were no litigation cases CEPA took against developers. However, there was an average of 3-4 cases per year where permit holders were issued stop notices for non-compliance or when their permits expired and they continued to operate.	There is a need to improve governance, monitoring and enforcement. This require training and capacity of staff, increase resources and funding, constant awareness and publicity, avoid compromise with proponents in order to achieve transparency and collaboration with other agencies. CEPA also need to set stringent measures that companies that fail to comply face penalties.

8.1.3. TOPIC/SUB-TOPIC: MINISTRY OF ENVIRONMENT BUDGET ALLOCATION

Indicator Definition: Percentage (%) allocation of national budget allocated to Environment Ministry or equivalent.

Status and Trend



PNG K100 notes (Photo by: A. Wilkins)

SDG/CBD Targets:

SDG: 15.a.1, 15.b.1

Aichi Target: 4, 5, 6, 7, 8, 9, 10, 11, 12, 20

Status and Trend Discussion

The Department of Environment and Conservation under the CEPA Act 2000 had transformed into Conservation and Environment Protection Authority (CEPA) in 2014 with the enactment of the CEPA Act 2014. Both CEPA and Climate Change and Development Authority (CCDA) are almagated under one Government's ministry, the Ministry of Environment and Conservation. CCDA was previously called the Office of Climate Change and Development (OCCD) and was housed in DEC but became an authority when the CCDA Act was enacted in 2016. Currently both organisations operates independently with different budget allocation.

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Furthermore, CEPA and CCDA depend much on government funding and annual budgetary allocations to conduct all their operations nationwide, to ensure both organisations reached their individual organizational milestones. Support funding also comes from donor agencies and other development partners to support their work. CCDA was previously called the Office of Climate Change and Development (OCCD) and was housed in DEC but became an authority when the CCDA Act was enacted in 2016. Currently both organisations operate independently with different budget allocation.

Figure 3.1 shows government funding allocation for CEPA between 2012 and 2017. The budget allocation for CEPA declined significantly by 85% from K43, 353,100.00 in 2012 to K6 326,200.00 in 2017. In 2013, budget was slashed with K24, 863,600.00 being allocated but in 2014 the budget increased by 37.07% to K33, 900,500.00. The increase was because DEC was transformed to become an independent revenue and self-sustaining authority, hence funding was increased. Thereafter, funding allocation was slashed again to K26 mil in 2015, K15 mil in 2016 and K6 mil in 2017.

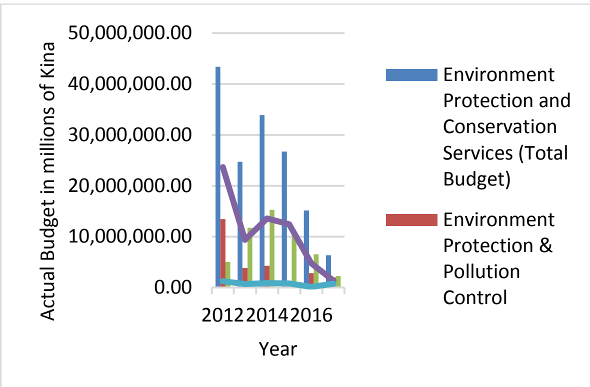


Figure 3.1: National Budget for Conservation and Environment Protecttion Authority between 2012 and 2017 (Department of Treasury Budgets 2012-2019).

Funding allocated for all divisions and activities also declined forthwith the total allocated budget. The government Budget is a legal document indicating all budget allocation for the country.

Moreover, the funding allocated to CEPA covers divisions and programs namely: 1) Environment Protection and pollution Control; 2) General Administration; 3) Nature conservation and wildlife protection; and 4) policy coordination and evaluation. These funds are allocated for personal emoluments (salaries) and recurrent (goods and services such as vehicle, overhead costs, furniture, stationaries etc), for Environment regulation (policing, compliance, permitting etc) for Biodiversity (site visitation, TAs etc). Some funds used by CEPA comes directly from donors such as JICA for waste management and conservation and the Australian Department of Foreign Affairs and Trade for conservation and livelihood development. Only UNDP GEF funding (GEF 3-7) is consistent with funding of US$5mill for each project cycles. Moreover, the Department of National Planning also allocates about K5mill for the Kokoda initiative, K1mill for Protected area work and K500, 000.00 for was waste management as part of government's co-funding arrangement (GoPNG, 2018).

In 2019, there i no government budget allocated by the Treasury Department to support CEPA, accept for the Personal Emoluments costs. Hence, CEPA will have to meet all its recurrent costs from its own internal revenue collected from regulatory activities as an Authority. This means CEPA was funded through the government for 5 years between2014-2018. Since the government is not funding CEPA's activities, any revenue generated by CEPA will shall thereon shall at least all its operational costs. That is CEPA is expected to become self suffient and sustainable in all its operations.

The revenue projection for CEPA to earn annually is K20million and this will come from regulatory and environment permits. However from past experiences, approximately between K7-10million is generated by CEPA annually. Thus, CEPA's model is not so much on revenue generation but cost-recovery.

Impact

The drastic cut in funding allocation by the government to CEPA means the organisation must be resilient and develop mechanisms to recoup money from permit holders and other development activities. Proper budget and strategic planning are also required and a CEPA Board must be established immediately to ensure management of funds generated are transparently managed and used effectively. An annual audited report of the use of these funds must be publically made available because if this is not done, CEPA will continue to struggle within its means.

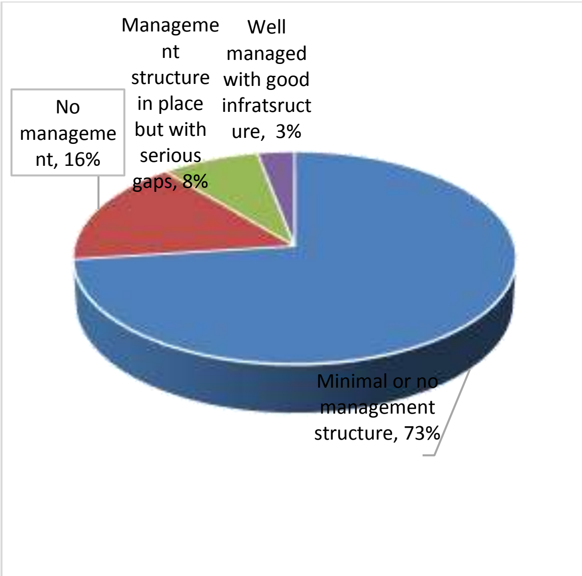


Figure 3.2: Management status of Protected Areas in PNG in 1999 (in IUCN, 1999; cited in GoPNG, 2018)

Moreover, with the decline in government funding over time, the activities for the organisation has dropped remarkably. For instance, the World Bank/WWF Alliance for Forest Conservation and Sustainable Use (Figure 3.2) shows 73% of PNG's protected areas have minimal or no management structure, 16% had no management at all, 8% had a management structure but there were serious gaps, and only 3% were well managed with a good infrastructure (IUCN, 1999:26; cited in Adams et al., 2018).

The METT analysis conducted by CEPA shows the progress of 58 PAs in the country. Since 2006 after the RAPPAM repor was publishedt, the conditions of PAs dropped remarkably. The RAPPAM Report of 2006 shows many protected areas have not been visited by a government officer or NGO for over decades, and some communities are not aware of the existence of the protected areas.

There were increasing pressure and threats to PAs, including increase hunting, poaching, forest clearance and other activities detrimental to the PA. In addition, management of most protected areas was minimal, with 22 of the 45 assessed protected areas scoring less than 33% of the possible score, and the remainder scoring between 33% and 67% (Leverington et al., 2018). Effective monitoring of Environment permit conditions has been lacking as well over the years and now has been focused mainly in mining and oil and gas projects. Other activities are minimal or lacking and are not prioritised by CEPA, especially non-revenue generating activities. There may be exceptions when an emergency rises or when a proponent make available funding for activities that requires CEPA's input or participation.

In 2017, there was little or no progress in PA management with 64%, there are some progress, with high concern in PA with 24%, followed by good progress, with some concern having 5% and very good progress with only 7% (Figure 3.3). All these are result of drop in CEPA's funding on conservation work and PA management over time.

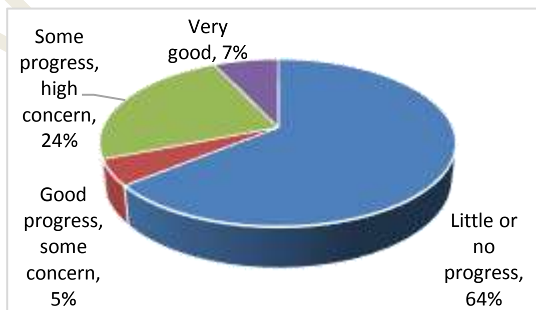


Figure 3.3: Overall progress in management effectiveness for protected areas in PNG in 2017 for 58 PA (Leverington et al., 2018)

All in all, funding is the biggest problem and challenge faced by CEPA for not only conservation but environment monitoring as well. Hence, lack of government budgetary support will certainly affect most conservation and environment work of CEPA, including staff performance as the regulators of all development activities in PNG. Consequently this will have an impact on all conservation and environment work in PNG.

Currently the government is facing financial issues as the global economy is facing a recession and down turn in prices of commodities. The new Money Regulisation Act 2018 requires all State Entities to pay 90% of their income to the Treasury Department while keeping the other 10%. This will affect most government departments and agencies, especially those that generate their own revenue to run their operations. Hence CEPA mandated functions will be greatly impaired.

Currently, most government department uses about one third or almost over K4 billion of PNG's national budget. This is a huge chunk, hence the government is now looking at ways to reduce this huge public expenditure cost. This has resulted in CEPA being asked to fund all its environment and conservation work. The onus is now on CEPA need to prepare its work plan and get it approved by the Departments of National Planning and Treasury so some funds can be realised.

CEPA's revenue will also depend much on the timely payment of prescribe annual fees and how effectively officers give notices for collecting the fees. Any delay may affect its operation. Hence a good sustainable financing model or system for fee collection and financial management has to be developed, thus a balance in conservation, environment and development can be achieved, including CEPA's goals and vision. Finally, there is a need for more funding and collaboration for enforcement and monitoring by CEPA and other government agencies.

Response and Recommendations

CEPA as an authority has to undertake a major reform in its business and usual (BAU) approach to all conservation and environment management. With drastic cut in government budget, ways to increase revenue and transparency are need to steer the organisation out of its financial burden Hence the following are required:

- Developed a 5 year Corporate development plan with goals, targets and activities
- Improve Environment Permit fee collection;
- Conduct effective monitoring and regulation and penalise those companies that breached the laws and conditions of the permits. This will help CEPA to raise more revenue;
- CEPA has to have a transparent funding mechanism in order to become appealing to donor agencies;
- CEPA has to establish a donor funding unit that specifically focus of proposal writing and managing of fund, implementation of projects, managing funds, and monitoring and evaluation;
- Establish an effect CEPA Board immediately; and
- Build capacity.

Reference

Adams V.A, Tulloch V.J, Possingham H.P (2018). *Land-sea conservation assessment for PNG June 2017*. CEPA, Port Moresby, PNG.

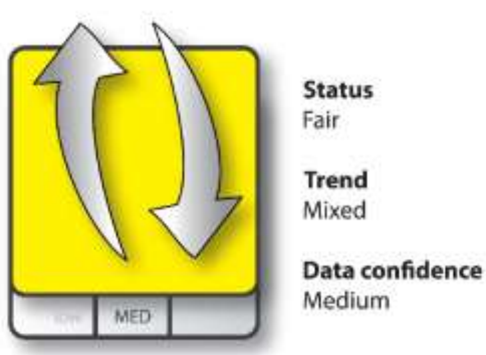
GoPNG (2018). *2019 Budget estimates of revenue and expenditure for national government departments for the year ending 31st December, 2019*. Department of Treasury, Port Moresby, PNG.

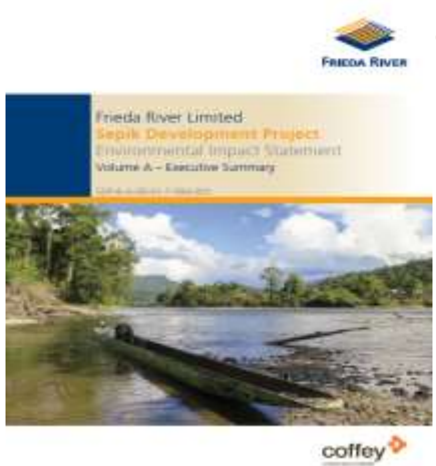
Leverington F, Peterson A, Peterson G, Jano W, Sabi J and Wheatley A (2017). *Assessment of Effectiveness for Papua New Guinea's protected area. Final Report*. SPREP, Apia, Samoa.

8.1.4 TOPIC/SUBTOPIC: APPROVED ENVIRONMENT IMPACT ASSESSMENTS (EIA) FOR DEVELOPMENT PROPOSALS

Indicator Definition: Percentage (%) of Environment Impact Assessments (EIAs) approved out of all submitted development proposals

Status and Trend





SDG/CBD Targets

SDG: 8.1.1, 8.2.1, 8.3.1, 8.4.18.5.1, 8.6.1, 9.1.1, 9.2.1, 9.2.2, 9.4.1, 9.5.1, 9.a.1, 9.c.1, 11.6.1, 12.2.1, 12.4.2, 15.5.1, 13.3.1, 14.7.1, , 15.2.1,15.3.1,15.5.1, 17.5.1

Aichi Target:1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14,15.16

Status and Trend Discussion

Table 8.1 shows the different category of different documents received by CEPA between 2015 and 2019. The total number of documents received by CEPA decline over between 2015 and 2019, with 148 documents received in 2015, 70 documents in 2016, 24 in 2017, 29 in 2018 and 17 in 2019. Documents for 2019 was recorded up to April. During that period, the number of documents received for Environment Permit application has dropped from a high of 53 applications, 31 in 2016, 22 in 2017, 16 in 2018 and 17 in 2019.

All other documents are renewals, amendments or reports required by CEPA for complying with processes required under the Environment Act 2000 and the Environment Regulations 2002. Only 5 damage complaints were received in 2015 but none in subsequent years.

In addition, the other documents in Table 8.1 received by CEPA are also done by respective proponents. Given the lack of capacity and resources, CEPA's operation is affected, hence there will be less or even no monitoring at project sites due to limitations like human resource, finance, technology, and expertise.

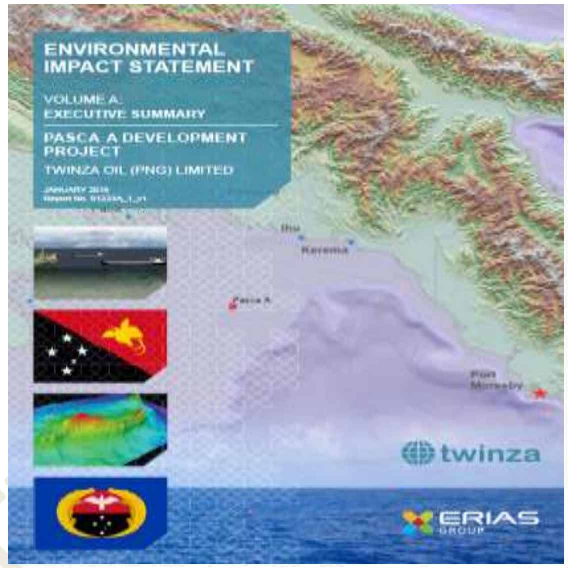
Generally the picture for documents submitted to CEPA depicts a drop in Environment Impact Assessment (EIA) and Environment Impact Statement (EIS) for activities. During that period, after the CEPA Act came into effect in 2014, CEPA was established. Hence only Level 2 Projects were approved whereas Level 3 projects were not assessed. The reason is there was no Environment Council put in place to review EIS documents and make recommendation to the Minister for final endorsement.

Prior to 2014, an average of 300 Level 3 project's EIAs were submitted and between 90-95% of the EIA submissions went through the Environment Council and got endorsed before the Minster gives a blanket approval. The remaining unapproved EIAs were downgraded because of certain issues. For instance, some Level 3 agroforestry projects were downgraded to Level 2 category because of agricultural activities that need no full EIS/EIA. This may have happen because of the status of their prescribed activities, or the forest area was already disturbed.

Under the Environmental Act 2000 and stipulated in the Environment Regulation 2002, there are three categories of Environment Permits issued to clients and developers by CEPA. According to the Regulation, Level 1 Activities are all those activities that are not prescribed as Level 2 or Level 3 activities. Level 2 activities are activities listed in Schedule 1, which are prescribed as Level 2 activities for the purposes of the Act. Within Schedule 1, Level 2 activities are classified as Category A activities or Category B activities for the purposes of the Act and the Regulations to the Act. Level 3 Activities are activities listed in Schedule 2 are prescribed as Level 3 activities for the purposes of the Act. These categories and levels are categorised based on the significance of their impacts and cost involved.

Since 2015 onward, there was no Environmental Council to deliberate on Level 3 projects. A new Council is yet to be selected and appointed through the NEC processes so that decisions to ensure all approvals can be made transparently. This is crucial for Mining projects such as Wafi and Freda, and other gas projects. Prior to 2014, there exist an Environment Council.

Since, 2015, roughly an average of 3 projects of Level 2 category were approved and permits issued. The number of assessment done on the ground is still limited. Few assessment verifications are done by CEPA, are mainly funded by developers, especially mining, petroleum, agriculture and forestry companies. Overall, from 2014 to 2019 about 600 plus projects were given Environment Permit by CEPA of which 20% are renewable and 80% are now-renewable.



Environment Impact Statements documents

Most renewable activities approved are logging and agriculture projects and activities whereas the non-renewable are mainly for infrastructures, bore water, construction, quarries and small scale mining. There were no permit given for Oil and Gas sector and large mining activities, but this will eventuate when an Environment Council is appointed. More recently, the Prime Minister Honourable Peter O'Neil signed an Agreement with Total, Oil Search and Exxon Mobil companies to resume the Papuan LNG. Other oil and gas projects began earlier than 2014 under the then Department of Environment (DEC).

Table 3.1: Different category of documents received between 2015 and 2019 for both renewable and non-renewable sectors (CEPA's internal data)

Category	Year				
	2015	2016	2017	2018	2019
Environment Permit Applications	53	31	22	16	17
Renewals	6	1	0	1	0
Transfers	31	1	2	0	0
Surrenders	0	2	0	2	0
Amendments	15	7	0	3	0
Notification of Intent	8	7	0	3	0
Environment Management Plans	8	3	0	1	0
Annual Environment Performance Reports	9	11	0	1	0
Environmental Monthly Reports	3	0	0	0	0
Waste Management Plans	5	2	0	1	0
Request for Approvals	0	1	0	0	0
EIS	4	1	0	1	0
EIR	1	3	0	0	0
Environmental Damage Complaints	5	0	0	0	0
Total Applications Received	**148**	**70**	**24**	**29**	**17**

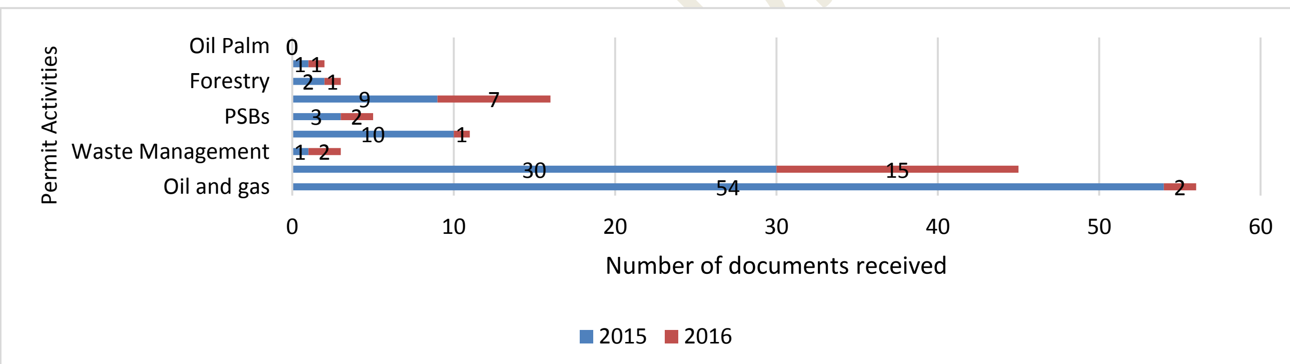


Figure 3.6: Number of activity's permit application received between 2015 and 2019 (CEPA's internal Data)

Figure 3.4 shows the number of EIA/EIS done by companies to receive Environment Permits from DEC before CEPA became an Authority in 2014. It also shows that most Permits were issued after 2014 and mainly for the non-renewable sectors as per the reasons stated above, thus conform to the figures shown in Table 3.1. However as stated earlier, the number of EIS application dropped because only Level 2 Activities were approved by CEPA.

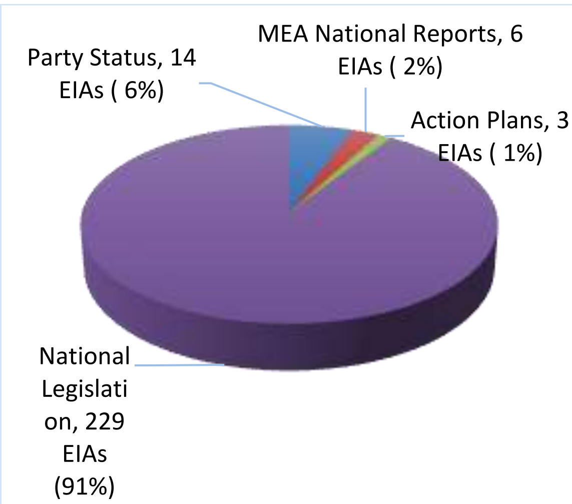


Figure 3.4: Number of Environment Permit issued by DEC between 2002 and 2004 before DEC became CEPA

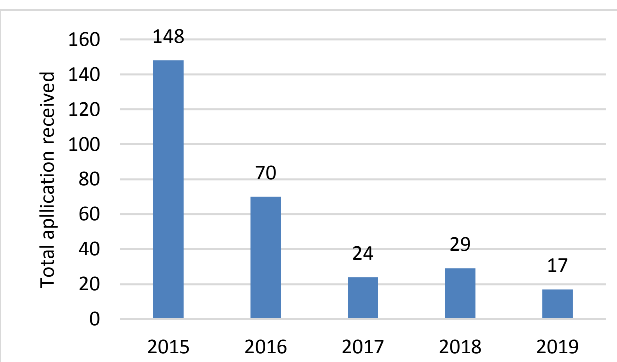


Figure 3.5: Total number of EIS application received between 2015 and 2019 (CEPA's internal data)

Figure 3.5 indicates 148 EIS application for Permits in 2015 which dropped to 70 in 2016, 24 in 2017, then rose to 29 in 2018 and 17 in 2019. EIS are important document for project approval showing how the proponent will address environment and social issues and mitigate problems. The record for 2019 is only up to April. Between 2015 and 2019, the number Permit application received by CEPA for approved of activities for both non-renewable and renewable resource projects dropped (Figure 3.6). Most documents were received in 2015 for the oil and gas sector, Infrastructure projects, Manufacturing, and Mining. PSB, Forestry, and agroforestry were less compared to mining, manufacturing and oil and gas. The number of Environment Permit applications decline over time and was highest in 2015 compared to 2016. From 2017 to 2019, there were no applications received.

Impact

The absence of CEPA's Environment Council is hindering the progress of approval of Environment Permits for proponents which are submitting their EIS and EIA. May also affect the revenue generation processes of CEPA to generate revenue for its operations. A sustainable income is much needed by CEPA as an authority and when that income is not flowing into CEPA, all its conservation and environment activities will become affected.

In addition, the absence of the Environment Council would allow undue influence creep in the organisation regarding matters pertaining to issuing of Environment Permits to companies. There may be instances where Permits are issued without proper debates and reviews of the EIS and EIA documents.

With lack of capacity and resources to review the EIS/EIA (usually thick documents bind together in volumes), the documents may not be thoroughly scrutinised. Hence, appropriate human resource training and secondment are required to effectively review the EIS/EIA submitted to CEPA.

In 2017 a publication was published for people to apply for the Council positions. No selection was done yet but in 2019, the some shortlisted candidates were selected by CEPA internally and the names were submitted to the National Executive Council for approval. Until and when this is done, the progress of issuing permits to developers will be in limbo, especially Level 3 projects.

Sawn Timber harvested from mangrove forest sawmill in Kikori, Gulf Province, by locals using mobile

Response

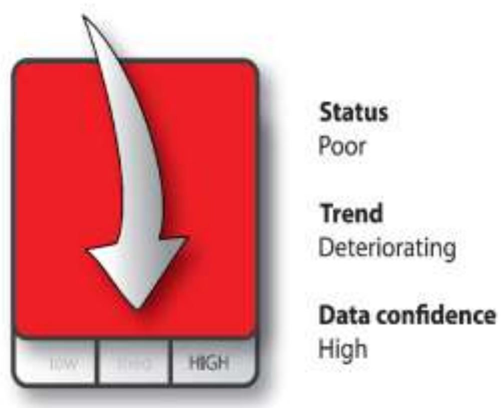
The number of EIA has slowed down over the years since the introduction of the CEPA Act, which does not have an Environment Council to deliberate on EIA and projects. This can affect project development and operations with financiers An Environment Council is to be appointed immediately to deliberate on EIA/EIS applications. In addition, capacity building, resources and revenue generation are needed to operate as an organisation which may result in ensuing effective monitoring and governance issues are addressed to achieve sustainable environment management. There is a need also for quality output and scrutiny of data and staff capacity and resources are need in order to improve EIS/EIA scrutiny before Permits are issued.

Reference

8.1.5 TOPIC/SUBTOPIC: MEA REPORTING REQUIREMENTS

Indicator Definition: Percentage (%) of MEA reporting requirements met on time.

Status and Trend



SDG/CBD Targets:

SDG: All 17 Goals

Aichi Target: All 20 goals

Status and Trend Discussion

PNG is a member State of the United Nations (UN) General Assembly, and is obliged like all other member countries, to integrate and implement internationally agreed goals and targets into its development plans and agendas. The UN proposes international agreements – both legally binding and non-legally binding documents for instance, the Sustainable Development Goals (SDGs), Convention on Biodiversity (CBD) and United Nations Framework Convention on Climate Change (UNFCCC) are fundamentally adopted to address trans-boundary or global environmental issues. These issues include movement of hazardous wastes, ozone depletion, climate change, and biodiversity conservation and management, which are interlinked or cross-cutting. Addressing them may address socio-economic and biodiversity issues such as poverty, health and sanitation, human rights, species extinction and protection, and environment management.

PNG is required to report sporadically and periodically to UN. In the last 4 years since 2015, of the 14 MEAs CEPA is administering on behalf of the government of PNG, about 6 reports have been submitted to the relevant MEAs secretariats namely CBD 5th National Report 2015, UNCCD National Report 2018, Report to UNESCO World Heritage 2015, CBD 6th National Report 2018, the Ramsar Report 2018, and the CTI Annual Report 2018. PNG does not have an MEA handbook for reporting to MEA, hence most MEAs reporting are not done on time.

Figure 3.7 shows PNG is a party to 14 MEAs and had sumbitted 6 National reports mainly pertaining to Basel Convention with 1 report in 2006, 2 CBD reports in 2010 and 2014 (the 6th National report is currently being drafted t). # reports have been submitted for Ramsar Convention in 1999, 20002 and 2018. So far, only 3 National Action Plans have been submitted for CBD for NBSAP in 2007, 2014 and for Stokholm Convention in 2013. Moreover, a total of 229 legislations are applicable for those MEAs. So far about 13 court decisions have used MEAs in their court decision and 11 contact hubs have been established with the MEA Secreteriat.

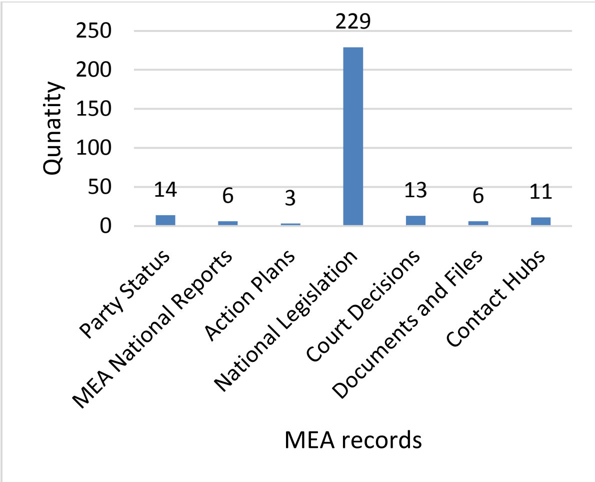
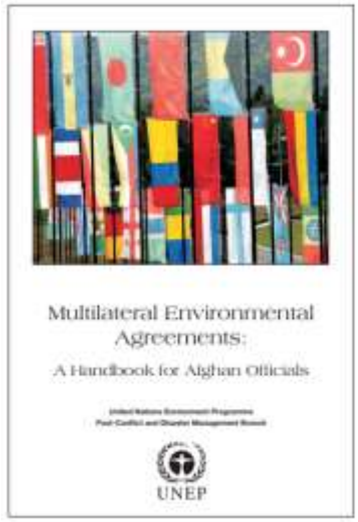


Figure 3.7: Number of records of MEA documents submitted by PNG between 2009 and 2018 (www.informea.org/countries/PG/Parties)

The 2010 UN's Summit on the Millennium Development Goals (MDG) concluded with the adoption of 8 global action plan, including 1) eradicate extreme poverty and hunger; 2) achieve universal primary education; 3) Promote gender equity and empower women; 4) reduce child mortality; 5) Improve maternal health; 6) Combat HIV/AIDS, malaria and other diseases; 7) Ensure Environment sustainability; and 8) Develop a global partnership for development (UN, 2018). Resolving those reporting issues are still far from achievement for some countries, particularly the developing nations such as PNG. For instance, the MDG 2010-2015 aims to achieve 8 milestones or targets such as eradicating poverty, achieving universal education, sustainable management of the environment, having access to universal education and clean water and sanitation by 2015.



United Nations Multilateral Environment Agreements (MEA)

Nonetheless, these targets were not achieved because more outstanding issues still persists to be achieved in developing countries for poverty and other indicators mentioned above. These issues are clearly stated by GoPNG and UNDP (2010). The challenge was to have complete achieving those targets, however lack of reliable data to measure those global indicators against the local policy indicators were lacking. In other words, not much has been conducted to meet those targets or goals.

Even though those global MDG indicators and targets were incorporated into the national development policies targets, most were fairly achieved while others were not achieved due to lack of implementation. In addition, most if not all MDGs were not captured in local plans of each provincial and district governments. Hence, achieving those targets were never achieved between 2010 and 2015.

PNG STaRS, Vision 2050 and MTDP 3 policies

Consequently, a new set of goals was adopted by the UN Congress, known as the Sustainable Development Goal (SDGs), sometimes referred to as Agenda 2030. The aim of the SDGs is to ensure by 2030 those goals must be achieved. The SDGs are comprehensive set of 17 goals, with 169 targets and 243 indicators, with a higher level of ambition than its predecessor the MDG 2010-2015. These goals are aimed at achieving "*a prosperous, high quality of life that is equitably shared and sustainable*", and biodiversity conservation and sustainable environment management is one of them. The PNG Government has added some more targets and indicators suiting PNG conditions through its national polices such as the Vision 2050, StaRS and MTDS III.

There are many MEAs managed by CEPA to be discussed but as highlighted earlier, reporting is below par. Hence the focus of this Section is to look at the Aichi Biodiversity Targets from the CBD Framework that comprised of 5 goals and 20 targets, herein referred to as Aichi Target to compare the progress f which PNG had achieved thus far. CEPA is administering the Aichi Targets on behalf of the Government of Papua New Guinea (GoPNG) while the National Planning is working on the pretext to ensure the SDGs are achieved as well. The SDGs are cross-cutting, hence CEPA is also responsible to implement these 17 global targets.

Table 1 in Appendix 1 shows the 20 different Aichi targets that must be implemented and results achieved by Vision 2050 by year 2050. Table 2 of Appendix 2 is the summary of the Development Strategic Plan 2010-2030 that provides the platform for the implementation and or achievement of the Aichi targets. Table 3 of Appendix 3 is the summary of the MTDP3 that provides the platform for the implementation and or achievement of the Aichi targets. It also shows other international convention and protocols that are also running in tandem with the implementation of the Archi Targets. There are some PNG policies and MEAs having cross cutting targets across the various Aichi Targets whereas some are general.

In almost all cases, most Aichi targets have been partially achieved in PNG. Among the partially achieved targets, good progress has been made on Targets 4, 11, 13, 16 and 19 with some promising progress on targets 2 and 14 as per DSP 2010-2030. Of the five Strategic Goals of the CBD, PNG has made good progress towards Goal A in mainstreaming, Goal C in relation to increased protection, and Goal E regarding knowledge management and capacity building (GoPNG, 2016).

The PNG government is a signatory to many international environment and conservation protocols, treaties and agreements such as convention on Biodiversity (CDB), United Nations Framework Convention on Climate Change, and Convention of International Trade on Endangered Species (CITES). It had also signed several regional treaties to regional organisations such as the South Pacific Environmental Regional Program (SPREP) pledging to support work on CBD and climate change activities in the south Pacific Region.

Though PNG is a signatory to many national, regional and international conventions and treaties or Multi-international Environment Agreements (MEAs), it is still lagging behind to achieve sound environment and natural resource management (Appendix 1-3). The following Achievement colour code applies to level of achievements and can be interpreted as: **Red: not achievable/off target; Orange: variable achievement/mixed; and Green: on target.**

Despite the government's interest in resource development, conservation and management of natural resources, it has its needs to produce or sell the country's natural resources for the much needed foreign exchanges. This is one way the government generates its income to support its budgetary and development aspirations. It seems the government has failed in its regulatory role to manage and conserve the natural environment and resources. Conservation of natural environment and the management of natural resources in many pacific island countries failed because of many challenges and issues such as; 1) resource discrepancies; 2) lack of participation by stakeholders and different challenges they are facing social; 3) complex political, social and cultural dynamics; 4) little collaboration between relevant stakeholders; 5) mismanagement of funding; inefficiency of productivity; 6) lack of sociocultural analysis;7) lack of participation by landowners; 8) lack of alternatives for local communities; 9) lack of collaboration; 10) no medium- or long-term sustainability of programs; and 11) lack of capacity development (Keppel et al. 2012).

Impact

Generally, most reports have not been done on time, or were submitted to the respective MEA Secretariats, thus making PNG country reporting poor to date. There are various reasons why the reports were not furnished on time. Staff capacity, resources, funding and collaboration with partners were major set-backs. These issues must be improved by CEPA and others so that reporting requirements are improved. In addition, though there is a Policy Coordination and Evaluation branch at CEPA that deals with all policy matters of both national and international status, must are yet to be done in a coordinated manner in order to tackle each tasks.

For instance, a coordination desk for the MEAs need to be established within CEPA. This desk is strictly responsible for all MEA reporting. In addition, those CEPA staff designated as focal point officers must be provided sufficient job description so they can report on each respective MEAs. An internal review of the progress of MEA reporting either through informal and formal discussions with some CEPA's staff indicate the following challenges or problems must be resolved amicably:

- Lack of coordination between different focal points of different reporting structures are not functioning effectively in terms of reporting;
- Some staff are incompetent or are untrained to report effectively;
- The focal points are ignorant or slack to furnish reports and submit reports on timely manner;
- The job descriptions of technical focal points are not clear and roles and responsibilities are overlapping;
- There is lack of coordination to provide leadership, oversight and update of reports;
- Capacity building is lacking;
- Information are personalised and not shared;
- The MEA reporting templates are not understood, hence officers need trainings and capacity building. Some reporting formats have changed overtime;
- Shortage of staff is hindering work on MEAs reporting. The current focal points have more work to do apart from CEPA's duty statement; and
- Poor support services and data management systems.

Response and Recommendations

Most reports are not done on time, hence reporting is poor. Hence, staff morals, incentives, capacity and training, resources, and collaboration with partners must improve in order to achieve timely reporting of the MEA targets and deadlines. In addition, a coordination desk for the MEAs must set up and the staff be given the right job description.This desk will report directly to the Department of National Planning on a coordinated basis because reporting directly by CEPA is very poort since 2009.

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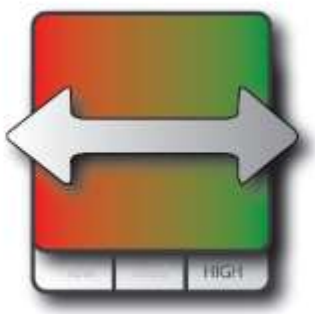
8.1.6 TOPIC/SUBTOPIC: ENVIRONMENT CASES PROSECUTED

Indicator Definition: Percentage (%) of environmental cases prosecuted in national courts.

Status and Trend



National and Supreme Court of PNG

SDG/CBD Targets

SDG: 16.5.1, 16.6.1, , 16.6.2, 16.10.1, 16.10.2, 16.b.1,

Aichi Target: 4, 5, 12, 20

Status and Trned Discussion

PNG is a very diverse country in the Western Pacific and is richly blessed with natural resources and cultures. It is a country where almost 97% of land is customarily owned by clan or clan groups with the remaining 3% owned either by the government or is privately owned. To date this figures has changed drastically as a result of the landowner and the State selling their land, with possibly traditional land is approximately more than 80%.

Most of the country's natural resources are found on land owned by traditional land owners, including the sea. Prior to the adaptation of the British law to formulate the laws that govern the country, most land, sea and resources were managed under some form of customary conservation and management systems (Cinner & Aswan 2007).

The National Constitution sets the foundation of the country's laws and legislations thus setting the premise for development and governance of the country. The country has a three-tier government system comprising of the Parliament, the Provincial Government and the Local Level Government (LLG). The Parliament is the overarching system of government that enacts laws (Acts of Parliaments) for the governance of the country at the national level, including conservation and resource management. Laws passed by the provincial government (Provincial Acts) and LLG compliments the Parliamentary system and do not supersede the Acts of Parliament.

Generally, the enacted parliamentary Acts or laws that protect the land, sea, environment, resources, people and the country enable the State through its government institutions to govern, manage and enforce these laws. The State entities are required by law to enforce any laws passed by the Parliament. Hence, the PNG Government is seen as the regulator of any development activities including, conservation and management of natural resources in the country.

However, over the last 40 years, the National Government has compromised its position as the sole regulator of development activities and enforcer of environment laws and regulations. It has now owned several resource industries such as Ok Tedi Mine and Tolokuma Mine. The National Government has also acquired shares in many major development activities, especially extractive industries.

It seems some multi-international corporations are controlling the system and often escape with little or no punishment by the laws of the country. Consequently the environment and conservation efforts are now undermined because of the loopholes in the existing laws, policies and regulations.

One of the examples of the PNG Government compromising its position is the *Ok Tedi Act* which forbids litigation of environmental issues at international courts overseas for environmental damages. Another example is the enactment of the Conservation and Environment Protection Authority (CEPA) Acts 2014 (CEPA, 2014). The CEPA Act gives the minister powers to decide on any resource development. The CEPA Act also lose focus on doing conservation work. Nonetheless, the CEPA Acts was purposely created for CEPA to collect development fees and conduct enforcement of all land, sea and resource development activities.

CEPA's capacity and resources are major set-backs in conducting its functions and responsibilities, hence, most enforcement activities are passed back to the provincial level. That is CEPA has not regional or provincial office as the PNG Forest Authority and can't effectively do enforcement and monitoring. Consequently this Act seems to affect CEPA's role and function as the environmental law enforcer and regulator of natural resource development activities and conservation efforts. The actions the government is now making are commercial decisions in nature that will most likely compromise the future of PNG.

In the 1990s and 2000s, the NGO movement was very active and several court cases were registered with both the National and Supreme courts of PNG, mainly dealing with logging and palm oil development and the impact on land and local people's livelihood. These litigation proceedings were spearhead by PNG Eco-Forestry Forum and Environment Law Center (both now defunct) and Center for Environment Law and Community Rights (CELCOR). Some cases were taken up by human rights groups such as Individual and Community Rights Advocacy Forum (ICRAF).

CELCOR is currently active and continuing its work representing landowners and litigating against multinational companies that deprived livelihood, land rights and environment for the local landowners, in mining, logging and palm oil. The first known Environment case won by a NGOs was by CELCOR. The case was in court for 8 years but in 2010, the verdict was handed down by the National Court for ther the Kiunga-Aiambak logging road forestry project in Lake Murray, Western Province.

Over K230mil was awarded to the landowners and plantiff for damages to the environment and people's livelihood. Unfortunately the company went into bankruptcy and hence did not pay the liability and damage costs. Another two successful court case was the victory in the National Court by the Collingwood Bay landowners in Oro Province in 2003 and 2014. The landowners engaged a private firm because their forest and land was illegally taken from them through some corrupt deals between the developer, the provincial forest office and PNGFA because due processes were not followed in awarding the concession areas.

PNG judges paying respect to one of their deceased colleague at the Court House in Port Moresby (Photo by PNG Court)

Another Eco-forestry project under SABL was the Turubu SABL project in East Sepik Province. In 2016, the SABL project was thrown out by the court, hence making all other SABL projects become invalid as well. In 2018 CELCOR registered another court case against an oil palm company operating in the Pomio-Baining SABL. In addition, CELCOR also brought to court a case against the world's first sea bed mining in PNG in the Bismarck Sea off the coast of New Ireland province.

There are other cases taken up by individuals against quarry, logging, mining and others which were not recorded in this report because of scarcity to access those information. When standards are not adhere to, ligation cases are taken out by landowners to courts. Moreover, several court cases previously registered with the National and Supreme Courts of PNG were either delayed or prolonged by the plaintiff, hence leading to thousands of dollars spent without success.

In the mining industry, at least 3 prominent international court cases were brought against Rio Tinto in Bougainville in AROB, Ok Tedi Mining Ltd in Western province (BHP Billiton) and Pogera Mining (Barrick Gold) Limited in Enga provinces.

The Bougainville case was against Bougainville Copper Mine's operator Rio Tinto filed by residents of Bougainville in a US Court. It was alleged that Rio Tinto was complicit in war crimes and crimes against humanity committed by the PNG army during a secessionist conflict on Bougainville; environmental impacts from Rio Tinto's Panguna mine on Bougainville harmed people's health in violation of international law; and Rio Tinto engaged in racial discrimination against its black workers at Panguna (Business and Human Rights Center, 2012). Prior to the environmental issues, landowner issues and concerns against the operations of Rio Tinto had led to a civil war that lasted for 10 years, from 1989 to 2009.

The civil lawsuit against Ok Tedi Mining Ltd was filed by landowners because BHP Biliton then failed to rectify a dam disaster burst into the river system after the structures failed, which the tailings and chemical affect local livelihood and health and the environment (Business and Human Rights Center, 2014). The National court under the presiding Judge, Justice Gibbs Salika, ordered the company to pay K19mil in damages to the plaintiff for rehabilitation of over 500km of downstream impact area. Another Court case was also lodged against BHP Billiton in an Australian Court. The matter was settled out of Court but led to the passing of a separate Ok Tedi Mine Act.

The landowners of Pogera Gold Mine sued the PNG government for $13.2 bil because of environment and social damages in breached of contract signed in 1989 by Barrick Nuigini (RNZ, 2018).

The above mines are some of the biggest mines in the world in terms of mineral production and percentages.

A typical logging road clearance in Western Province (Photo by W. Modu)

In the last 5 years, there were no litigation cases CEPA took against developers. However, there is an average of 3-4 cases per year where permit holders were issued stop notices for non-compliance. In addition, when environment permits expired, stop notices are also issued to companies, ther operations still continuing (*R. Ramil, pers. comm*).

The NGOs though CELCOR has registered some new court cases every year, however some previous court cases are still dragging on. The reason is because of lack of number of judges to preside over a case or simply caused by delay in court proceedings, process or procedures.

From discussions with some environmentalists and NGOs, it was indicated that poor governance and regulatory by the resource governing bodies such as MRA, PNGFA, DAL, NFA and CEPA, is not effective and often compromised. Some Environment Permits were not fully scrutinised and thorough studies or evaluations being made before Environment Permits are issued. Simple things such as design may go wrong (e.g. discharge iof silt into streams and seas), hence Environment Impact Statements must be critically reviewed by CEPA and terms and conditions of the Permits must be adhered to at all time by the developer to avoid prosecution and or being penalised.

Furtheremore, prior to the CEPA Act 2014 coming into effect, there were different Acts that governs the environment and operations of companies and municipality governments (i.e. Water Resource Act, Environment and Planning Act and Contaminant Act). Though those Acts had been repealed, they have given DEC staff powers to act as environment inspectors to monitor and regulate the industries, to collect Permit fees and fine those companies that breached those Acts. That is, the staff have the powers to charge offenders that contribute to changes in the water quality and environment.

However, when the Environment Act 2000 and CEPA Act 2014 came into effect, things changed profoundly because of the change in government priorities and the way CEPA does business. For instance, most of the mining and oil and gas projects in the country have government's equity in several major operations. This had compromised the effectiveness of CEPA's participation to ensure accountability and transparency are maintained during project review and monitoring. That is, under CEPA Act, companies were to provide funding allocations for all Environment Impact Assessments (EIAs) and Monitoring work studies for CEPA, who then engages independent consultants to conduct reviews and monitoring. Consequently, CEPA may compromised its position and becomes more or less a policy oriented institution, with little enforcement and regulatory function performed. Only a handful of staff within the monitoring and regulatory wing at CEPA goes to the field to monitor activities that are normally catered for by the proponent.

Since the Barnett Inquiry into forestry in 1987, most monitoring units have been to be abolished in almost all sectors. That Forestry Inquiry found most logging activities have problems with non-compliance issues and poor environment management. At some stages it seems politics have crippled the functions and responsibilities of CEPA to some extent.

Lack of knowledge and no provincial presence in individual provinces, lack of training on data collection, lack of equipment and materials and no laboratory to test data provided by the developers have all affect CEPA greatly as the government's enforcement and regulatory agency. Section 41 and 77 of the Environment Act 2000 requires all developers to provide data and information to the Managing Director or CEPA anytime, however, CEPA has to have its own personal, materials and equipment to verify those reports.

Since CEPA came into existence in 2014, only 5 damage complaints were received from complaints by CEPA. The challenge is now on CEPA to address issues and getting hard on those proponent who does not comply with their Permit conditions. CEPA is the mandated statutory authority that addresses environmental, conservation and social issues with communities. If it fails to uphold its duty, whoever complaining to the court will have CEPA held liable for issues pertaining to negligence. It is most likely the number of environmental cases will rise in the future and recorded by CEPA when companies are not transparent and complying to Permit conditions by upholding their social, environment and corporate responsibilities, more court actions will be taken by individuals and CEPA.

Impact

There are no or lack of physical visitation on the ground by CEPA except few activities covering mining and oil and gas sectors. Most mining and oil and gas companies are funding the costs for CEPA as per the Environment and CEPA Act at their own costs to visit project sites and reaffirm reports and data provided by them (the permit holder). Consequently, monitoring and enforcement or regulatory is often poor or satisfactory. CEPA most often engages independent contractors to do verification but whether this is effect or not is something that need to be investigated further. When developers meet all the monitoring and evaluation costs for CEPA, sometimes the work of CEPA can be compromised.

The enforcement and regulatory work for CEPA staff using CEPA Act is important because any developer or proponent that breaches the law or Permit Conditions can be penalised or brought to court. Funding independent assessment by environment or permit fees is a way forward. Hence, CEPA must avoid any thing that compromises its work with any developer. With lack of training, equipment and laboratory for CEPA to test and verify data, the costs for doing monitoring is most likely to rise. Thus, proper training of staff and uses of appropriate equipment are important for verification and monitoring purposes.

Corruption is a huge topic that cross cut into the fabric of many countries in the world. The former prime Minister of PNG, and current member for Moresby North-East, Honourable Mekere Mourata describe corruption as systemic and systematic. Though this topic will not be captured here, it is worthwhile mentioning it because corruption still affects many government functions unless it is weeded out. Figure 3.8 shows PNG is the 138 least corrupt nation out of 175 countries, according to the 2018 Corruption Perceptions Index from the report by Transparency International (TI). Corruption Rank in PNG averaged 140.13 from 2003 until 2018, reaching an all time high of 162 in 2007 and a record low of 102 in 2004 (Trading Economics, 2018).

In the Asia Pacific Economic Countries (APEC) which PNG is a member, PNG is rated first in corruption. This means PNG is a highly corrupt State in the way it operates in terms of discrimination, lawlessness, violence, transparency, access to basic rights and other criteria that TI has put in place. For CEPA to be transparent in its operations, it must ensure corruption is weeded out of its operations, is transparent and companies doing business in PNG must abide to existing laws.

Unless financial mechanisms, capacity, equipment and materials, and knowledge are improved, environment management and conservation would not be achieved. This will be encouraged or supported by proper planning and priority of important tasks, with more staff trained on enforcement and regulatory of operations using available resources or institutions such as involving the police and Justice and Law sector to train CEPA staff as enforcers. CEPA staff can also be seconded to other countries such as Australia and the US, including agencies such as the World Bank and Asian Development Bank to be trained on international standards and their applications. Once this is done, we can be pessimistic that this would improve CEPA's capacity to effectively monitor development activities and ensure law enforcement in the country is done effectively to achieve compliance and good governance.

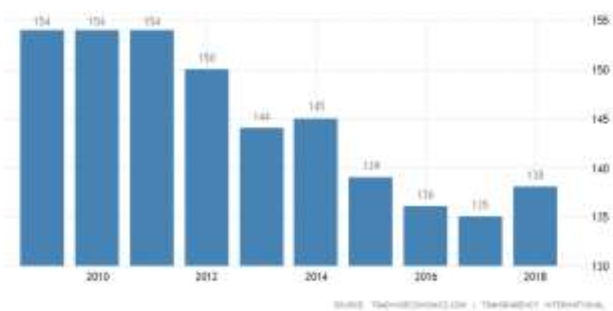


Figure 3.8: Papua New Guinea Corruption rank between 2010 and 2018 (Transparency International; in Trading Economics, 2018)

Response and Recommendations

There is a need to improve governance, monitoring and enforcement. This require training and capacity of staff, increase resources and funding, constant awareness and publicity, avoid compromise with proponents in order to achieve transparency and work in partnership with other agencies. CEPA also need to set stringent measures that companies that fail to comply face penalties.

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8.2. THEME 2: ATMOSPHERE AND CLIMATE

8.2.1 Overview

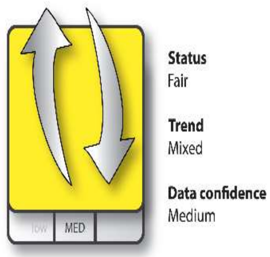
This Chapter on the state of Papua New Guinea's Atmosphere and Climate focuses on six areas: Trend in Greenhouse Gases (GHGs) emissions; Trend in Consumption of Ozone-depleting Substances (ODS); Physical Climate (air temperature, precipitation, and extreme climatic events); Climate-related Disaster Loss; and Climate Adaptation and Disaster Funding (food security, water security, health and flood risks).

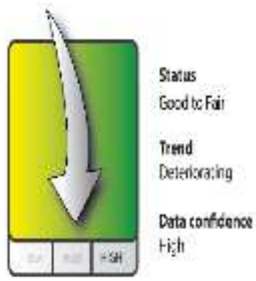
Through the greenhouse effect, the increase in the concentration of GHGs in the atmosphere has been shown to influence global climate change, which results in more intense storms and droughts, and higher sea level and temperatures. The Papua New Guinea Climate Change Policy seeks to achieve 100% renewable energy by 2050 to address GHG emission commitment. As of 2014, 49 per cent (%) of the country's energy comes from renewable sources (hydroelectricity 40% and geothermal 9%), thus it is necessary to prioritise the development of the renewable energy sector. The other energy sources come from natural gas and diesel with 14% and 37% of respectively. ODS is a major challenge for PNG to address as most of its imports does have some ODS. Chlorofluorocarbons (CFCs) were phased out in2010 and PNG is ahead of schedule in phasing out Hydrochlorofluorocarbons (HCFCs) by 2050. Currently the progress is slow given the increase in importation of air conditioning and refrigerator equipment such as in transport and building industries. Cook Islands phased out ODS over the last decade and has fully complied with the Montreal Protocol.

Climate adaptation is recognised as a priority and PNG is assessing the vulnerability to climate change effects. Rising oceanic temperature in the Pacific Ocean may lead to increase intensities in more warm days and nights. Increase droughts, short heavy rainfall, increase cyclones and other issues such as coral bleaching, diseases and food security concerns are also possible. Hence, appropriate measures must be undertaken now at the global, regional and national level by PNG and the global community in order for developing and vulnerable countries to become climate resilient.



8.2.2 ATMOPSHERE AND CLIMATE CHANGE HIGHLIGHTS

Topic	Status, Trend and data confidence	Key Findings	Response and Recommendation
Trend in Greenhouse Gas (GHG) Emissions		PNG is an insignificant contributor to the global GHG emissions annually. However, the general trend indicates that the amount of GHG emission has increased since 2000 as PNG is undergoing rapid transformation. Urban and rural greenhouse (GHG) emissions have increase over the years since 2009, due to demand for energy, and increasing population and standard of living. The demand for energy, for transport, electricity, manufacturing and construction industries and other land-uses will certainly increase Heavy dependence on fossil fuel will continue as number of cars and electricity demand increases.	There is lack of monitoring and data across all sector. Proper assessment and GHG inventory, reporting process, awareness raising and mitigation on climate change impact and adaption, mitigation measures, technology development and transfer, capacity building, education, training and awareness raising, finances and enabling environment are required.
Trend in Consumption of Ozone Depleting Substance (ODS)		PNG is not a producer but importer of ODS materials, in the form of cars, equipment, air conditioning plants and equipment. Factory production components are on the rise due to increasing demand and uses.	There are no manufacturing industries of ODS in PNG. PNG is importing and using ODS in refrigeration and air conditioning, hence importation will increase. There are no alternatives. Hence, Proper assessment, GHG inventory and reporting must be done. technology development and transfer, financing, capacity building, education training and awareness raising must take prominence.

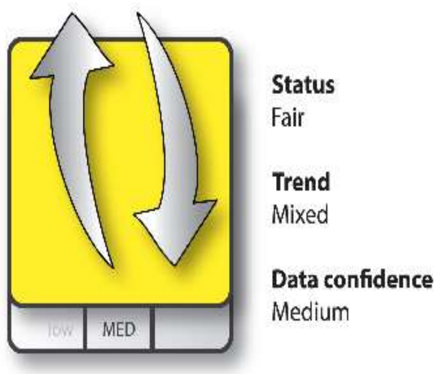
Physical Climate	 	PNG's climate is influenced by its location in the 'Pacific Warm Pool' within the Intertropical Convergence Zone (ITCZ) and to a lesser extent the South Pacific Convergence Zone (SPCZ). These oceanic zones influence the precipitation structures and trade winds in the Pacific Ocean and countries. The weather in PNG is is influenced by the West Pacific Monsoon and the El Niño-Southern Oscillation (ENSO). Over the last 60 years, maximum and minimum temperatures have increased significantly, mainly influenced by the oceanic temperature around the pacific ocean.	Proper assessment, GHG inventory and reporting must be conducted. Technology development and transfer, financing, capacity building, education training and awareness raising must take prominence that target vulnerable sectors, ecosystems and infrastructures.
Renewable Energy	 	PNG is blessed with abundant natural resources to tap into renewable energy such as wind, ocean, rivers, geothermal and solar. However, almost 70% of the population does not have access to electricity despite several years of economic growth. By 2050, almost 100% of the country will be connected with electricity. Currently, major development partners are working with the government to ensure by 2030, 70% of the country have access to electricity. At the moment, hydroelectricity provides 39.5% of energy, followed by diesel with 37.3%, natural gas with 14.1%, and geothermal with 9.1%.	The government must work with development partners to implement renewable energy projects by 2030. Proper assessment and reporting process on climate change impact and adaption, mitigation measures, technology development and transfer must be done

Climate related Disaster Loss		Climate change related disasters are increasing as the physical climatic conditions of the region is deteriorating or becoming more variable or pronounced. Instances of increasing cyclone, flood, diseases, food security and loss and death are major concern. Government funding are also lacking. Hence, PNG must plan head to face any pressing problems and challenges and get prepared and resilient to climate change impacts. This begins at the government level down to the grassroots and citizens.	Increase awareness and improve early warning systems so people must be prepared for climate related disasters and impacts. Mitigation measures and steps must be undertaken to minimize the impact and swift response and funding are required emergency. Increase funding as well for NDC to response swiftly to issues.
Climate mitigation and adaptation Funding		Increase surface temperatures has accelerated changes in global and regional climatic patterns. This may result in coastal flooding, inland flooding and landslides and new hazards such as diseases outbreak, changed agriculture practices and impact on crops, increase sea temperatures thus changing in local weather patterns and coral bleaching. Funding by the government is small compared to donor funding.	Proper planning, assessment and reporting process on climate change impact and adaption, mitigation measures, technology development and transfer must be done. Enabling environments such as technology transfer and financing, improving capacity for institutions, and ensure education, training and awareness raising are important that target vulnerable sectors, ecosystems and infrastructures.

8.2.3 TOPIC/SUB-TOPIC: TREND IN GREENHOUSE GAS (GHG) EMISSIONS

Indicator Definition: Trend of nationally determined contribution

Status and Trend



SDG/CBD Targets:

SDG: 7.1.2, 7.2.1, 7.3.1, 7.b.1, 9.4.1, 9.5.1, 12.1.1, 12.2.1, 12.4.1, 12.4.2, 12.5.1, 12.6.1, 12.a.1, 12.c.1, 13.2.1, 13.3.2, ,13.a.1,15.1.1, 15.2.1, 15.3.1, 15.5.1,

Aichi Targets: 1-5, 7, 8, 14, 17

Status and Trend Discussion

PNG contributes about 0.01% of total global GHG emissions in 2000 (GoPNG, 2000), but in recent times this value may have increased slightly over the years given the reported emissions data provided below. The GHG inventory preparation for PNG by the Climate Change and Development Authority (CCDA) was completed in 2018, after 5 years of assessment using the standardised Intergovernmental Panel on Climate Change (IPCC) process.

Table 3.2 shows total GHG emissions in 2015 for Land use, Land-Use Change and Forestry (LULUCF) was 15,193 Gg (giga gram) Carbon dioxide equivalent (CO_2 e-) compared to 13,477 Gg CO_2 e- without LULUCF. In 2000, emissions from LULUCF was -14,179 Gg CO_2 e- to 7,475Gg CO_2 e- without LULUCF. This represents an 80% increase of emissions without LULUCF from 2000 to 2015. There is some fluctuation in the national total emissions/removals due to the LULUCF sector influence on the total GHG emissions (GoPNG, 2019).

Table 3.2: Total emissions and removals by gas (GoPNG, 2018)

GHG Source	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Energy	6274	6536	6342	6631	6603	6826	6984	6185	6385	6367	5701	5837	5929	6296	7507	11806
IPPU	1	1	1	2	3	3	3	3	3	3	3	3	3	2	2	2
Agricult-ure	682	681	676	698	764	695	725	733	744	796	788	769	791	812	787	796
LULUCF	-1654	-21508	-13064	-13682	-10583	-18015	-12538	-9984	-8515	-4633	-255	2117	-2398	3898	817	1716
Waste	518	539	560	586	609	630	653	676	701	724	748	772	798	822	847	872
Total with LULUCF	-4179	-13751	-5485	-5766	-2604	-9862	-4173	-2386	-686	-3256	6984	9499	5124	11830	9961	15193
Total without LULUCF	7475	7757	7579	7916	7979	8154	8365	7598	7833	7890	7239	7382	7521	7932	9143	13477

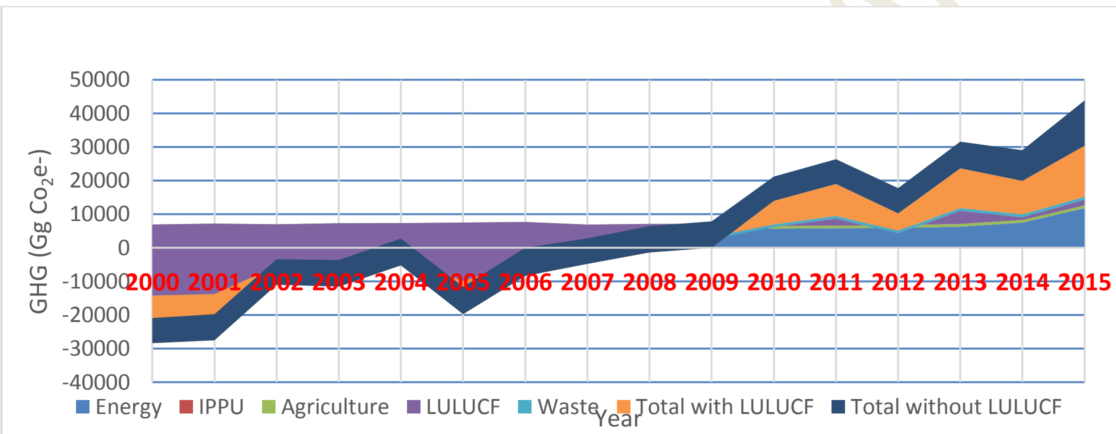


Figure 3.9: Time series of GHG emissions and removals (GoPNG, 2018)

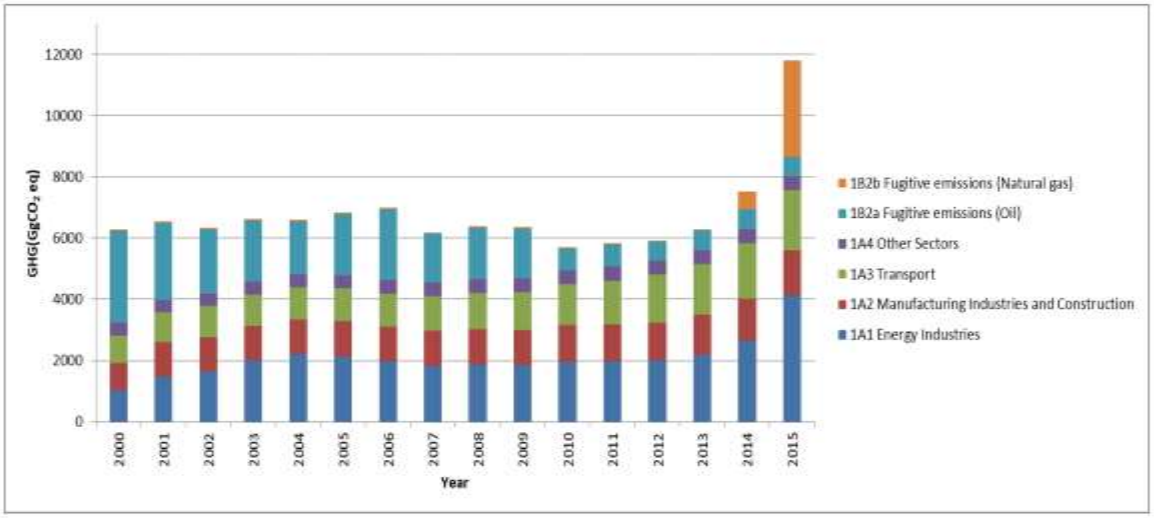


Figure 3.10: Emissions from the energy sector by catergories between 2000-2015 (GoPNG, 2018)

In addition, in 2000, the non LULUCF sectors, namely the energy sector contributed the largest to the total GHG emission with 83.9%, followed by the agriculture sector with 9.1%, the waste sector with 6.9 %, and the Industrial Processes and Other Product Use (IPPU) with 0.01 %. In 2015, the energy sector increases its contribution to the total GHG emission with 87.5%, followed by the waste sector with 6.5 %, agriculture with 5.9 % and (IPPU) with 0.2 %. Hence both Figure 3.9 and Table 3.2 indicate the energy consumption and production of natural gas has increased rapidly from 2000 to 2015, resulting in an 88.2% increase of the energy sector emissions (GoPNG, 2018). That is, over time, the emissions from the energy sector increased from 5,532.37Gg CO_2e- in 2000 to 11,806.28 Gg CO_2 e- in 2015.

Figure 3.10 also shows that within the energy sector, the industries contributed 35% to the total sector's emissions in 2015, followed by fugitive emissions from natural gas with 27 %, and transport with 17 % (GoPNG, 2018). Emissions from fossil fuel and LPG account for 80% of emissions of CO_2. In terms of gas emissions, Figure 3.11 shows 68% of emissions comes from CO_2, followed by CH_4 with 31% and N_2O with 0.04% (GoPNG, 2018). In contrast, Figure 3.12 shows the annual global anthropogenic emissions by gas from 1970-2010 rose from 27Gt to 49Gt. CO_2, fossil fuel and industrial processes contribute the largest share of gases with 55% in 1970 that increased to 65% in 2010. Emissions from CH_4 and CO_2 FOLU declined from 18% in 1970 to 16% in 2010 and from 17% in 1970 to 11% in 2010 respectively. N_2O emissions also declined from 7.9% in 1970 to 6.2% in 2010 while F-gases rose from 0.44% in 1970 to 2% in 2010. These trend shows that there is increase in carbon dioxide and methane emissions while there is a degree in other emissions.

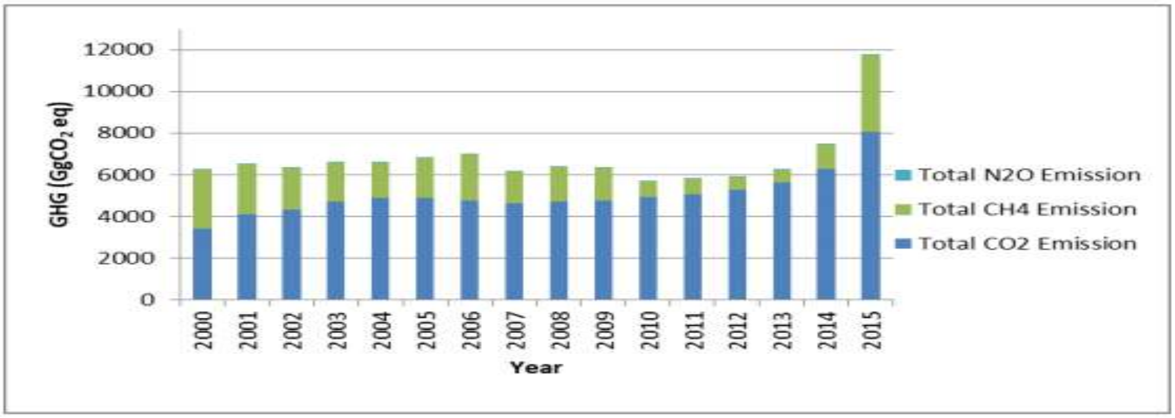


Figure 3.11: GHG emission from the energy sector by gas between 2000 and 2015 (GoPNG, 2018)

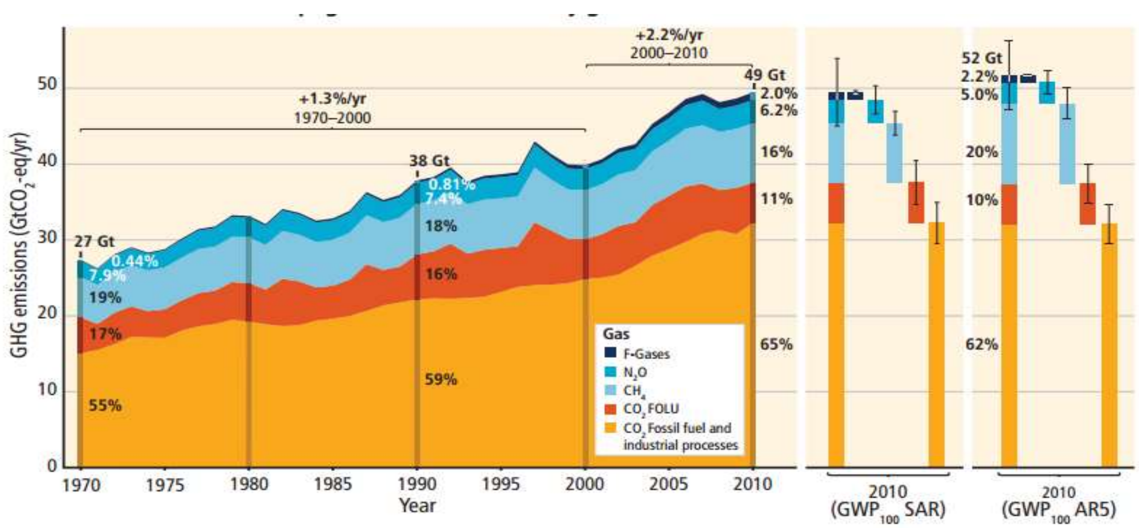


Figure 8.12: Total annual 1970-2010 antropogenic gas emissions by gases (IPPC, 2015)

The global trend is more similar to that experienced in PNG but at a lower emission rate. There was an increase in the energy industry because of increase in the use of electricity. The same occurred in the transport sector and the trend is increase profoundly, but the fugitive emissions from gas decline in the oil sector, in contrast to rise in the gas sector with the production coming from the PNG LNG gas project (GoPNG, 2018).

The total energy supply for PNG is estimated at 1800 kilotion of oil equivalent: 78% oil, 18% gas and 4% other fuels (GoPNG, 2014). PNG is a net energy exporting country yet 70% of PNG's population have no electricity. The total energy installation in 2010 was 582MW with hydroelectric producing 39.5% electricity, diesel 37.3%, gas 14.1% and geothermal 9.8% (GoPNG, 2014).

There is constant emissions from other sectors as well namely the manufacturing and the construction industries where 1.38 Gg CO_2 e-was emitted in 2000 compared to 35.29Gg CO_2 e- in 2015 (GoPNG, 2018). In addition, 58% of the

GHG session comes from medical use of N_2O and 42% comes from lubricant use. The agriculture sector emits 682 Gg CO_2 e- in 2000 to 796 Gg CO_2e- in 2015. The most significant change was in the Land Use Land Use Change in Forestry (LULUCF) sector which produced the highest removal and emissions, hence become a sink over time as forest land clearance decreases. The net removals is 21635.94 Gg CO_2 in 2000 to 1716.46 Gg CO_2 in 2015. The waste sector also sees an increase in GHG emissions from 354 Gg CO_2 in 2000 to 872.5Gg CO_2 in 2015 (GoPNG, 2018).

The lack of data and analysis from different sectors may hampers PNG's emission estimates. There are relatively good data for oil and gas and electricity generation and transport, however the consumption data may be lacking. Lack of country specific emission factors is also a problem because currently PNG is using the IPCC values and processes. The second National communication report (GoPNG, 2014) and the biennial Update report (GoPNG 2018) provides detailed activities and recommendations to address those issues. The National REDD+ Strategy (GoPNG, 2016) also provides ideal pathway to address deforestation and forest degradation as well.

Impact

PNG is an insignificant contributor to the global GHG emissions annually. However, the general trend indicates that the amount of GHG emission has increased between 2000 and 2015. It is most likely to increase over the next 10 years because of PNG is undergoing rapid transformation from the traditional subsistence economy to a market driven and industrial economy. PNG's energy demand is also increasing as the population and standard of living improves. The demand for energy, for transport, electricity, manufacturing and construction industries and other land-uses will certainly increase substantially, hence leading to more GHG emissions. Heavy dependence on fossil fuel will continue as number of cars and electricity demand increases. Since PNG is at the forefront of addressing climate change through REDD+, increase in GHG emissions would be of concern because it might affect PNG from benefit from any opportunities to invest in environmental friendly, sustainable development and carbon free initiatives the parties to the UNFCCC are embarking on.

Response and Recomemndations

There is lack of monitoring and data collection across all sectors. Hence more data collection is needed. Proper assessment and GHG inventory, reporting process, climate change impact and adaption, mitigation measures, technology development and transfer, capacity building, education, training and awareness raising, finances and enabling environment are required. Promotion of low carbon growth economy, do REDD+ are way forward to build toward carbon neutral by 2050 as stated in Vision 2050 (GoPNG, 2009).

The contribution by various development partner agencies and government to develop green energy such as hydropower and biofuel need to be promoted in order to address reduction of GHG emissions and to ensure 70% of the country has access to electricity (GoPNG, 2010).

Moreover, there is a need to have PNG determined environmental standards and to systematically monitor pollution. Determining sources of pollution in major growth centres, large village communities and within the natural environment from all sources is needed. This will require a broadening of technical training within PNG universities to support future pollution research, standards, monitoring and compliance that are put in place.

Using the example of airborne pollution in the major urban towns and cities like the nation's capital Port Moresby, air pollution is noticeable as a haze that is a combination of dust, vehicular exhaust, the burning of fuel wood, hard rubbish and plastic. Therefore determining a monitoring protocol on the chemical and particle composition of this air pollution would inform future pollution control measures in this city and other population growth centres across the country.

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8.2.4 TOPIC/SUBTOPIC: TREND IN CONSUMPTION OF OZONE-DEPLETING SUBSTANCEs (ODS)

Indicator Definition: Trend in consumption of ozone depleting substance (ODS)

Status and Trend

SDG/CBD Targets:

SDG: 9.2.1, 9.4.1, 9.5.1, 9.b.1, 11.1.1,11.2.1, 9.4.1, 9.b.1, 11.3.1, 11.6.111.7.1, 12.1.1, 12.4.1, 12.6.1, ,12.8.1, 12.a.1, 12.c.1, 13.2.1, 13.3.213.a.1

Archi Target: 2, 10

Status and Trend Discussion

Chloroflorocarbon (CFC) substances were recognised in the 1987 Montreal Protocol (implemented in 1989), as substances that deplete the ozone layer, hence called ozone depleting substance (ODS).

ODS are chemical substances once emitted react with the atmosphere to destroy the ozone layer, a critical filter layer that absorbs most of the sun's ultraviolet radiation. ODS substances are widely used in refrigerators, air-conditioners, fire extinguishers, in dry cleaning, as solvents for cleaning, electronic equipment and as agricultural fumigants (SPREP, 2016).

The target for eliminating production and consumption of ODS, minimising the negative effects and reversing the damage to the ozone layer for a range of ozone depleting substances (ODSs) was 2010, particularly the choloflorocarbons (CFCs), and hydroloroflorocarbon (HCFC) (UNDP, 2009). Though the target was not reached and challenges remain, the Montreal Protocol has been recognized as a global success, demonstrated by the massive reductions in ODS use worldwide. By its 20th anniversary in September 2007, the Montreal Protocol had succeeded in facilitating the sustainable phase-out of over 95 percent of the ozone depleting substances (UNDP, 2009). Parties to the Protocol, including PNG are encouraged to promote the development and the availability of alternatives to HCFCs that minimize environmental impacts, in different sectors, mainly foam, refrigeration and air conditioning.

Table 3.3: GWP and ODP of the most commonly used ODS (compared to CO_2)

Substance	Global Warming Potential (GWP) 100 years	Ozone Depleting Potential (ODP)
CO_2	1	0
CFC-11	4750	1
CFC-12	10900	1
HCFC-22	1810	0.055
HCFC-141	725	0.11
HCFC-142	2310	0.065

Table 3.3 shows CFCs are powerful greenhouse gases where their Global Warming Potential (GWP) is 4,000-10,000 times greater than for CO_2. Over the years, CFCs were substituted with HCFCs. HCFCs have contributed significantly to lowering ozone depletion and GWP. With the dramatic increase in the production and consumption of HCFCs over the past two decades, the threat from these chemicals to the ozone layer and climate change has become more imminent. HCFCs were due to be phased out in developed and developing countries by 2030 and 2040, respectively.

For developing countries like PNG, by 2015 the target was to reduce HCFCs by 10%. There is no reliable data to verify this target, however, a study by Wilmot (2015) shows increase use of alternative ODS for air conditioners account for 14-16 metric tonnes, followed by refrigerators with 6-13 metric tonnes and others that are neutral with 5-7 metric tonnes. Apparently, there is still a considerable volume of air-condition imports that use ODS. R-22, a potent ODS, represents a share of 47% of all refrigerant imports. However, the striven regulation of ODS will lead to a shift to alternatives, which are likely to be HFC based.

In terms of refrigeration, products using natural refrigerants such as R600a are available, yet cheap equipment that uses HFC134a still constitutes a large share of imports.

To meet the Montreal Protocol obligations, HCFC consumptions in the Pacific need to be frozen in 2013, and then reduced to 90 per cent of the average consumption in 2009–2010 by 2015, to 65 per cent of consumption by 2020, and to 32.5 per cent of consumption by 2025 (SPREP, 2016).

The target set by the Protocol for 2020 is 35% and by 2025 is 67.5%. The complete phase out deadline is 2030, but 2.5% is allowed for developing countries to work toward full out phased between 2030-2040 (UNDP, 2009).

All Pacific island countries have successfully phased out the use of CFCs, and currently face the challenge of completely phasing-out consumption of HCFCs, which are the main ODSs used in the Pacific region primarily as a refrigerant in refrigeration and air-conditioning servicing.

A survey conducted by CEPA in 2014 found that there are no use of ODS alternatives in the local foam manufacturing nor is there any in the solvent sector. There are also no manufacturers of aerosol nor was any solvent use were identified during that survey. This is good for PNG, however, foam manufacturing does exist. Companies have never use ODS but instead use Methyl chloride and water in foam blowing processes to manufacture cushions, pillows and mattresses. The main sectors of ODS concern relate to air-conditioning and refrigeration, including mobile air-conditioning such as in the transport sector were prominent (Wilmot, 2014). In the local foam manufacturing there is no use of ODS alternatives nor is there any solvent sector.

ODS that comes with cars, equipment, air conditioning plants and equipment, and factory production components are on the rise due to increasing need and uses.

Figure 3.13. shows the different ODS alternative used by the sector in AC (HCF, Ref (HCF) and Ref (Natural)

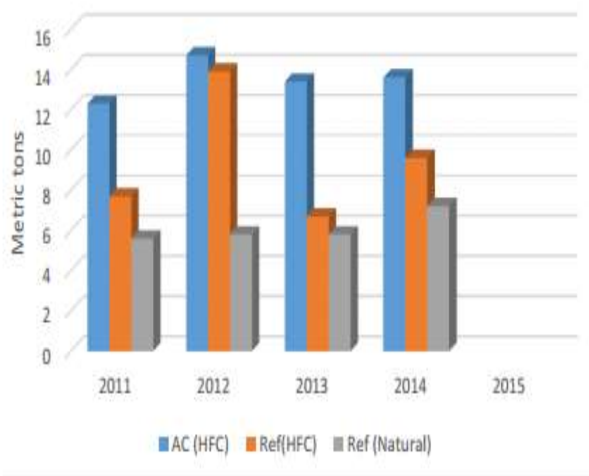

Figure 3.13: Use of ODS alternative by sector (Wilmot, 2015)

The main sectors using ODS are air-conditioning and refrigeration sectors, including mobile air-conditioning. Imports of refrigeration and air-conditioning (RAC) equipment over the period of 2011 to 2016 involved 500 companies and organizations. According to the PNG Customs records, approx. 25,000 air-conditioning units have been imported in 2015 (Wilmot, 2015). The number of small cars, vans and large vehicles imported between 2011 and 2015 also increased and decreased periodically from 41,159 and 45,609 at 2%/year, instigated by variation in custom duties. Between 10,000-15000 units of domestic refrigeration equipment is imported into the country annually.

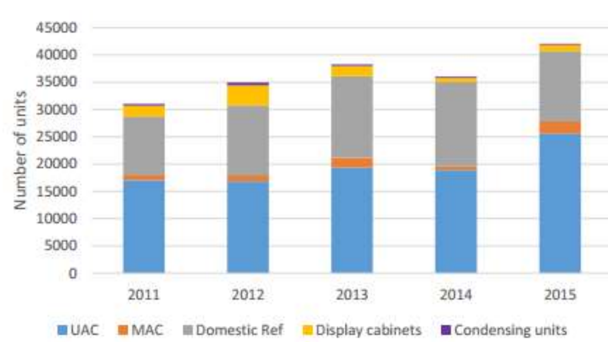

Figure 3.14: Import of refregeration and airconditioning equipment (Wilmot, 2015)

Figure 3.14 shows the importation of refrigerator and air-conditioning (RAC) increase substantially between 2011 and 2015. The estimated annual import of RAC equipment is approx. 40,000 units in 2015 compared to 30,000 in 2011, growing at a 5% growth rate over 5 years. The use of alternative ODS has also increase in tonnage between 2011 and 2014. This growth is predominate by domestic refrigeration need followed by the unitary air-condition, the dominant product imported.

Figure 3.15 shows the refrigerant HCFC 22 is highest with 47%, followed by HCF134 with 26%, R404A with 12% and R410A with 11%. Figure 3.16 shows the growth of air conditioning equipment is predicted to increase rapidly between 2015 and 2030 compared to refrigerators, probably because of the building boom, increase importation of cars and uses of air conditions by users. Figure 3.17 shows air-condition importation is rising and hnec is projected to do so into the future, and more significantly, the use of Alternative HCF.

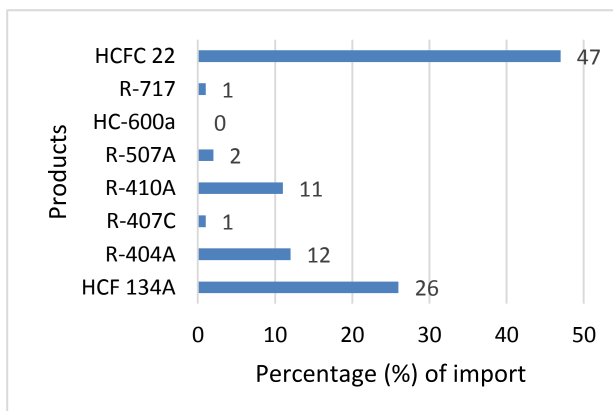

Figure 3.15: Percentage of refregerant use in 2015 (Wilmot, 2015)

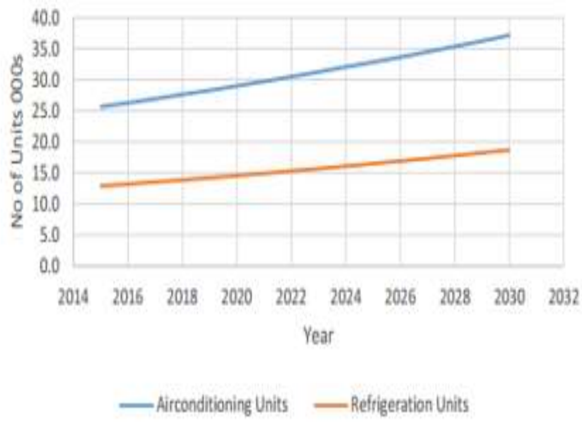

Figure 3.16: Predicted growth of imports of RAC between 2015 and 2030 (Wilmot, 2019)

Though PNG is not manufacturing CFCs and HCFCs in the country, its growth in usages of ODS will continue as expected as PNG undergoes rapid development and change in its living condition and lifestyle. However, lack of data and its availability will hamper the progress toward addressing ODS mitigation and targets.

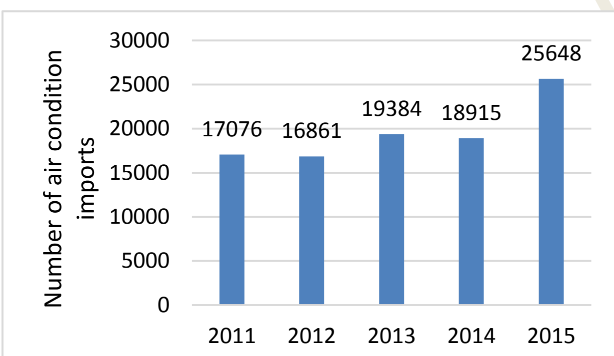

Figure 3.17: Number of air condition imports between 2011 and 2015 (Wilmot, 2015)

Impact

The increase in PNG's import of ODS products is rising steadfastly and will continue to do so into the future. The building boom and increasing in demand for air-condition and refrigeration will rise. Unless PNG is not taking drastic measures to address the targeted deadlines of the Montreal Protocol, ODS targets will not be met. There is no systematic monitoring of air pollution in urban growth centres and no vehicle emission standards set.

ODS are harmful to the ozone layer and HCFs are very potent. Phasing out ODS will benefit PNG's climate change mitigation plans. As a signatory to the Montreal Protocol, there is potential to get penalised if PNG trades illegal ODS.

Since no manufacturers are using ODS in refrigeration and air conditioning in PNG, importation is likely to increase. Hence shift to alternatives is required. Proper assessment, GHG inventory and reporting must be done. Technology development and transfer, financing, capacity building, education training and awareness raising must take prominence. A predicted annual growth of between 2.5-5% in RAC imports may occur since projections of the future are based on an increase of 2.5% annual growth.

CEPA must be strict in issuing environment permits, monitoring importation and ensure enforcement is carried out. Under the Environment Act 2000, it is requires that all importers of HFCs and RAC equipment must obtain Environment Permits. This is a way the government is looking at controlling the imports of ODS substance, and the eventual banning of certain types of RAC equipment. The onus is on individual importers to report to CEPA, the agency responsible for the Protocol. Agencies such as PNG Customs Services must also work closely with CEPA to enforce and regulate the sector.

Reponse and Recommendations

In order to initiate a shift from current business as usual practices of importing either HCFC or HFC equipment, the government of PNG will have to implement specific measures to enforce a change in the market structure. For instance, enact or adopt legislations to stop the import of ODS based RAC so PNG does not become a dumping ground for HCFCs.

Ensure communication of the importance of ozone layer protection and linkages with climate change impacts to industries and importers. Customer awareness of the effects of ODS and high-GWP refrigerants is necessary in order to raise interest in alternative solutions. At the same time, these solutions must be advertised accordingly.

Enforcement of licensing systems for the import and control of ODSs are needed; and ongoing capacity development of National Ozone Offices, refrigeration servicing technicians, local stakeholders and customs and enforcement officers to support the phase out of HCFCs. Finally, do analysis of the possibility to introduce fiscal incentive for importers that could encourage the import of non HFC equipment and increase the competitiveness of the price of HFC equipment on the market.

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8.2.5 TOPIC/SUBTOPIC: PHYSICAL CLIMATE

Indicator Definition: The local weather pattern of the area or a place over time

Status and Trend

SDG/CBD Targets

SDG: 13.1.1, 13.1.2, 13.1.3, 13.2.1, 13.3.1, 13.3.2, 13.a.1, 13.b.1

Aichi Target: 15, 19

Trend and Status Discussion

Intertropical Convergence Zone (ITCZ) and to a lesser extent the South Pacific Convergence Zone (SPCZ)

PNG is situated in the tropics and its weather can be described tropical and in general as hot and wet all year round. Its climate is influenced by its location in the Pacific Warm Pool, between the equator and Tropic of Capricorn. This 'warm pool' lies within the Intertropical Convergence Zone (ITCZ) and to a lesser extent the South Pacific Convergence Zone (SPCZ), the most prominent precipitation structures in the Pacific Ocean. The ITCZ and SPCZ are low-pressure zones where trade winds converge and considerable precipitation occurs because of excess solar heating and strong convection (Hou et al. 2016). Hence, the weather in PNG is also is influenced by the West Pacific Monsoon and the El Niño-Southern Oscillation (ENSO).

Figure 8.18 is the time series precipitation anomalies from 1998 to 2014. Figure 8.17a and 8.17b indicates the first two statistical seasonal modes that are significant and distinguishable, and contribute to 20.8% and 7.4% of the total variance respectively, indicating dominant seasonal variabilities in precipitation exist (Hou et al., 2016). Figure 3.18 also shows seasonal variability of precipitation in the Pacific Ocean characterized by the first two empirical orthogonal function (EOF) modes: (a,b) are the spatial patterns of EOF modes (Unit: mm/h); (c,d) are the time series of normalized principal components (PC).

Figure 3.18a shows the spatial variation pattern of precipittion in summer and winter where the most notable spatial feature is the approximately symmetrical but opposite variation structure north and south of the latitude 5N and within 5-20N. For instance, during the summer, rainfall increases in the ITCZ and tropical offshore regions, such as the South China Sea, Philippine Sea, and the seas west of Mexico and Colombia, but decreases within 20 S–5N, especially in the SPCZ region and the eastern equatorial Pacific between 5S and 5N (Hou et al., 2016).

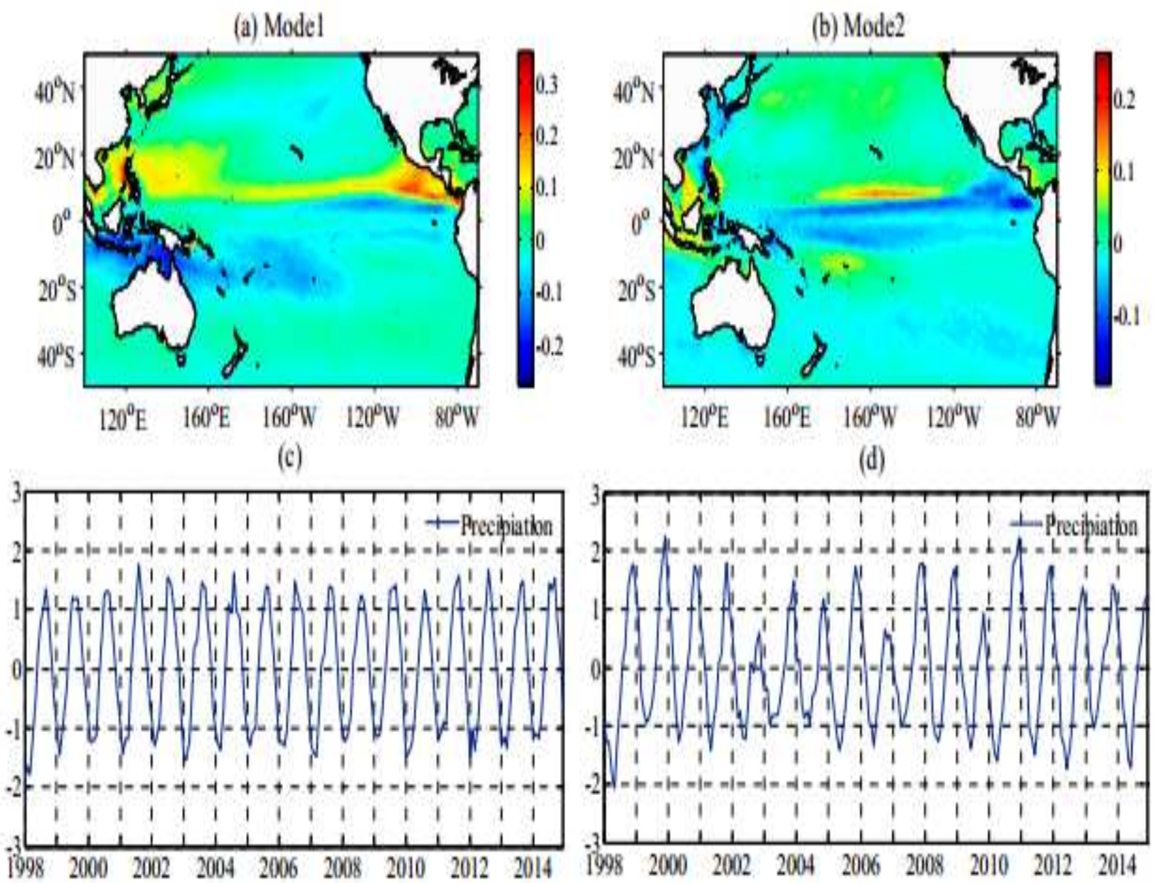

Figure 3.18: Time series seasonal variability of precipitation in the Pacific Ocean characterized by the first two empirical orthogonal function (EOF) modes: (a,b) are the spatial patterns of EOF modes (Unit: mm/hr); (c,d) are the time series of normalized principal components (PC) (Hou et al. 2016).

Hou et al. (2016) iterates for the midlatitudes of 20–50N, precipitation increases along the western offshore region but decreases in the northeastern Pacific during summer, and the contrast occurs during winter. In the midlatitudes of the South Pacific Ocean, precipitation is different and increases less significantly during austral winter but decreases in austral summer (Hou et al., 2016).

Moreover, Figure 3.18b presents the spatial variation pattern of precipitation in the spring and autumn. During autumn, the ITCZ shrinks during autumn thus initiating a widespread decrease in precipitation in the equatorial Pacific, whereas it increases in the SPCZ and over the Maritime Continent (Hou et al., 2016). During spring, a double ITCZ forms, 5N and 5S of the equator respectively. Consequently, Hou et al. (2016) iterates this creates a narrow high pressure zone that reduced precipitation forms between these two convergence zones. In addition, in the mid latitudes of the Northern Hemisphere, conditions become dry on the eastern coast of China and wet across most of the North Pacific Ocean during autumn. For the mid latitudes of the South Pacific Ocean, precipitation increases in austral autumn but decreases in austral spring. Thus, most ENSO events tend to reach their peaks at the end of the year.

In term of temporal variation, the PC of the first mode shown in Figure 3.18c indicates seasonal variation of precipitation peaks in June–August (summer) and troughs in December–February (winter), whereas the PC of the second mode shown in Figure 3.18d exhibits variation with peaks in September–November (autumn) and troughs in March–May (spring).

The combination of the PCs for the two modes thus describes a consecutive annual cycle of variation in precipitation over the Pacific Ocean (Hou et al. 2016). As a result, positive precipitation anomaly dominates the ITCZ and SPCZ regions in the equatorial Pacific, while the negative anomaly mainly occupies the Maritime Continent region and southeast of the Solomon Islands. This is when cyclones build up and head towards PNG and Australia (Hou et al., 2016).

Figure 3.19 illustrates the average position of the major climate features in November to April for the Pacific Ocean. It is a scenario model simulation of the effect in the Pacific Ocean developed by CSIRO Asutralia. It shows the trade winds and resultant westward ocean currents push warm equatorial water into the western tropical Pacific, maintaining a warm volume of water ('Warm Pool') with surface temperatures nearing 30°C (Howe et al. 2018). The near surface winds with the blue colour represents the bands of rainfall convergence zones, the dash oval is the Western Pacific Warm Pool, and H represents the typical position of the wind (GoPNG, 2014).

Figure 3.20 also shows another model of the annual SST the wider Pacific Ocean experienced where a rapid shift to warmer sea temperatures in the mid-1970s occurred, warming by 0.288°C between 1950-2009 due to both natural (e.g., IPO) and anthropogenic climate forcing. In the western South Pacific, such as PNG, the temperatures have increased by 0.456°C between 1950-2009 (Hoegh-Guldberg et al., 2014; cited in Howe et al. 2018).

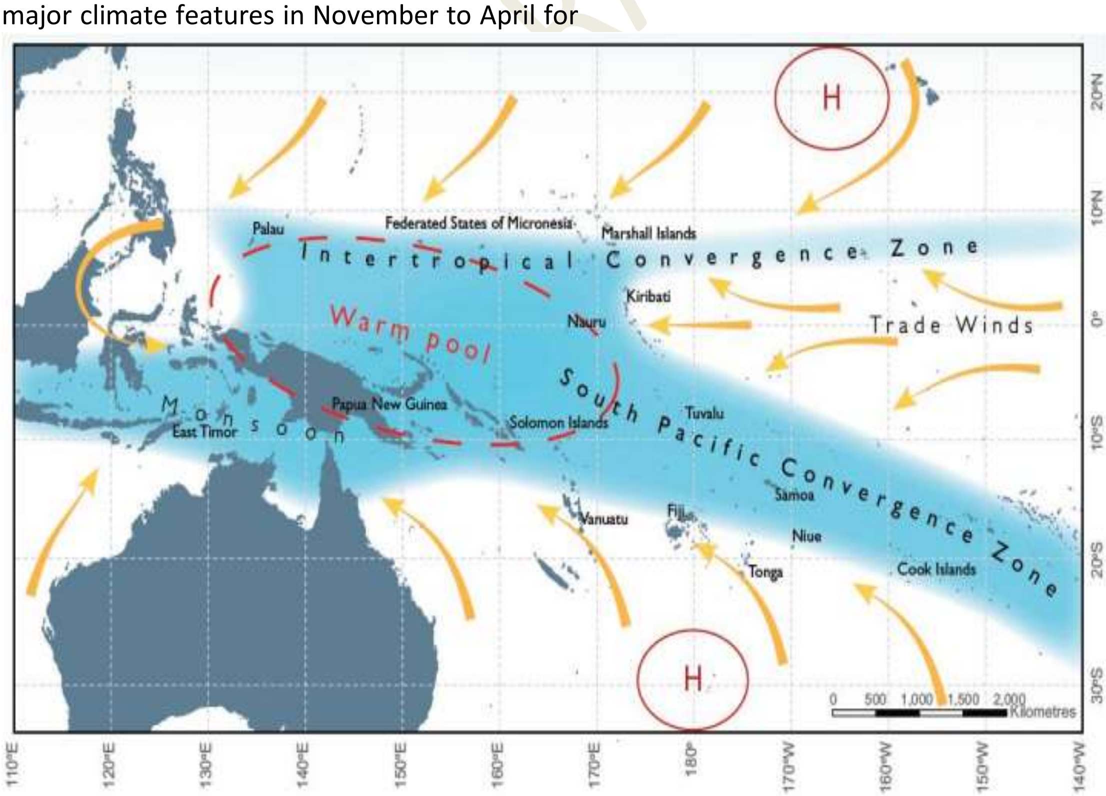

Figure 3.19: The average position of the major climate features in November to April (CSIRO 2011, cited in GoPNG, 2014; Howes et al. 2018)

Figure 3.21 is the global average land and ocean surface temperature anomalies and the globally averaged sea level change, indicating surface temperature and sea level are rising almost exponentially. These are likely causing rise in surface temperature in the Pacific Ocean that affects the weather patterns in the region or the melting of icecaps that leads to more rising sea. Annual and global average combined land and ocean temperature anomalies relative to the average over the period 1986 to 2005. Colours indicate different data sets. (b) Annually and globally averaged sea level change relative to the average over the period 1986 to 2005 in the longest-running dataset. Colours indicate different data sets.

Basically, when the ITCZ is repositioned to the south of PNG between May and October, south easterly winds or trade winds are experienced blowing over the Coral Sea. During this period heavy rainfall occurs in areas conducive to orographic influences such as the highlands and the windward slopes of areas exposed to the south-east, including New Britain, the southern face of the central cordillera and the southern face of the Huon Peninsula (McAlpine, 1983). Otherwise there is generally less and irregular rainfall elsewhere. The brief periods between the two seasons, during late October and November and during late April and May, are known as the doldrums and characterised by weaker multi-directional winds (SPREP, 2007).

The sea surface temperatures (SSTs) in the South Pacific are strongly influenced by the position of the ITCZ which is affected by large scale climatic drivers. Howe et al. (2018) iterates that much of the year-on-year variability is driven by the ENSO, whilst longer term (decadal) variability is governed by the Interdecadal Pacific Oscillation (IPO). Although SST decreases with distance from the equator, there are still significant regional variations in SST.

Figure 3.22 depicts the rising global temperature and CO2 level since the industrial revolution of the 1900s. Global average combined land and ocean temperature and sea levelk change from 1850 to 2010 has been rising remarkable. This could mean the pacific, including could become more vulnerable to climate change effect, especially rainfall, temperature and wind patterns will be altered.

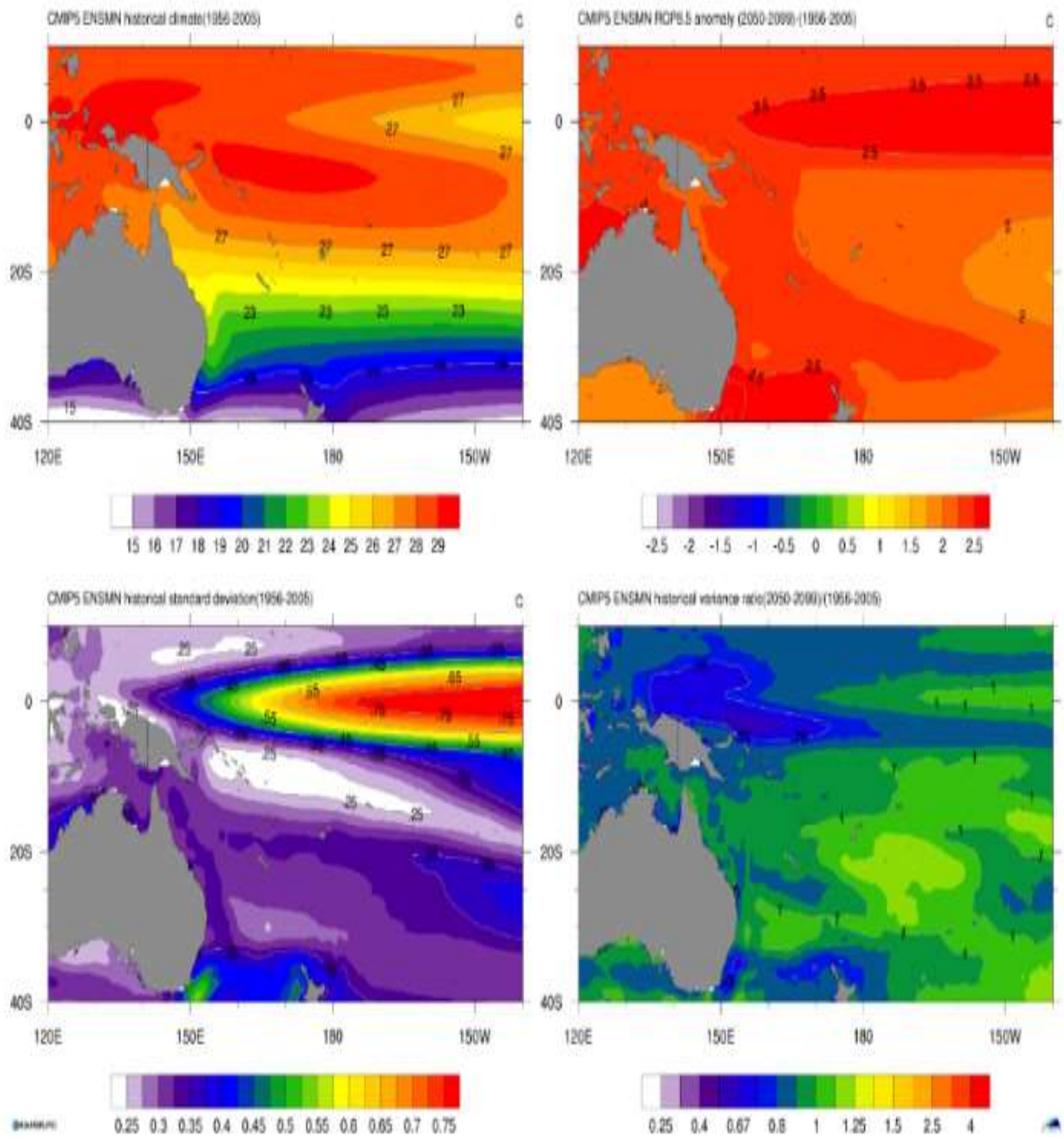

Figure 3.20: Annual sea surface temperature under a high emissions scenario RCP8.5, modelled using the CMIP5 model. Left panels: the CMIP5 representation of historical conditions (1956-2005 –upper panel: mean lower panel: standard deviation [de-trended]). Right panels: the comparison between the historical period and the subsequent 5 decades (2006-2100 – upper panel: different in the mean; lower panel: ratio of the de-trended variance). (Howes et al., 2018)

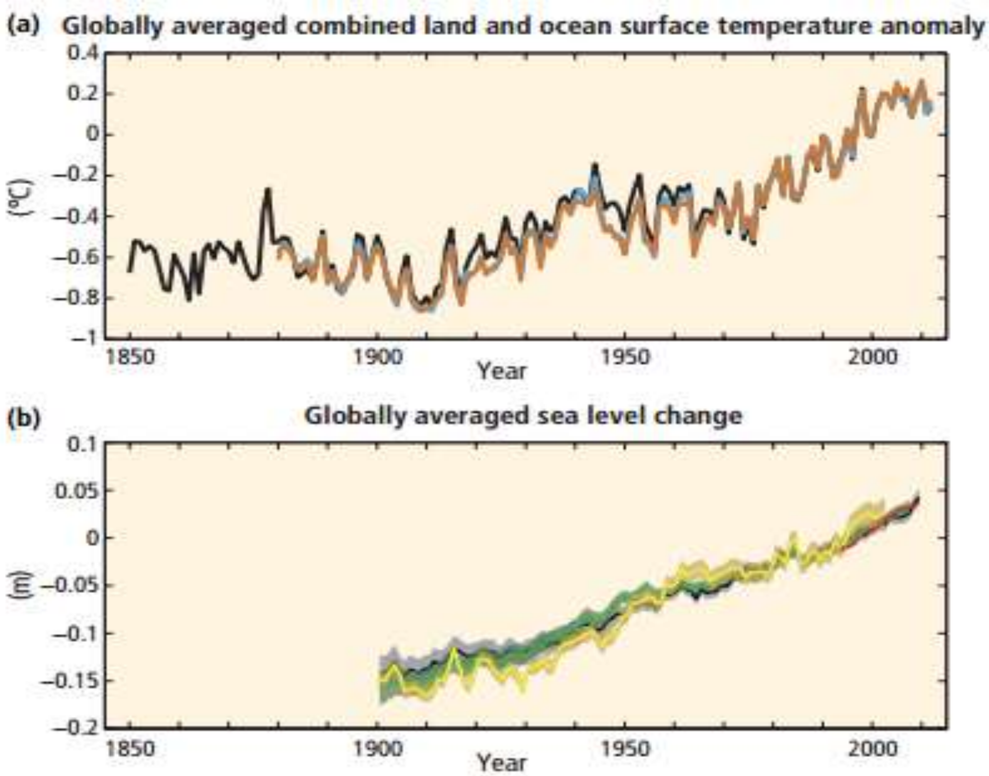

Figure 3.21. Global average combined land and ocean temperature and sea levelk change from 1850 to 2010 (IPCC, 2015).

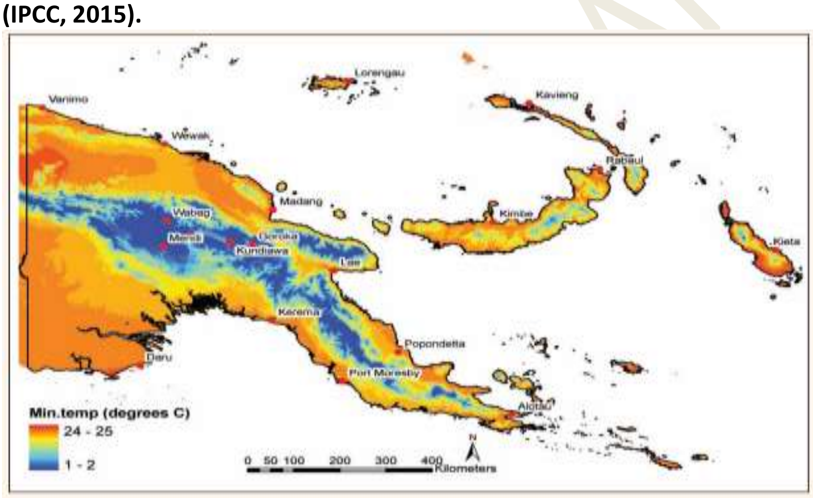

Figure 3.22: Minimum temperature thoughout PNG (Bryan and Sherman 2008)

Rainfall and temperature

Figure 3.22 and 3.23 shows the maximum and minimum temperature distribution across the country whole country over 38 years. The maximum temperature is found in the coastal low altitude regions with 33-34°C while in the highlands or higher altitude regions the maximum temperature is between 5-6 °C. On the contrary, the minimum temperature is 24-25 °C in coastal low altitude regions with highlands or high altitude areas with 1-2 °C.

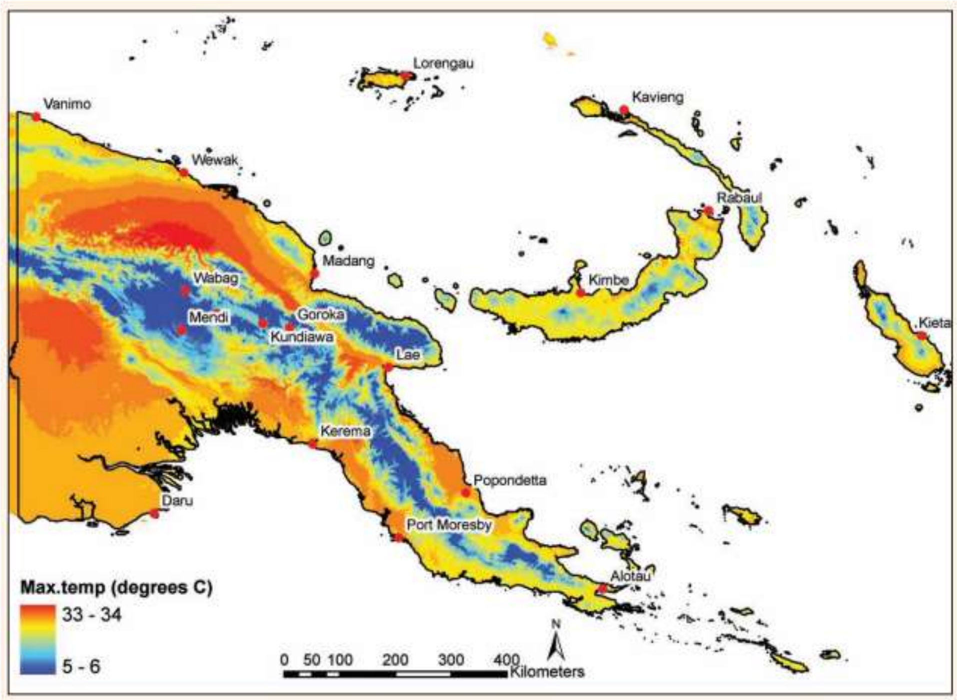

Figure 3.23. Maximum temperature for PNG (Bryan and Sheraman, 2008)

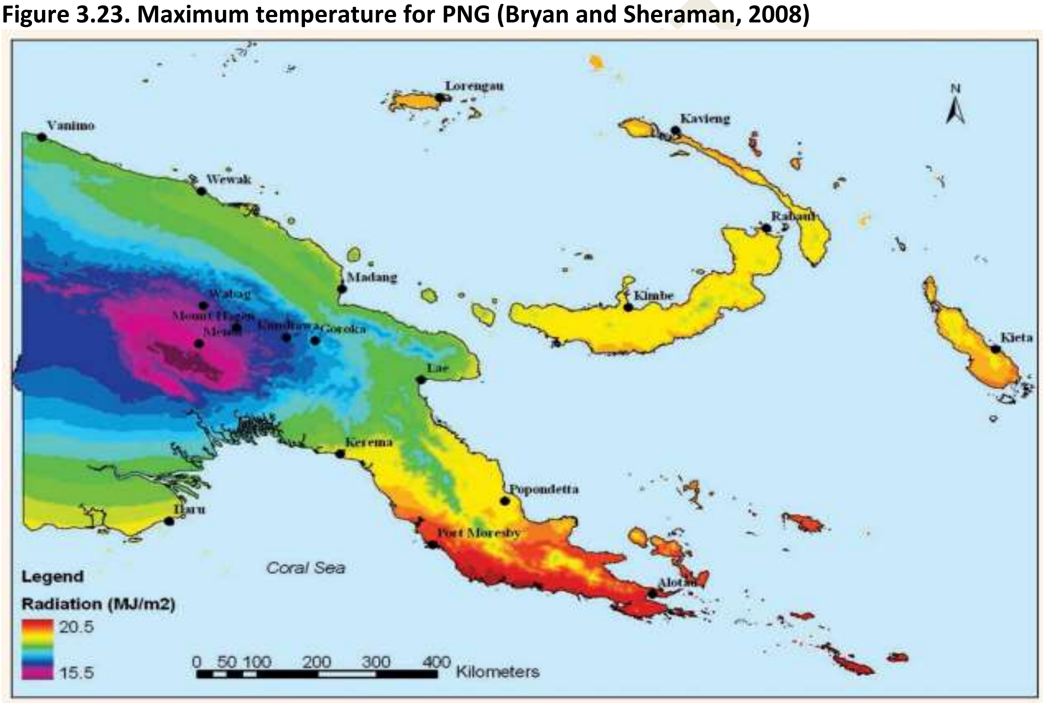

Figure 3.24: Mean annual solar radiation for PNG (Bryan and Shearman, 2008)

Although PNG is in the tropics and receives direct overhead sunlight, the amount of solar varies across the country because of altitude and cloud cover. Figure 3.24 shows the mean annual solar radiation experienced in the country varies. It is very high in the southern tip of PNG around Central, Oro and Milne bay Provinces with 20.5 MJ/m^2 and slightly high in the New Guinea Highland region and parts of Western province. Morobe and Gulf. In the highlands region of PNG, where the altitude is high, the solar radiation reduces to 15.5 MJ/m^2.

Moreover almost half of the country receive high rainfall of greater than 2500 mm annually. In some places such as Lae, parts of Gulf province like Kikori and the Hindenburg Range in Western Province, the annual rainfall is about 8000mm per annum. In few locations such as the Markham Valley, Bulolo Valley, Maprik - Angoram area, Eastern highlands, and coastal areas near Cape Vogel, Port Moresby and Daru, spatial distribution of annual rainfall ranging from 1000-2000 mm of rainfall is experience (McAlpine 1983).

Generally, large areas receive over 4000 mm per year, notably the northern and southern flanks of the highlands and the south coast of New Britain (SPREP 2007). The consistently highest annual rainfall of more than 10,000 mm has been recorded in the Ok Tedi area in the Star Mountains. A detailed account on the climate of PNG is documented by McAlpine et al. (1983) and SPREP (2007).

More recently, the study by Brayan and Shearman (2008) shows some interesting results on mean annual rainfall patterns. Figure 3.25 shows rainfall varies throughout the country from coastal regions, islands provinces and highlands region. Some parts of the country receive lower rainfall such as parts of Central, Gulf, Western, Morobe and Eastern Highlands provinces, receiving between 1100-1100mm of rainfall. On the contrary, high rainfall is experienced in hinterlands of Western, Gulf, Central, Morobe and East and West New Britain provinces, receiving between 4000-8600mm of rainfall per annum. The rest of the country receive average rainfall of over 2000mm per annum.

Figure 3.26 portrays rainfall variation indicating seasonality of wet and dry seasons. Generally, monthly average rainfall is 100-200mm however only few places in the country receive rainfall throughout the year than others. Heavy rainfall are experienced in Gulf, Southern Highlands, Hela, East and West New Britain, Milne Bay AROB and Manus provinces. Provinces will low rainfall are CentralMorobe, Gulf and Western Provinces.

Climate variability

The changing climate experienced over the years has had a major impact on the weather patterns in PNG. The two main determinants of climate in PNG are the topography and the seasonal latitudinal movements of the two air streams or movement, separated by a low pressure system known as the ITCZ. When the ITCZ is positioned north of PNG, north-westerly winds predominate from late December to mid-April, bringing heavy monsoon rain (SPREP, 2007). In parts of the southern region, between December and March, cyclone occurring down south in Australia and other eastern Pacific Islands, brings strong gales and rains.

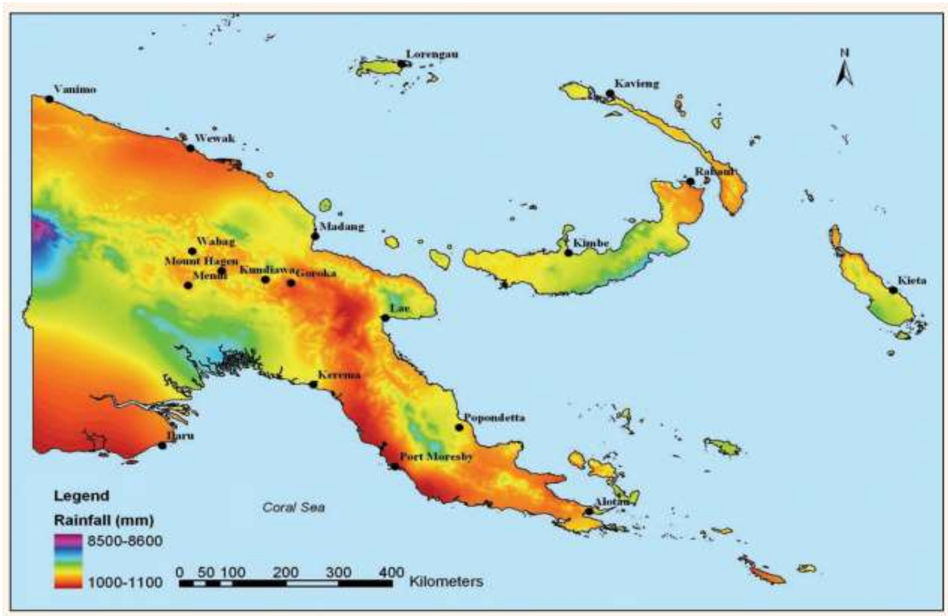

Figure 8.25: Mean annual rainfall for PNG (Bryan and Shearman, 2008)

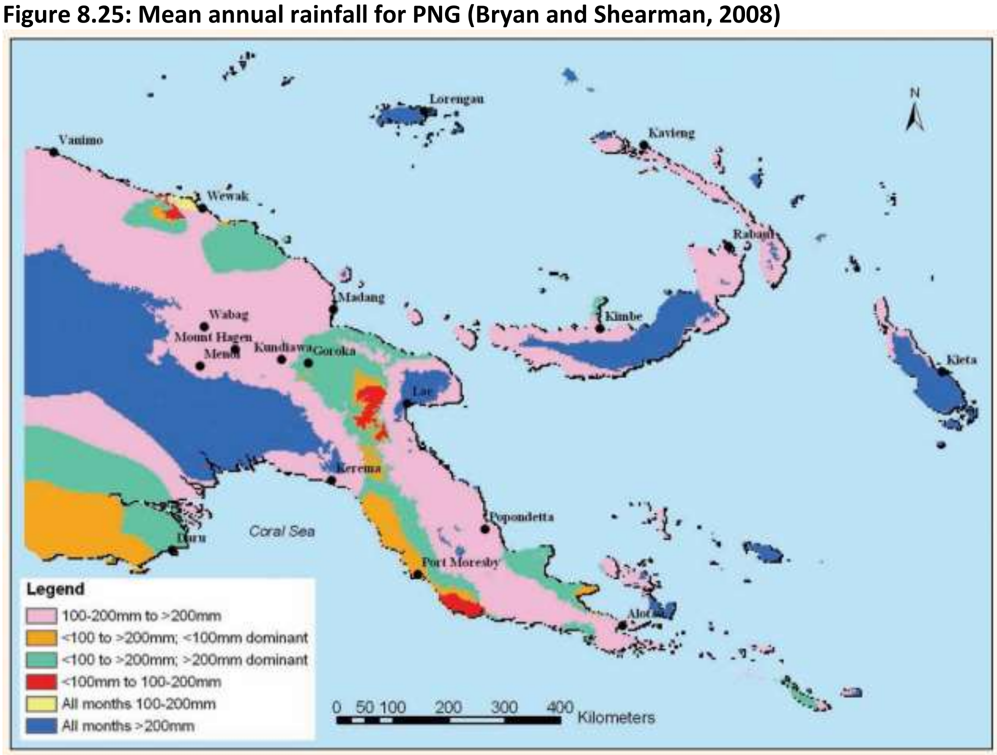

Figure 8.26: Rainfall seasonality map for PNG (Bryan and Shearman, 2008)

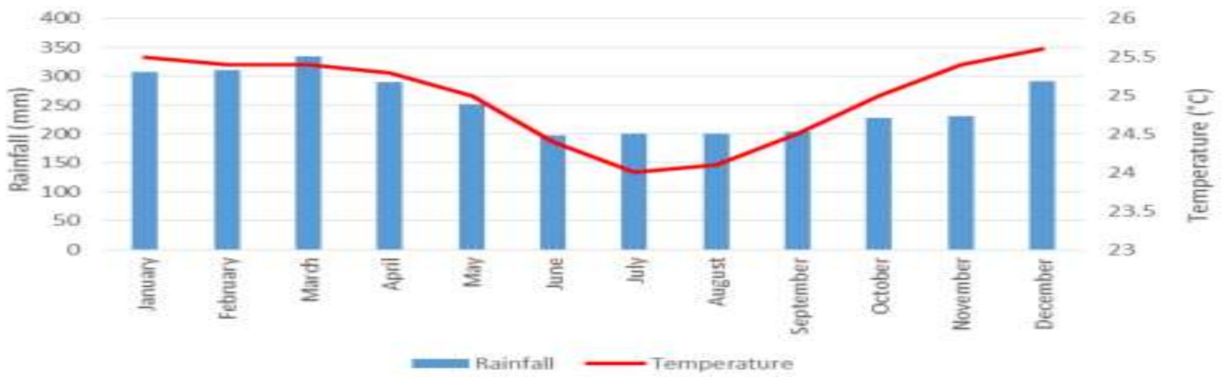

Figure 3.27: Annual average rainfall and temperature patterns of PNG (World Bank Portal)

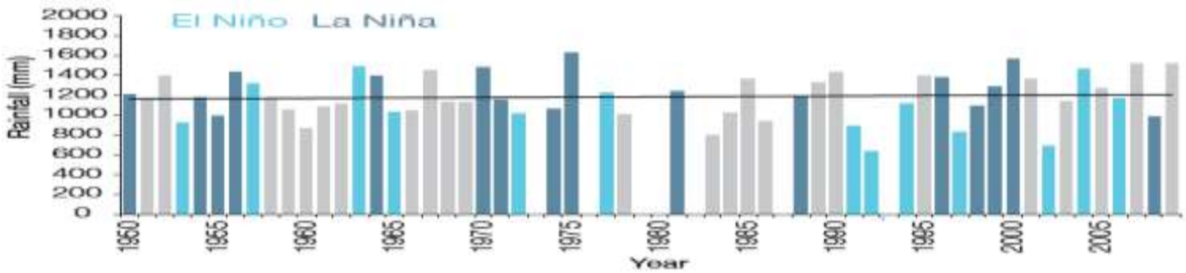

Figure 3.28: Average annual rainfall for Port Moresby between 1950 and 2010 for La Lina (ligth blue), and El Nino (dark Blue) and neutral years in grey bar (GoPNG, 2014).

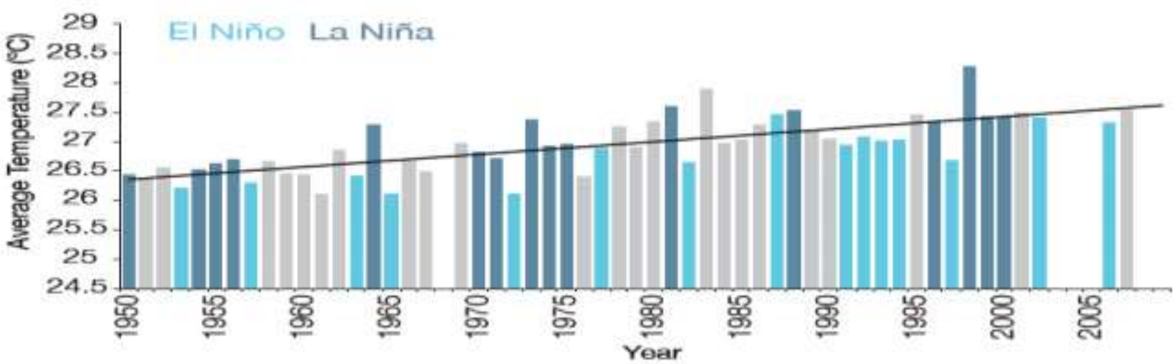

Figure 8.29: Average annual minimum and maximum temperatures for Port Moresby between 1950 and La Lina (ligth blue), and El Nino (dark Blue) and neutral years in grey bar (GoPNG, 2014)

Figure 3.27 shows the general average annual rainfall and temperature for PNG will change due to changing weather patterns. Howe et al. (2018) stated that El Niño events have marked effects on the South Pacific island countries thus will impact rainfall and drought, wind speeds and sea surface temperatures (SSTs). In recent years, the weather patterns has changed remarkably with three distinct patterns experiences for the Southern Region, Islands Region and the Highlands Region. The main climate drivers that influence the PNG weather are the El Niño ENSO, the Pacific Monsoon and to a lesser extent influenced by the position of the South Pacific Convergence Zone or SPCZ (GoPNG, 2014). The ENSO is stronger on the southern region and the mainland of PNG than the northern region in terms of rainfall. The main impact of El Nino is a late start to the monsoon season that begins around December.

The lowland coastal areas of PNG experience an average temperature of 32°C, the inland and mountain areas average 26°C, and the higher mountain regions with 18°C (GoPNG, 2018). Relative humidity is quite high in PNG and ranges between 70 and 100%. Dry season is experienced from June to September, and wet season from December to March. During the wet season tropical cyclones effects experienced in the Pacific and Australia are felt as well in PNG.

Since PNG is situated in the tropics, it experience very little variation in the maximum and minimum temperatures. High daily mean temperatures are experienced in the lowlands with little annual variation. Mean maximum readings of 28 – 34 degrees Celsius and mean minimum readings of 20 – 25 degrees Celsius are usual with daily fluctuation of approximately 7 degrees Celsius (McAlphine, 1983). In the highland areas, mean maximum daily temperatures range from 20 -29 and mean minimum temperatures are in the region of 10 – 18 degrees Celsius.

In recent times, the heat wave experienced over the ocean and the stratosphere are influencing temperature patterns thus sometime PNG experiences heat waves of above 34^{O}C. Over the last 60 years, maximum and minimum temperatures have increased significantly, mainly influenced by the oceanic temperature around the Pacific Ocean (SPREP, 2007).

Seasonal temperature and variation is prominently distinct between the Islands region, the southern region and the highlands region, thus influencing their local weather patterns as well. Temperature variation are markedly noticeable around the southern region than further north; e.g. the annual minimum and maximum temperatures have increased in Port Moresby since 1950 at a rate of 0.11 ^{O}C per decade (McAlpine 1983). In recent time, places like Port Moresby has experience temperature and rainfall variation. Traditionally, many areas receive more than 3000 mm annually, but few places like Port Moresby, lie in a rain shadow and receive 1190mm or less (BoM and CSIRO, 2011; cited in GoPNG, 2018).

Figure 3.28 and Figure 3.29 depicts the average annual rainfall and average annual maximum and minimum temperatures for Port Moresby between 1950 and 2010 as a case study for weather variation in PNG. These graphs show the spread of La Niña (rain) and El Niño (drought) over 60 years. There are periods where both El Niño and La Nina are frequently alternating to become frequent. Between 50s and 80s there were 8 El Niño occurrence compared to 10 La Lina seasons. Between 1980 and 2010, there were 9 El Niño seasons and 6 La Niña seasons. These variations La Niña and El Niño seasons are becoming prominent with increasing occurrence.

However, this cycle and prediction can change as temperature in the Pacific Ocean changes. Studies on climate change indicate that there will be more changes in the local weather patterns. GoPNG (2018) reported based on CSIRO analysis, that there is a high confidence that over the course of the 21st century:

- The surface air temperature and sea-surface temperature are projected to continue to increase;
- Annual and seasonal mean rainfall is projected to increase;
- The intensity and frequency of days of extreme heat are projected to increase;
- The intensity and frequency of days of extreme rainfall are projected to increase;
- Ocean acidification is projected to continue; and
- Mean sea-level rise is projected to continue.

Cyclones often bring strong wind and rain and can be destructive and comes with pressure build up in the eastern Pacific. Studies have shown that the total number of tropical cyclones in the south west Pacific has decreased, while others have shown an increase in the number of intense and severe tropical cyclones that occur over time (Howe et al. 2018). It is believed the global frequency of occurrence of tropical cyclones will either decrease or remain unchanged, or if it occur, its intensity will increase with increase wind speed and precipitation (Christensen et al., 2013). The future influence of climate change on tropical cyclones is likely to vary by region, but the specific characteristics of the changes are still remote to quantify and predict.

The Australian Bureau of Meteorology (BoM) and the Commonwealth scientific and Industrial Research Organisation (CSIRO) detect that between 1969 and 2010 (41 years), 23 tropical cyclones passed within 400 km of Port Moresby, an average of less than one cyclone per season (BoM and CSIRO, 2011; cited in GoPNG, 2018). In recent times, cyclones occurred more frequently in neutral phases of the ENSO and has devastating effects bringing more rain clouds and rain, thus causing flooding and landslides in various parts of PNG.

Figure 3.30 shows the number of cyclones passing 400km of the coast of Port Moresby. These cyclones formed either in the Eastern Pacific Oceans in Fiji, Vanuatu and Solomon Islands and passes through to Australia. The area's most susceptible to cyclones are Milne Bay province which is often hit before the cyclone hits landfall in Queensland, Australia. Sometimes, the Cyclone brew in the Top end Northern Territory and the effects are felt mainly around the southern region area of PNG including Milne Bay, Central, Gulf and Western Provinces. This result in rain, strong gale, storm surges and rough seas.

Impact

Based on the observations of Port Moresby since 1950, it can be concluded that steading warming is occurring at an average of 0.1^{O}C every decade. Thus temperatures are expected to continue to rise by 0.4-1^{O}C by 2030 and by 2050 it was projected to reach 1.1-1.9OC warming (Antea Group, 2018). The increase in average temperature will result in more hot days, consequently having the potential to affect agriculture, human health, species and other environment services and functions.

Despite lack of rainfall and temperature data, there is no clear long-term historical change but general data has shown decline in precipitation. As the atmosphere becomes warmer, so too precipitation is expected to increase. Hence more rainfall are expected to occur that brings flooding. However, the regional pattern may be uncertain given the year to year variability in temperature and rainfall (Antea Group, 2018). Thus it is expected to see more El Niño and La Niña events increase in occurrence and intensity.

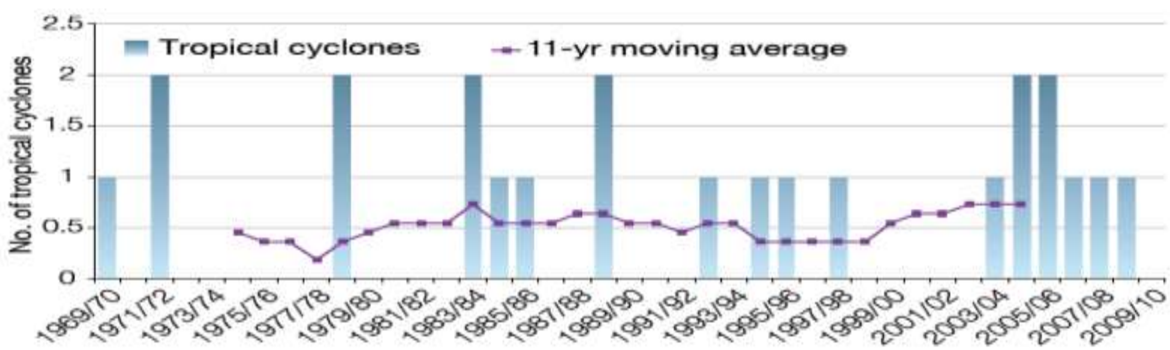

Figure 8.30: Number of tropical cyclnes passing within 400km of Port Moresby (GoPNG, 2014).

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Precipitation is one of the basic climate factors that drives large-scale circulation and influences the water cycle on Earth. It brings fresh water into the ocean, which dilutes the concentration of salt and has considerable impacts on ocean ecosystems (Hou et al., 2016). El Niño–ENSO, is the dominant mode of interannual variability over the Pacific Ocean and influences convection and precipitation with anomalously warm sea surface temperatures (SSTs) in the eastern and central equatorial Pacific Ocean, and thus affects the sources of fresh water upon which millions of people rely (Hou et al., 2016).

Therefore, understanding the variability of precipitation and its relationship with ENSO are of great importance.PNG is prone to many natural disasters induced by climate change, climate variability and sea level rise, including tsunamis, cyclones, inland and coastal flooding, landslides and droughts (Antea Group, 2018). Any changes in local weather pattern will certainly have a greater impact on the local economy, food security, species population, health and the way people live. Increase surface temperatures has accelerated changes in global and regional climatic patterns. This may result in coastal flooding, inland flooding and landslides, and new hazards such as diseases outbreak, and changed agriculture practices and impact on crops. This may also increase sea temperatures thus changing local weather patterns that results in coral bleaching.

Hence, the PNG government is currently is looking at addressing climate change hazard induced issues and funding and early warning systems are a major constraints. Currently, ADB with funding from the Climate Investment Fund, is implementing a US$ 27 million climate change adaptation, food security, water and sanitation and early warning systems project in selected costal islands in five maritime province. The European Union through GIZ is also supporting adaption work focusing on water supply and sustainable energy worth EU 1.4 million.

Despite the unavailability of data to predict the weather pattern, the case study of the Port Moresby area clear signify that there is indeed a warming trend over time in the last 60 years. Changes in the local weather patterns is correlated to the changes in the surrounding ocean temperature. It can also be predicted that the frequency of warm days is increasing and cool nights has decreased. There is also fluctuating trend in the rainfall pattern.

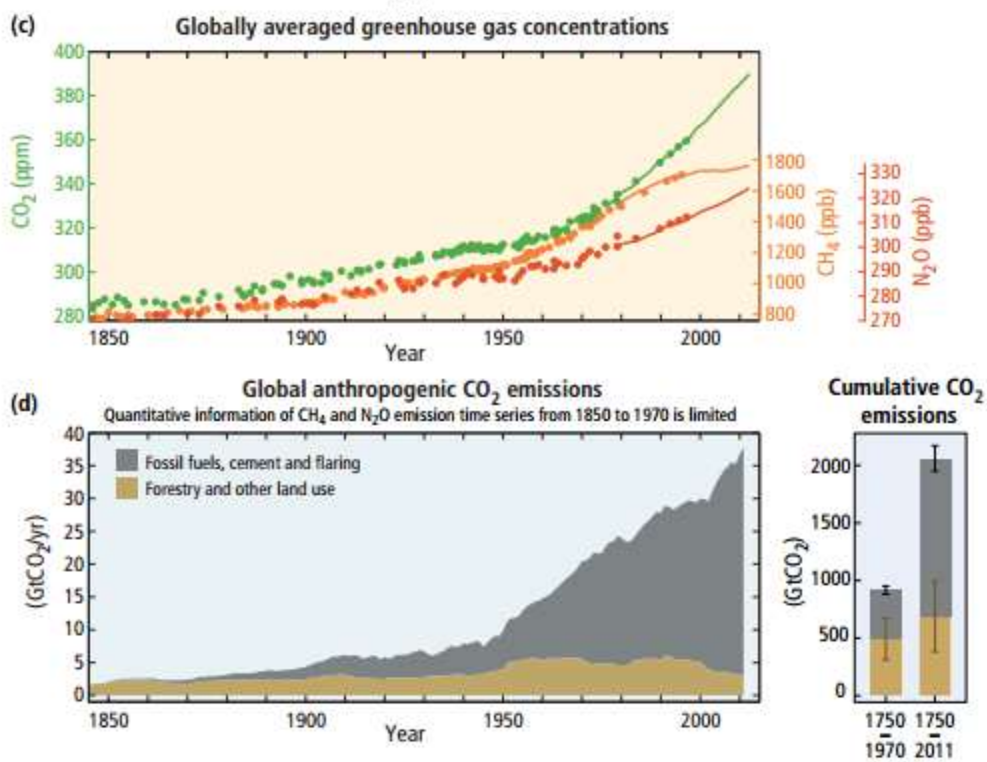

Figure 8.31: (c) Atmospheric concentrations of the greenhouse gases carbon dioxide (CO_2, green), methane (CH_4, orange) and nitrous oxide (N_2O, red) determined from ice core data (dots) and from direct atmospheric measurements (lines). Indicators: (d)Global anthropogenic CO_2 emissions from forestry and other land use as well as from burning of fossil fuel, cement production and flaring. (d) Cumulative emissions of CO_2 from these sources and their uncertainties are shown as bars and whiskers, respectively, on the right hand side. The global effects of the accumulation of $CH_4$and N_2O emissions are shown in panel c (IPCC, 2015).

Figure 8.31 shows the appalling state of the increasing GHG concentration and CO_2 in the atmosphere (IPCC, 2015). With the increase in global average of GHG concentration and anthropogenic CO_2, the earth is most likely to become warmer, hence affecting climate patterns across the globe. Hence the climate change will become more pronounced as the earth becomes warmer. Unless, the world tackle GHG emissions, the problem will continue to escalate and many people and their environment will be affected. This would affect the SST and the ITCZ within the pacific, hence influencing the climatic patterns and sea level rise in the pacific, including PNg. Consequently, many climatetic effects suchs a coastal erosion, sinking islands and atolls, coral bleaching, destructive flood and winds, increasing droughts and temperature anomalies, increasing water and airborne diseases and other impacts will be closely felt in PNG. When this happens, PNG would be grately affected because the government fuding allocated to natural disseaster by the government of PNG is not sufficient.

In conclusion, seasonal temperature, rainfall and variation is prominently distinct between the Islands region, the southern region and the highlands region. These regions experienced different local weather patterns. Temperature variation are markedly noticeable around the southern region than further north; e.g. the annual minimum and maximum temperatures have increased in Port Moresby since 1950 at a rate of 0.11 ^{O}C per decade.

Response and Recommendations

Proper assessment, GHG inventory and reporting must be conducted. Technology development and transfer, financing, capacity building, education training and awareness raising must take prominence that target vulnerable sectors, ecosystems and infrastructures.

Appropriate adaptation mechanisms must be done in preparation for any extreme weather events and natural disasters. Most of these are spelled out clearly in the PNG 2nd National Communication to UNFCCC (GoPNG, 2014), the first biennial Report to UNFCCC (GoPNG, 2018) and the study by Antea Group (2018).

Improvement in knowledge and information on physical weather and associate impacts are needed. Hence there is a need to define terrestrial or marine ecological systems in a collaborative effort between PNG, Indonesia and the Solomon Islands for an agreed conformity that will allow climate change comparison across the region.

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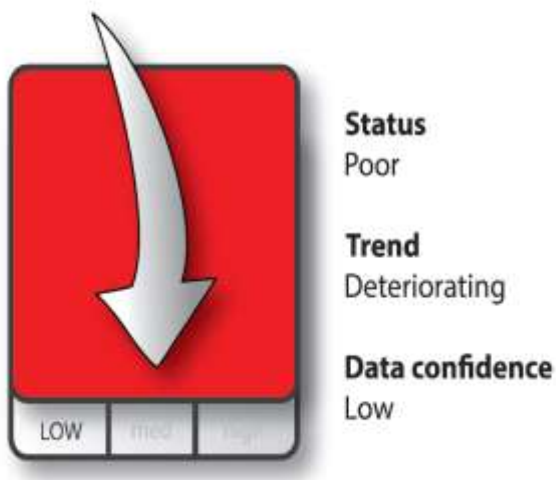
8.2.6 CLIMATE RELATED DISASTER LOSES

Indicator Definition: Total dollars of financial loss occurring due to climate-related disasters, defined as cyclones, flooding, landslides and droughts

Trend and Status



SDG/CBD Targets

SDG- 13.1.1, 13.1.2, 13.1.3, 13.3.1, 13.3.2, 13.a.1,13.b.1 , 14.2.1, 14.a.1, 15.2.1, 15.5.3, 15.4.1,

Aichi Target- 1, 2, 3, 4, 12, 14, 19, 20

Status and Trend Discussion

Global warming is a phenomena where an increase in carbon dioxide concentration in the atmosphere may lead to the warming of the earth's atmosphere. Thus global warming is defined as an increase in combined surface air and sea surface temperatures averaged over the globe and over a 30-year period (IPCC, 2018). Warming greater than the global average has already been experienced in many regions and seasons, with higher average warming over land than over the ocean. Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels in 2017 per decade, with a likely range of 0.8°C to 1.2°C. IPCC cautioned that global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.

Given the geographic and physical characteristics of PNG, the country is subjected to the impacts of global warming and climate change. GoPNG (2014) stated in its second Communication report to UNFCC that the global climate impact and vulnerability assessment for PNG was completed and indicates that PNG is expected to have:

- A rise in annual average temperatures between 0.4 ^{O}C and 1 ^{O}C by 2030, accompanied by hot days and warm nights;
- An increase in annual and seasonal rainfall between now and 2100;
- Inconsistent drought projects and variability;
- Decrease number of tropical cyclones but with increase maximum wind speed and high intensity rainfall;
- Rising sea level with 4-15cm and by 2100 with 20-60cm rise; and
- Experience flooding (coastal and inland);
- Climate-sensitive crops affected;

- Increase malaria and diseases; and
- Occurrence of increasing coral bleaching; and
- Others impacts. e.g. biodiversity loss, and water and sanitation

Given the above assessment, PNG is vulnerable to climate change impacts and is highly susceptible to natural disasters, including volcanic eruptions, earthquakes and tsunamis. Global climate change has increased the occurrence of extreme weather events, such as droughts and floods, threatening the population, food security and causing economic disruption in rural areas. In 2012, a landslide in Tumbi Village, Hela Province, killed about 33 people and severely disrupted trade and transport in that province.

One of the worse climate disaster was the last devastating El Niño experienced in PNG in 1997 and 1998. That disaster caused a severe reduction in crop yields due to below average rainfall, with up to 80% loss in yield in many areas (Unocha, 2014). The El Nino also brought an increased anthropogenic bush fires and occurrence of frosts in the highlands at 1,450m above sea level. The frost affected areas were those above 2,200m in the Western Highlands, Southern Highlands and Central Provinces. Almost everyone in rural PNG was affected to some extent with an estimated 40% were seriously affected.

Unocha (2014) in its study found 260,000 people then were in a critical, life threatening situation plus an addition 1.9 million people were consuming limited food. In addition, water scarcity was also a problem with 5,000 people faced a critical, life threatening situation with extremely limited water supplies and 363,000 people with minimal amounts of quality water available for drinking, cooking or using.
The El-Nino, is very much experienced in the Southern and Mainland than the Northern Region, but the recent 2015-2016 El Nino event that occurred 20 years later after the last event had a significant impact on PNG. The drought and frosts impacted many rural villagers, with the impact continuing in early 2017 in some areas. The National Weather Service (NWS) on 7 August 2015 declared the country to experience a severe El Nino event, which was forecasted to continue for 8–10 months with reduced rainfall in all parts of the country. The National Disaster Centre (NDC) estimated that almost 2 million people were affected and that the operation of food distribution by the World Food Program cost up to $12.6 million. The Provincial Disaster Centre of Chimbu Province also reported 24 people confirmed dead as a result of prolonged drought in the Highlands region (IFRC, 2015; cited in GoPNG 2018).

Papua New Guinea's drought has ranked eighth in aid group CARE's top 10 most under-reported crises in the world for 2016. During the La Nina season, there were reported cases of children and man drowned in flooded areas. According to government figures, in the first half of 2013, more than 100,000 people were affected by disasters in PNG, mostly flooding in 15 provinces, resulting in nine deaths, six injuries and more than 600 people being temporarily displaced (NDC, 2019). In Port Moresby alone, an averages of 3 deaths were reported dead in the 2018 flash flood while another 2 were death in the Wahgi River flood mishap in Chimbu province. However, consistent records of flood deaths are scares.

The NDC is the national agency responsible for all natural and man-made disasters in the country. It operates under the Department of Provincial and Local Level Government (DPLLG). DPLLG received K25mil in 2017, K42.6mil in 2018 and K116.2 mil in 2018. The budget is projected to increase to K164.7mil in 2020, K155.7mil in 2021 and K108.1 in 2021. The funding earmarked for DPGLLG is not sufficient to implement NDC activities. Currently, NDC is handicapped with funding and depends much on international and national donors, individuals and humanitarian organisations to support its activities at both the national and provincial level.

The Climate Change and Development Authority (CCDA) is another agency implementing climate adaptation programs. It has done some work on climate adaptation and resilience work with international donors and partners. Figure 3.32 shows funding to CCDA declines over the years, being highest in 2018 and 2019 with K17.4 mil and K23.1 mil. However, the budget was reduced to K6.5 in 2020 and is further projected to decline to K7-8 million in 2021 and 2022. CCDA also receives funding and aid from other international development partners such as UNDP, World Bank, ADB and EU among others.

With the increase climate change impact incidence rising, the cost of its impact and response will also rise. The government estimates the cost of responding to climate change impact diseases such as malaria could affect about 50% of the total population of 8 mil at a cost of $400mil (GoPNG, 2014). For the coffee rush impacted by the coffee berry borer (CBB) in 2018, the cost for eradicating the disease was projected at K15mil. These examples shows the unexpected consequences of climate change impact disasters would be increase substanttially.

Looking at the above figure, it is still too small to cater for all issues because the biggest slice of the budget are factored into the recurrent budget whch one could assume the funding received by NDC is small. Figure 3.33 shows funding for NDC is very small in 2005 withUS$200, 000 but increased to US$1.3 mil in 2006 and then reach US21.3 mill in 2013 (NDC, 2019). This limited funding is not enough to respond to sudden and major natural disasters, in a country such as PNG which faces disasters frequently. The provincial governments may also have their own budgets that supports the provincial disaster center office, yet funding is still limited.

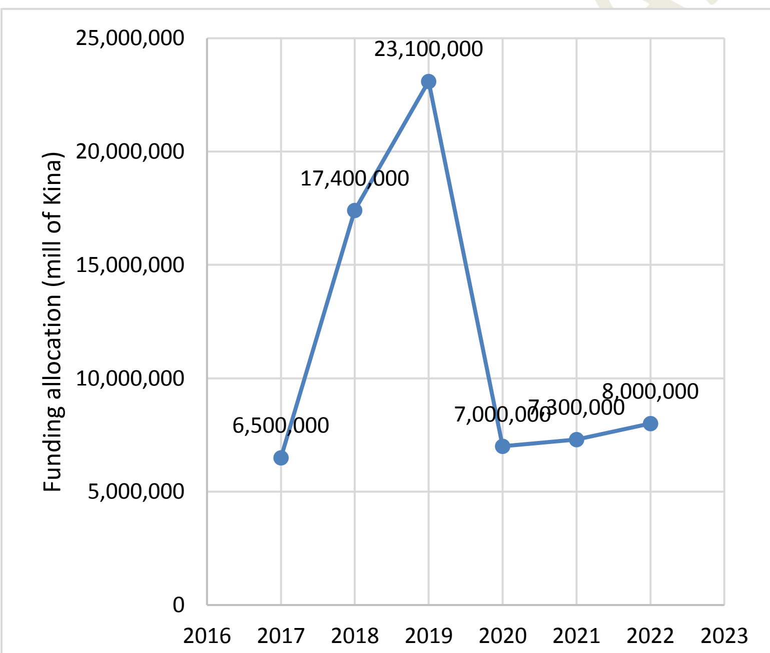


Figure 3.32: Government funding to CCDA for 2017 to 2022 (GoPNG 2018)

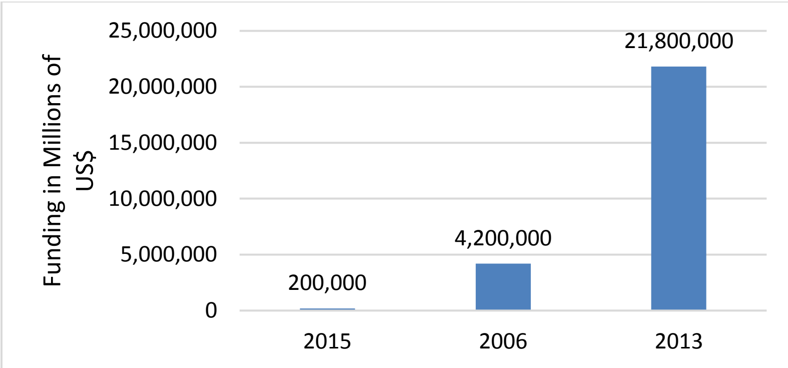


Figure 3.33: Funding for National Disaster Center (NCD, 2016)

Impact

The above scenarios illustrate the impact will be massive and unless PNG is not prepared and become resilient, any future chamate change impact will have a negative impact on the people, economy, livelihood, species and ecosystems. Frequent and severe storms, droughts, flooding, diseases and other impacts will have a series repercussion on PNG and its economy and well being. The main climate change impacts in PNG and their effects identified by GoPNG (2014) are summarised below and some have cross-cutting effects.

1. Coral bleaching and sea acidification. Rise in sea surface temperatures (SST) and acidification may potentially over time destroy PNG's coral reefs, the fifth largest in the world. Between 50,000 and 70,000 coastal inhabitats rely on reefs for their food, livelihood, and economy. Not only reefs contribute to economic growth through fisheries and tourism, they also protect coastlines from stroms that can cause land loss or coastal erosion. Corals are also a major sequester of GhG and if destroyed will not assist in sequestrating GHG. Death of corals would most likely affect marine habiats and ecosystem functions thus affecting local community livelihood and fishery species associated with corals.

Through the industrial era, anthropogenic CO_2 has caused a decrease of 0.06 pH units in the tropical Pacific ocean at approximately 002 units per decade, with the pH of the tropical Pacific Ocean projected to decrease by 0.15 units relative to averages in 1986-2005 period (Hoegh-Guldberg et al., 2014; cited in Howe et al., 2018). By the end of the century, it is predicted a further decrease of 0.23-0.28 pH units relative to average in 1956-2005 would occur. Figure 3.34 indicates the sea being blue (optimal) where the corals will surve but as the sea becomes too acidic or extreme (red brown), corals are most likely to die. This model also predicts lower variance in pH, particularly in waters to the east of PNG, Nauru, Kiribati (Gilbert and Phonex Islands) and the Marshall Islands.

2. Coastal flooding and sea level rise will affect coastal regions in PNG. In the last 20 years and though more than five catastrophic flood events, coastal floods have affected some 8, 000 people a years (GoPNG, 2018). On an annual basis, the floods caused US$10-20 mil of damage, displaced 5000 people and killed more than 10 people. Rising sea levels has worsen the effct of coastal floods and neccessiated the evacuation of people from Caterret Atolls and Duke of Yoke Island, as salinization and flooding are damaging fragile communities and their livelihood and culture, making most areas uninhabitatble.

There is also threat loming from sea level rise (SLR) and there are evidence SLR does affect low lying islands and atolls. It was projected the global mean SLR would increase by 2100. Regionally, SLR is predicted to increase by up to

0.,5m (relative to averages during 1986-2005) for some of the more northern and eastern SIDs, while eastern SIDs will experience an increase of up to 0.6m. Global mean sea level have been steadily rising at a rate of approximately 3.2± 0.4 mm per year over the last two decades (CSIRO, et al., 2015; Fasullo & Nerem, 2016; cited in Howe et al., 2018).

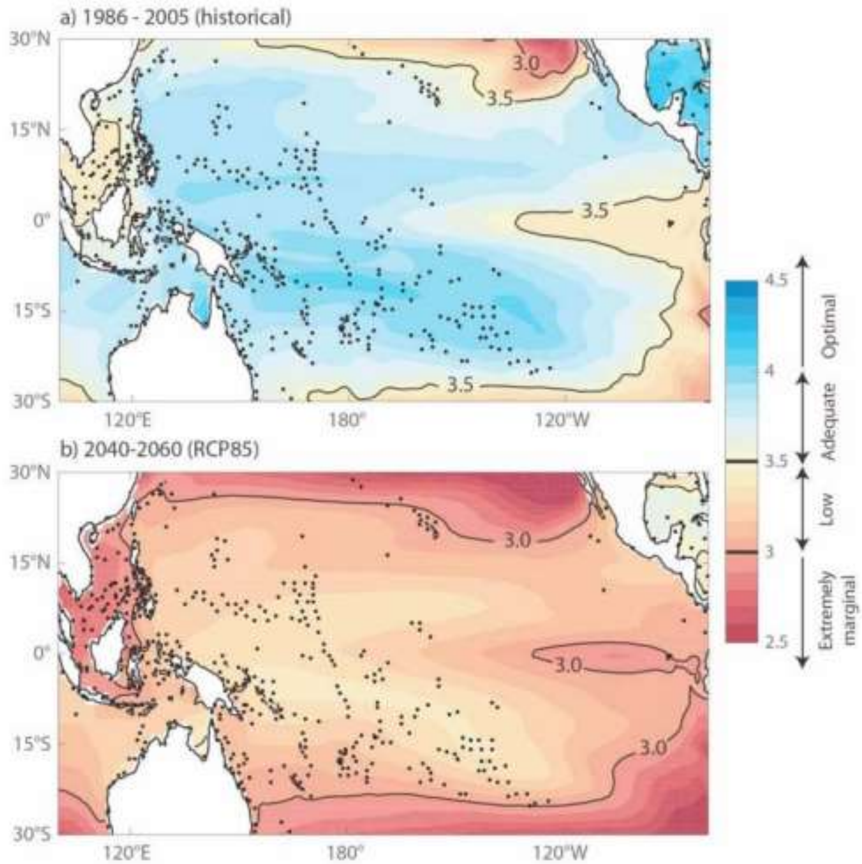


Figure 3.34: Aragonite saturation state for the periods (a) 1986–2005 (based on a multi-model median from the CMIP5 historical simulations) and (b) 2040–2060 (based on RCP8.5 simulations). Contour lines of 3 and 3.5 are superimposed. Black dots indicate location of coral reefs. (Taken from Johnson et al. 2015; Cited in Howe et al., 2018).

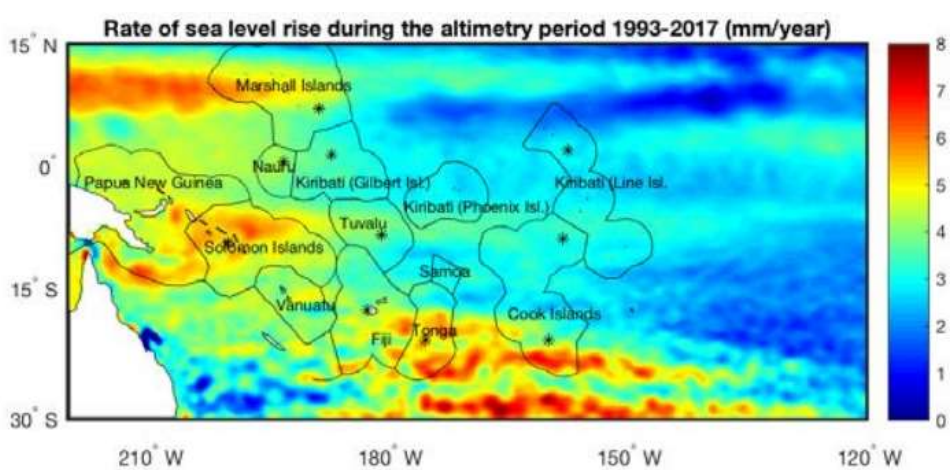


Figure 3.35: Rate of of sea level rise from satellite altimetry (Aucan, 2018; cited in Howe et al., 2018)

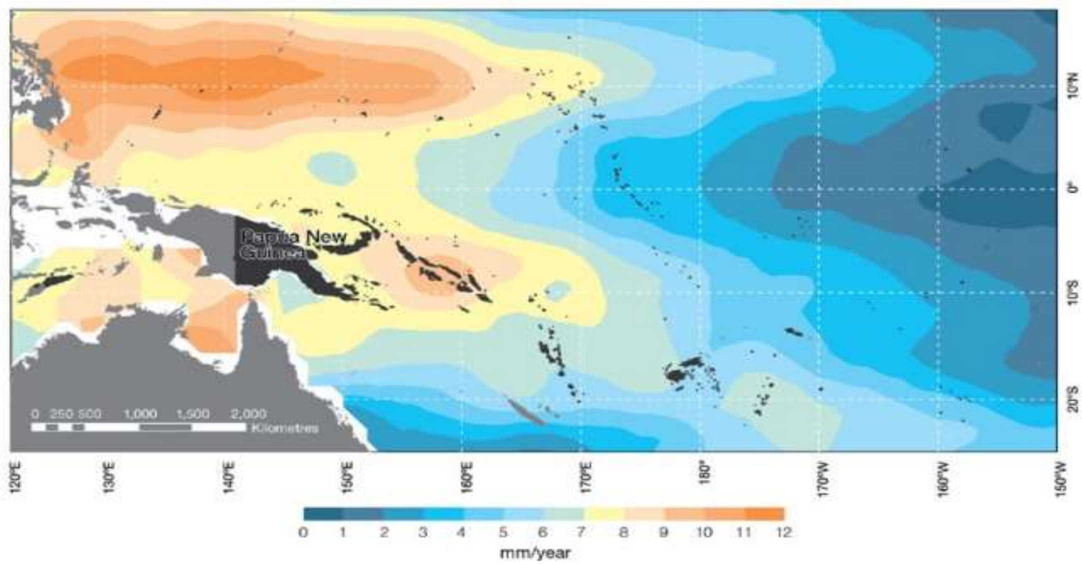


Figure 3.36: Regional distribution of sea level rise measured by satellite altimeters from January 1993 to December 2010 (CSIRO, 2011; cited in Inape 2012)

Figure 3.35 shows data from satelites and the tide gauge readings for in the Western Pacific, indicating the rate of SLR has since 1993 has tripled that of the global average. This was common around the Solomon Islands, PNG and the Marshall Islands. Hence the region is projected to have SLR increase up to 0.6m and 0.7m respectively, relatively to averages during 1986-2005 (Howe et al., 2018). Recent research suggest the Western Pacific is one of the tregions that would most likely become affected in terms of SLR, exarcebate by gravitational changes, as a result of loss of land ice and terrestrial stired ground water (Carson et al., 2016). Figure 3.36 also shows PNG is prone and vulnerable to be severely affected by SLR. Many smaller islands and atolls will be inundated or undergoe coastal flooding.

3**. Increase in vector disea prevalence and occurence**. Malaria severely affects people's daily lives in the tropics, with 1.7mil people infected annually. Almost 60% f the population that lives in high-risk malaria infested regions of PNG (GoPNG, 2014). In the last 25 year, climate change has worsen the effects of malaria and incidence. This was promoted by rising temperatures that promote malaria carrying parasites to expand their boundaries into high altitude and cooler climatic zones of PNG. Consequently, the parasite have become established in areas it was noit previously present. Additional rise in temperature over the next 20 years wll introduce malaria to previously risk-free regions and could worsen the impact of malaria for those living in low-risk zones. Hence, cost of eradicating or controlling malaria would increase.

4. **Increase inland flooding**. Inland flooding, instigated by heavy irregular rainfalls, may affect valley, mountains and wetlands in both lowlands and highlands. The effects of inland flooding are amplified by steep inclines in deforestation rate. Based on a 19 year data, 22,000 to 26,000 people are affected annually by inland floods that displaced 6,000 – 8,000 people resulting in few deaths each year. Media reports stated that over 5 people havedied from flood related causes. In addition, the estimated annual damage caused

by flooding stands at US$8-12 mil. Changes in climatic conditions, either through increase average precipitation and increased extreme rainfall events, will strongly influence the impact of inland floodings.

6. **Landslides**. Increase in landslide occurence in mounyainous and rugged country can eventuate, triggered by increase rainfall intensity and landuse change that causes destabilisation to the soil. In recent decades, landslides have caused considerable damages to road infrastructures, local economy and travel by remote communities or the travelling public, between towns and cities. For instance, the Okuk Highway (Highlands Highway) which is situated along the rugged mountains of PNG succumbed to landslides annually. The Highway is the lifeline of populous highlands provincial centers and some of the biggest mine, and oil and gas and agriculture projects in the country. When there is a massive landlide, it affects business and the travelling public. Changes in precipitation patterns and lanuse are likely to increase in correspondence to landslide. The effect of landslide is still not well understood given it unpredictability, and unavailability of data due to lack of research.

6. **Reduction or change in crop yield**. Variability in agriculture yileds will affect agricultureal regions in PNG. The Highalnds region is particularly sensitive to variability in agricultural yileds as a result of change in climatic conditions. Sweet potato, coffee and coca are examples of climate-sensitive crops that almost 80% of rural communities in PNG are dependent on for food, livelihood and as cash crops. Susistence farmers will be the most affected by any changes in the climatic condition of an area, and may need to look for alternative crops. During the 1997 and 2013 drought season, some people in the islands died from eating wild mushrooms because of impact of drought and frost in the highlands. In the coastal communities, such as the Western province, many people suffered from drought.

If climate change become prominent in PNG, which PNG is not resistant, disaster preparedness and planning must be done in order to avoid future disaster and costs due to unpredicatable climate and weather patterns. The government though agencies responsible must take bold steps to address this, taking into consideration the impact that may occur due to unpreparedness and the effect disasters such as landlides and drought may have at the community level. Food security, diseases, deaths and loss of economy caused by climate change effects must be addressed swiftly and amicably. Although these issues are elaborated in the next section on adaptation, funding must be made available for disaster and climate change impacts. Also more awareness has to be raise to avoid more issues.

Responses and Recommendations

Increase awareness and improve early warning systems so people must be prepared for climate related disasters and impacts. Ensure mitigation measures and steps must be taken by authorities and communities to minimize the impact on the availability of food and water, disease and other necessities of life. Institutional strengthening through training and capacity building, setting of disaster response committees and resources upscaling (e.g. increase funding for NDC) must be addressed to ensure swift response when disaster or emergency occur.

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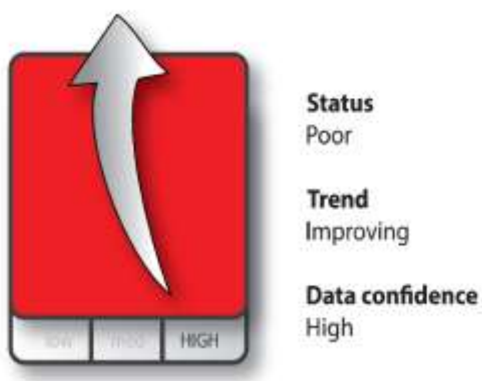
8.2.7 CLIMATE ADAPTATION AND MITIGATION FUNDING

Indicator Definition: Climate change adaptation refers to activities that safeguard and protect infrastructure, people and resources against climatic variability and events such as rising sea levels, floods, droughts and storms. Mitigation funding is total funds received for climate adaptation and mitigation projects

Status and Trend



SDG/CBD Targets

SDG: 13.1.1, 13.1.2, 13.1.3, 13.3.1, 13.3.2,13.a.1, 13.b.1, 14.2.1, 14.3.1, 14.5.1, 14.a.1, 15.3.1, 15.4.1, 15.5.1, 15.8.1, 15.9.1, 15.a.1,15.b.1

Aichi Target: 1, 2, 9, 10, 11, 12, 13, 17, 19

Status and Trend Discussion

According to the Intergovernmental Panel on Climate Change (IPCC) definition, adaptation is the process of adjustment to actual or expected climate and its effects (IPCC, 2015). IPCC iterates that in human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities while in some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

Campbell (2014) and GoPNG (2014) have identified major climate change issues common that PNG need to be address in order to ensure adaptation is implemented effectively by government's plans. They are:

1. **Sea level rise that causes inundation, coastal erosion and storm surge exacerbated**. Definitely, coastal flooding and sea level rise will affect coastal regions in PNG. Thus land security in coastal and atoll locations may be severely reduced and there may be impacts on livelihood security through loss of agricultural land and salinisation of soils, plants and water supplies;

2. **Reduction in water quality and sanitation**. Water resource impacts due to rainfall uncertainty, increased frequency and magnitude of droughts, reduced quantity and quality of water resources and salinization would be affected. Hence, livelihood security of communities may be affected by decreased agricultural productivity and habitat security may also be adversely affected by water borne diseases;

3. **Death of coral reefs**. Coral reefs' health may decline causing reef degradation as a result of

increased sea surface temperatures (SST) and increased ocean acidity. Consequently, community livelihood security may be compromised by reductions in fisheries and other marine resources who are dependent upon healthy coral environment. Land security may also be reduced by increased exposure to high waves and storm surge;

4. **Decline in agriculture production and crop yield**. Agricultural production may decline thus having adverse effects on a variety of processes. This is compounded by temperature rise, reduced water availability, salinisation, and exposure to tropical cyclones (wind, rain and wave damage). Subsequently, this may reduce agricultural productivity and yield thus affecting the livelihood security of the people. If the weather is extremely severe, it may render some locations to become uninhabitable and unproductive; and

5. **Increase disease prevalence**. Human health challenges can occur resulting in changing disease vectors such as malaria, dengue, increased incidence of water borne disease, and increased incidence of heat related diseases. Consequently, the effects on human health are likely to reduce the habitat security habitations and where severe may render some locations uninhabitable.

The above issues are cross-cutting and oftenoverlap with other development activities around energy, drinking water, resource and infrastructure development and land use at all levels – community, country, regional. Hence, adaptation is a priority for PNG. The PNG second national communication report to UNFCCC (GoPNG, 2014) identified several adaptation strategies and mechanism to these issues and they are:

- Improve the capacity of the institutions (national and local) to enhance risk assessment capability, considering scenarios of climate change impacts downscale to country, at sector and local level;
- Mainstreaming climate change concerns factored into national development plans (sectoral plans for national, provincial, districts and LLG);
- Adaptation research need to be conducted to fill knowledge gaps and ensure adaptability; and
- Target selected areas, ecosystems, and infrastructure, areas of special importance, as well as special vulnerable groups and make them resilient.

Once the above strategies are in place, the following adaptation measures should be undertaken, and may include:

- The key elements of the climate compatible development strategic approach where participation; partnership; targeting; learning by doing and replication are done;
- Addressing the issues highlighted above through biophysical as well as socio-economic interventions;
- Tackling climate challenges at different levels including community, LLG, district, provincial and national level; and
- Ensuring functional partnership across all levels of governments and across all departments, NGOs, and academic and research institutes (both national, regional and global) is achieved.

The following are some principles to guide the adaptation process because climate change impact and adaptation may create its own issues and misconception with the communities or people:

- The climate (and variability) change is a development challenge for all stakeholders and has no boundaries. The government must ensure there is appropriate budget made available;
- Building community resilience under girding livelihoods and reducing dependence on

ecologically fragile sources will be a tough ask and most people will not support. Hence gaining trust and support through education and awareness is vital;

- Integrating climate-related concerns in national development planning (climate compatible development at all levels) is necessary and must not be left until disaster struck; and
- Conduct analysis of global, regional and national impacts to form the basis for adaptation, including reliable data collection to make predictions need support from all sectors and people.

Detailed adaptation measures to climate change impacts in PNG are well documented in the second national communication report to the UNFCC.

Figure 3.37 is the graph from the Bureau of Meteorology, Australia showing the time series of minimum and maximum sea level tide from 1994 to 2018. The average sea tide level is above 0.5m-0.8m. Actual sea level is approximately 30mm per year. IPCC predicted the sea level to rise by 50cm in 2050 and 100cm in 2100. There are evidence that the sea level rise has reached 5-20m onshore in places like small atolls in Manus provinces. There are instances of King tides destroying coastlines in PNG, such as Western, East Sepik, Madang, and Manus, just to name a few. The effects were devastating, especially in low lying areas thus, causing coastal erosion, and destruction to crops, water sources, and cemeteries.

Figure 3.38 shows the rise in sea level on four atolls in Manus and New Island Provinces. A study by Wildlife Conservation Society (WCS) shows the areas of the four atolls affected were Andra with 23 ha, Limanak 51ha, Nonovaul with 92ha and Tugalop with 306ha. Using the sea level rise reference of 0.5m and 1m to measure the vulnerability of the island to rising sea level, the study shows that between 3-10% of atolls will be submerged under water at 0.5m. Andra has the highest percentage of 93% .In comparison to the percentage of land that are vulnerable to be inundated under the 1m range, 2-4% of the land will be submerged, with the highest recorded for Limanak at 14% (Kimagl, 2016).

Figure 3.39 depicts various sources of funding coming from bilateral and development partners in the pacific. Australia is the major source of aid for adaptation funds and dwarfed the funding coming from EU, New Zealand and others. Since 2014 to date, Australia has provide the biggest source of climate change adaptation funding to PNG for transport, disaster risk and management and climate change resilience, with US$615.7 mil. EU provided US$65mil for water and sanitation project while the World Bank provides US$ 6.5 mil for disaster risk management. ADB also support PNG with US$ 27 to build resilience to climate change risks. The USAID also sponsored programs such as capacity building for climate change champions with 0.49mil. There are other sources of funding over time but are not available during the write-up of this report.

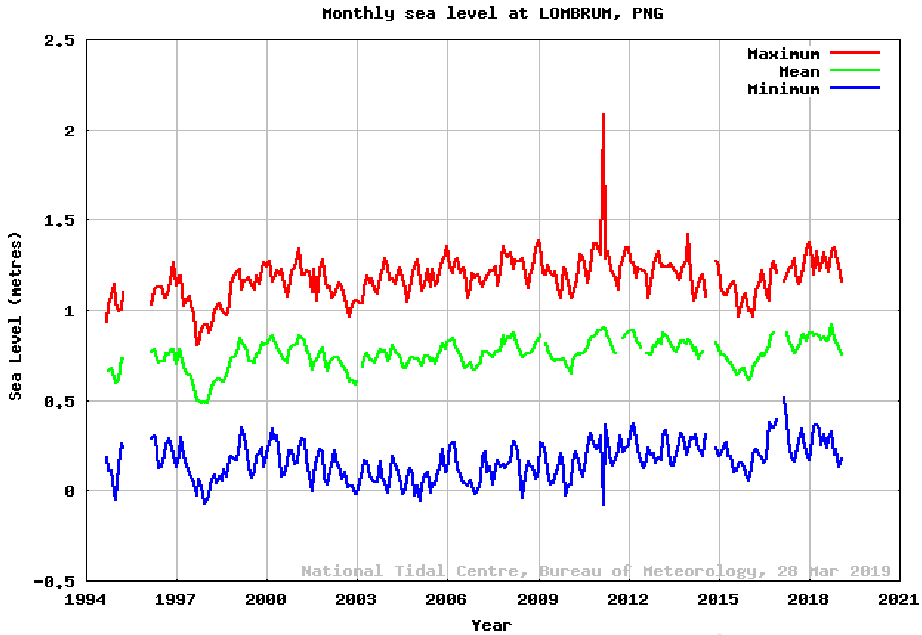


Figure 3.37: Montly sea level for Manus PNG (BOM, 2019)

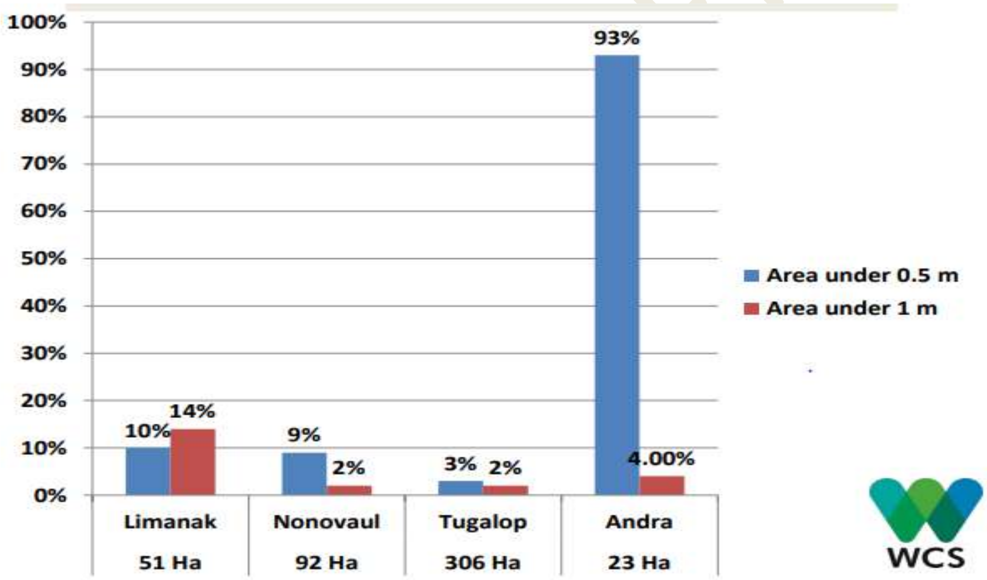


Figure 3.38: Percentage of land under sea as a result of rising sea level in four islands of Manus province (WCS)

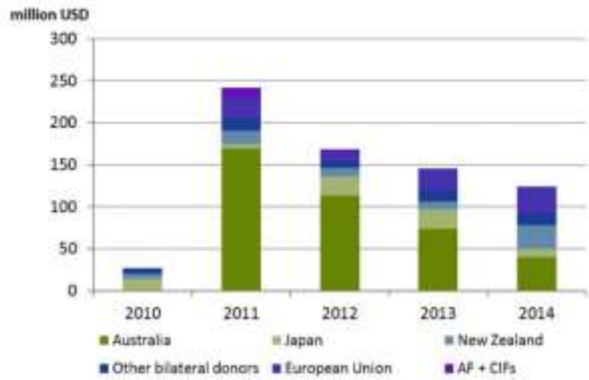


Figure 3.39: Overall climate change adaptation aid by donor from 2010-2014. ***A****F=Adaptation Fund, CIFs=Climate Investment Funds.* **(OCED; cited in Betzlod, 2016)**

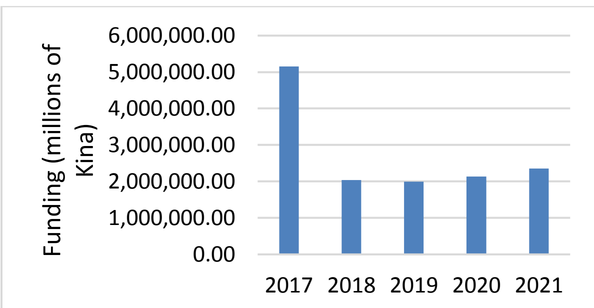


Figure 3.40: National Government Budget from 2017 to 2022). Figures for 2020 to 2022 are projected (GoPNG, 2018).

Figure 40 shows the actual government funding to NDC from 2017 to 2019, with projection being made for 2020 to 2022. Generally, the budget for NDC is very low and cannot support the impact caused by unpredictable natural disasters, including climate disasters. This is one area the government should increase funding because portion of the budgeted costs goes for operation functions and may not cover the 22 provinces in PNG.

Figure 41 is the budget allocation for Climate Change and Development Authority (CCDA) for "building resilience to climate change' project. The funding is a matching or counterpart funding. No funds were allocated in 2017 but in 2018 9.75 mil was allocated and in 2019 K14.46 mil. The funding was for CCDA achieve some of its project goals on climate adaptation.

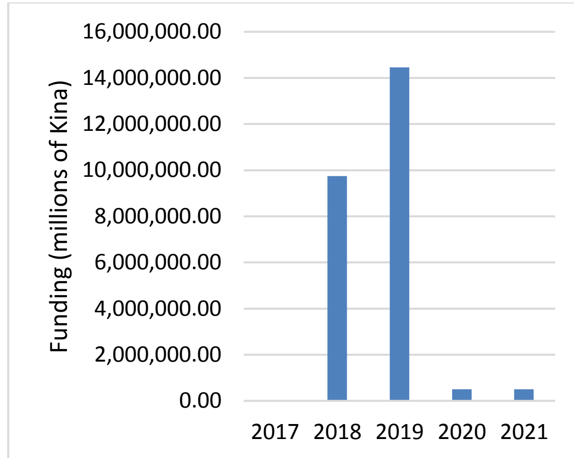


Figure 3.41: Funding allocation for CCDA with projection made for 2020-2022 (GoPNG, 2018)

Impact

The IPCC report showed that recent climate changes have had widespread impacts on human and natural systems because warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia (IPCC, 2015). The report iterates that atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen and recent climate changes have had widespread impacts on human and natural systems. In recent decades, changes in climate have been observed to cause impacts on sensitive natural and human systems on all continents and across the oceans as seen in Manus and Cartaress Island. Some sceptics may argue the earth's crust is moving and as a result causing islands and atolls to sink.

With sea-level rise, the estuarine area is dynamic. The mangrove ecosystem has been exploited and often cleared previously but with education and advocacy there is drastic turn around and improvement in people's behaviour. Within Central Province, there are ongoing mangrove rehabilitation and replanting projects with many different communities. With the support of USAID PACAM, the PNGCLMA together in partnership with local communities engaged with the women mud crab harvesters to initiate mangrove rehabilitation with the support of their village chiefs.

Mangrove Nursery and planting out Hall Sound, Central Province (PNGCLMA, 2018)

The National Fisheries Authority (NFA) has an established nursery that also assists in the planting out of seedlings along coastal systems to the east and west of the capital Port Moresby.

These built upon the USAID supported MARSH (Mangrove) Project worked with these partners plus the then OCCD now CCDA, UPNG, PNGADP (PNG Assembly Disabled Persons) and PwM (Partners with Melanesians) and had an extent of NCD, Central, Manus, New Britain and New Ireland Provinces and ran from 2012-2017 with the aim of building resilience in communities and to reduce forest degradation.

Climate changes are also predicted to lead to changes in many extreme weather and climate events. Some of these changes have been linked to human influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions such as rainfall and cyclones (IPCC, 2015).

Thus, IPCC argued that continued emission of greenhouse gases will cause exacerbate warming and long-lasting changes in all components of the climate system, thus increasing the likelihood of severe, pervasive and irreversible impacts affecting both people and ecosystems.

Limiting climate change is challenging and would require substantial and sustained effort in the reductions in GHG emissions which, together with adaptation, can limit climate change risks. There are multiple mitigation pathways that are likely to limit warming to below 2°C relative to pre-industrial levels to address global warming and this must take place at the global and regional scale, and country level (IPCC, 2015). If no effort is made and countries persist to continue to do things on business as usual, then adaptation measures must be undertaken. IPCC states that there are many adaptation and mitigation options that address climate change, but there is no single suitable option.

Therefore, effective implementation of Government polices depends on cooperation at all scales and can be enhanced through integrated responses that link adaptation and mitigation with other societal objectives (IPCC, 2015). Some of which have been identified above and in the PNG second communication report to UNFCCC. Others have been suggested by organisations such as IPCC. Adaptation and mitigation responses are underpinned by common enabling factors. These include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods and behavioural and lifestyle choices (IPCC, 2015).

Adaptation options exist in all sectors, but their context for implementation and potential to reduce climate-related risks differs across sectors and regions. Some adaptation responses involve significant co-benefits, synergies and trade-offs. Increasing climate change will increase challenges for many adaptation options.

Response and Recommendations

Increase funding for NDC and CCDA to cater for unpredictable disasters and adaption work is the major set-back. NDC has to work in and CCDA has to work in collaboration with other government agencies to implement disaster management work. Agencies such as CEPA, DAL, NFA and others can work in tandem with those two organisations in partnership to deliver awareness to the wider public on climate adaptation, species conservation, food security, sanitation and other areas of interest. NDC also need to work with the National Maritime Services, the Volcano Observatory and others to maintain or improve early warning systems to ensure they become reliable. Training and capacity building needs improvement.

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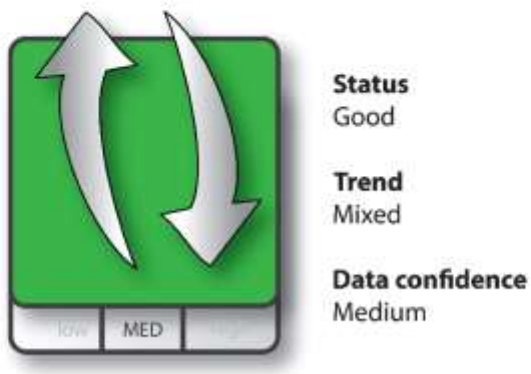
8.2.8. TOPIC/SUBTOPIC: RENEWABLE ENERGY

Indicator Definition: Trend in percentage production of energy from renewable sources

Status and Trend




Sirunumu hydro dam in Sogeri, Central province (Photo by E. Kaitokai)

SDG/CBD Targets

SDG: 7.1.1, 7.1.2, 7.2.1, 7.3.17.a.1, 7.b.1, 9.4.19.5.1, 9.a.1, 9.b.1, 11.2.1, 11.3.1, 11.3.2, 11.6.1, 11.a.1, 13.2.1, 13.3.2, 13.a.1, 13.b.1

Aichi Target: 4, 8

Status and Trend Discussion

PNG is an energy resource rich country with a diversified portfolio of potential energy assets. Its self-sufficiency in fossil fuels is unusual among Pacific nations because most of it are exported than used in the country. It also has a large hydro potential. The current energy consumption rate in PNG mostly depends on three main fuels; electricity, oil and biomass. In terms of primary energy supply in 2011, hydro accounted for approximately 57%, oil products 37% and biomass, gas and geothermal power the remaining 6% (Oxford Business Week, 2015). The energy sector accounts for 14% of the country's GDP. With the available information, it is estimated that electricity comprises only 24 % of the total energy and transport accounts for 60% and other accounts for 16% in PNG. Annual consumption of energy has rapidly increased over the years mainly due to increase in the population and number of customers from industrial to household sectors and increase used car imports into the country. The energy most important measure in the energy balance of Papua New Guinea is the total consumption of 3.24 billion kWh of electric energy per year. Per capita this is an average of 392 kWh (WorldData, 2019).

The rate PNG's energy consumption per capita is 50% below World Bank lower middle income. Increasing the rate of sustainable energy consumption in PNG is one of the main development focus that is outlined in the PNG's development plans. With a population of 8 million plus people, of which only about 12.5% are estimated to live in urban areas, it is principally the urban areas that have access to grid connected electricity, and it is estimated that less than 10% of the total population has electricity access (Oxford Business Week, 2015). Electricity access in rural areas is estimated to be under 3.7%, and parts of the country not covered by the utility grid are powered by mini-grids, which are predominantly powered by diesel. The total production of all electric energy producing facilities is in PNG is estimated at 3 bn kWh, which also comprise of 108% of the country's own requirements (WorldDat, 2019).

While it is important to recognize that off-grid PNG households are at the bottom of the spectrum of CO_2 emitters, the burning of kerosene and particularly diesel do create significant emissions. Papua New Guinea's CO_2 emissions from the combustion of fuels are projected to reach 14.8 million tonnes in 2035, which is almost a 2.8 times increase from the 2010 level of 5.5 million tonnes. In 2035, electricity generation and other transformation are projected to contribute the largest shares of CO_2 emissions, followed by industry and transport.

Since PNG's economic performance continues to grow strongly in recent years, so too its demand for energy supply will increase. Thus, energy production, distribution, transmission and management is critical for the development and growth of the country. The total primary energy supply estimated in 2007 was 1,835 kilotonnes oil equivalent (ktoe) of which oil and petroleum products account for 78%, natural gas 18% and other fuels (GoPNG, 2014). Since then, the total installed electricity capacity in 2010 was 582 megawatt (MW). ADB estimated that total national power generation capacity is around 582 MW, less than the output of a single large power plant in many countries (ADB, 2015).

Without a coal mining industry that can supply cheap fuel for its power plants like many other countries, PNG has historically relied on renewable sources for power generation supplemented by diesel-fired generators. Hydropower plants form the single largest contributor to the national power grid with 230 MW of installed capacity, or 39.1% of the total. Diesel generators run a close second with 217 MW or 37.4%, followed by gasfired with 82 MW or 14.1% and 53 MW of geothermal power production or 9.1% (Oxford Business Week, 2015). PNG main energy comes from fossil fuel (oil and gas) and renewable energy (hydro, biomass, and geothermal) resources but only 12% of its population has access to electricity (ADB, 2018). Petroleum products catered for 82% of energy, geothermal with 15% and hydropower with 3% of all energy supply in PNG (APERC, 2017).

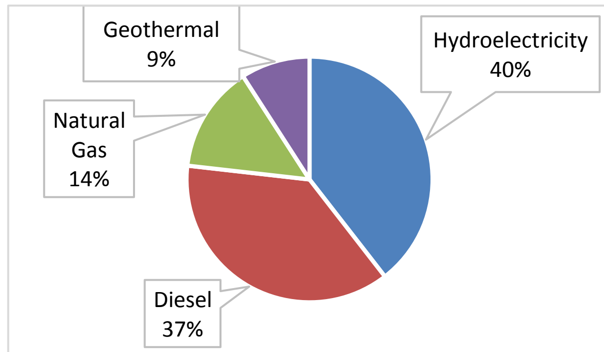


Figure 3.42: Energy demand by diferent sources (GoPNG, 2014)

Figure 2.42 shows hydro-electricity is the most common form of energy source with 39.5%, followed by diesel with 37.3%, natural gas with 14.1%, and geothermal with 9.1%. Apart from hydro and geothermal, there are great potential for the development of other clean and renewable energy sources such as wind, biomass, ocean and solar.

PNG has volunteered to undertake the sixth peer review on low carbon energy supply policy, after Thailand; the Philippines; Indonesia; Malaysia and Viet Nam (APERC, 2017). Even though PNG is strategically positioned and has a wealth of natural resources and potential to invest in renewable energy options, and to promote low carbon energy development in the economy, its current renewable energy capacity is far below its potential. Hydropower is the most dominant energy resource, however, it has less than 2% of its potential capacity installed in the economy. Thus PNG's energy consumption is one of the lowest compared to the OECD nations.

Despite PNG enjoying about 8% in GDP growth over the last decade, her development aspirations were not fulfilled because of the challenging economic conditions such as high debt services, low prices of commodities and poor service delivery by the government. Few rural electrification programs were done in some rural areas. Currently, the Asian Development Bank (ADB) is supporting the government's energy program with $238 million of ongoing investments projects in the country. These projects are scaling up renewable energy development and expanding transmission and distribution networks. At the 2018 Asia Pacific Economic Countries (APEC) Leader's Summit in Port Moresby in December, the governments of Japan, Australia, United States of America and New Zealand pledged to invest in the energy sector to provide electricity for PNG, covering 70% of the population by 2030. This program was launched in March 2019 in Goroka. Some private companies from China have also partnered with PNG Power Ltd to develop Ramu 2 and Naoro-Brown Hydro dam projects in Morobe/Eastern Highlands province and Central province as well. In addition, the developer of the PNG LNG also proposed to use the LNG gas to powered homes in Hela Province and Port Moresby. Consequently, these projects would help lower electricity costs, and meeting power demand across PNG.

Access to electricity is seen as a basic social need and an important driver of development to improve living standards as a basic social need. Women and children are particularly disadvantaged by this very low access, as electricity is seen as critical for complementing basic education needs and providing competent health facilities. The PNG Government recognises this as a major development priority, hence capture as one of the objectives of the Vision 2050 development plan to achieve 100% electrification by 2050 (GoPNG, 2009). Currently, PNG Power Limited, the agency responsible for all energy development in PNG, envisaged to increase its sales from 76,000 customers to 103,000 customers, but problem of unprofitability has been a major setback to expand its commercial interest in both rural and urban areas.

Since independence, PNG's electricity supply was very low. Between 2008-2009, PNG produced an estimated 547MW (40 hydro and 38% thermal) energy. More recently, its capacity has increased to approximately 260 MW (66% hydro, 44% thermal) with independent power producers, mainly mining and oil and gas companies adding 50 MW of thermal capacity. Approximately 280 MW is generated by the mining industry as captive power for their own consumption (ADB, 2018). According to an APEC report in 2009, PNG's primary energy supply was projected to increase at a rate of 5.1% from 1.8 MTOE in 2005 to 6.3 MTOE in 2030 (APECR, 2017).

Even tthough PNG is a net energy exporter (exporting oil and gas to overseas markets), it is not utilising its oil and gas produced locally. The reason is because the government did not initially agree to terms with the developers to manufacture or use those petroleum products on shore. This resulted in higher import of oil and petroleum products from overseas markets to meet the short fall as well. In recent times, the prices of oil and petroleum also decline between 2013 and 2014 because PNG went through a mini recession where availability of US dollar to purchase goods and services from overseas was affected by falling *Kina* value and lack of US dollars for purchase of goods and services. Consequently in 2013, the net energy imports accounted for 72.4% of the TPES compared to 2014 where net energy imports accounted for 84.5%, a 12.1% increase from the 2013 level. Net imported energy in 2014 comprised of nearly 100% oil and oil products (APECR, 2017).

Figure 3.43 shows imported oil and petroleum products are the leading source of energy despite PNG producing oil and gas in country. There are also some biodiesel and ethanol produced by some agriculture firms namely New

Britain Palm Oil Ltd but these were not capture in those percentages indicated above. Thus, total final energy consumption (TFEC) in 2014 reached 1.194 MTOE, a 5.1% increase from 2013 level of 1.133 MTOE. By sector uses, the transport sector remained as the biggest energy consuming sector in 2013 (APECR, 2017).

Figure 3.44 shows the biggest energy demand is from the transport sector with 49% followed by Industry with 37% and residential with 14% (APECR, 2017). Another report by the European Union shows a detailed break-up of the energy uses in PNG. Figure 3.45 shows the Road Transport sector is the biggest energy user with 47.5% followed by Aviation with 8.6%, Shipping (domestic and international bunkers) with 8.0%, Other Transport with 0.4% and shipping with 0.2%.

The next highest sector using energy is the non-energy sector with 14.5% compared to the energy sector with 5.4% while the residential energy use is 5.9%. The industry consumes or uses 4.8% energy , agriculture and forestry uses 2.2%, and services with 2.5% (EU, 2016).

Moreover, Figure 3.46 indicates the renewable enegy is roughly around 70% and has been decreasing slighly from 72% in 1990 down to 60% in 2015 (WorldData, 2019). The reason probably is because of increasing demand for electricity.

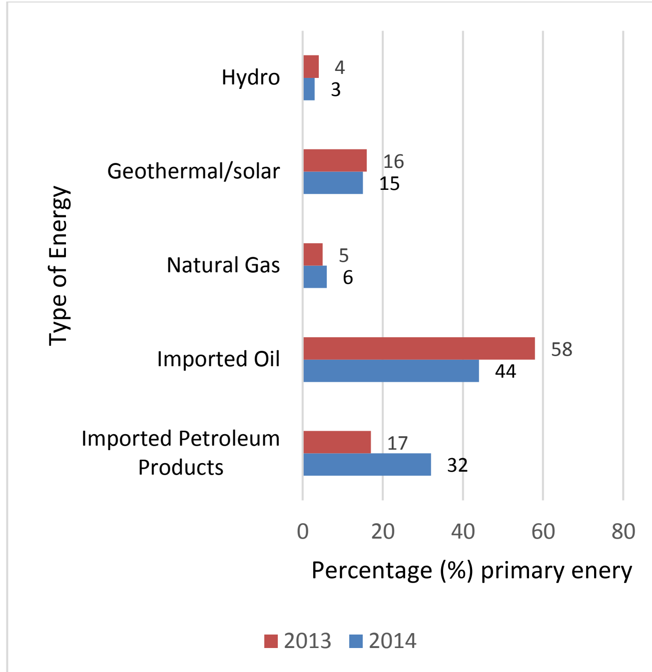


Figure 3.43: Type of energy used between 2013 and 2014 (APECR, 2017)

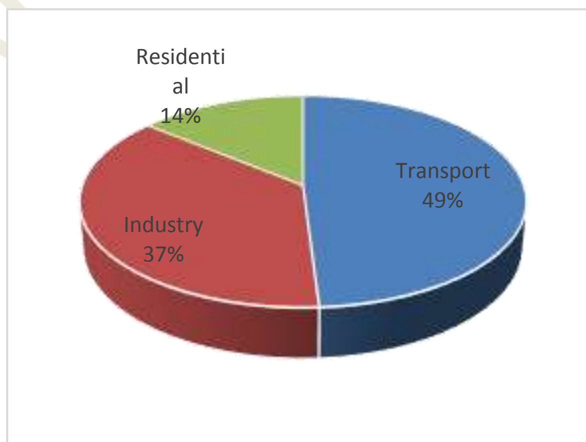


Figure 3.44: Three main energy sectors and their percentage of consumption (APECR, 2017)

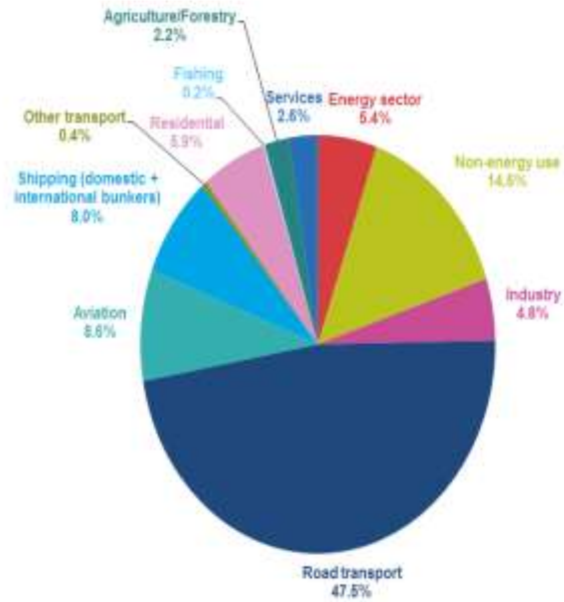


Figure 3.45: Energy use and consumption by different sectors in PNG (EU, 2016)

Table 3.4 shows the envisage Plan of using various clean energy to meet PNG's energy demand by 2030 and 2050 by tripling and doubling respectively. There are plans to increase the capacity over time and 2050, renewable energy from hydro would produce about 3680MW, followed by geothermal with 110MW, solar with 35 MW, biomass with 34MW, wind with 20MW and ocean with 5MW.If this plan cannot be implement with those of PNG's development partners, the vision of ensuring 70% of Papua New Guineas are connected to some form of clean energy or the country mitigating on reducing GHG cannot be realised. PNG has a policy of being fully renewable in its energy use by 2030.

The aim now is for PNG is to reduce its GHG emissions by increase usage of clean energy sources. With the support from big economies and developed countries and the private public [partnerships (PPP), drastic steps in addressing energy issues and GHG emissions through technological transfer and financing may become immenent. That is one of the major reason PNG has been at the forefront with Coaster Rica, in the Coalition for Tropical Rainforest Nations in advocating and promoting REDD+ through forest conservation and carbon trade and getting compensated from emitters, especially developed and industrialised nations. Howvere, this program is still lagging behind and not much being achieved thus far. Also, increase in demand for renewable energy is timely for PNG as development challenges are lurking.

Table 1: Renewable energy installation atrgets (APECR, 2017)

SECTOR	INSTALLED CAPACITY (MW)	TRIPLING EXISTING CAPACITY BY 2030 AND COVER THERMAL					2030 TARGET 2500 MW	DOUBLING 2030 TARGET TO 2050 (5000MW)					2050 TARGET 5000 MW
		2011 - 2014	2015 - 2018	2019 - 2022	2023 - 2026	2027 - 2030		2031 - 2034	2035 - 2038	2039 - 2042	2043 - 2046	2047 - 2050	
HYDRO		255.0	25.0	394.0	900.0	164.0	1483.0	654.0	826.0	0.0	2200.0	0.0	3680.0
BIOMASS		0.0	30.0	0.0	32.0	0.0	62.0	0.0	2.0	30.0	2.0	0.0	34.0
SOLAR		0.0	0.0	50.0	0.0	15.0	65.0	15.0	5.0	15.0	0.0	0.0	35.0
WIND		0.0	0.0	10.0	10.0	10.0	30.0	0.0	20.0	0.0	0.0	0.0	20.0
OCEAN		0.0	0.0	5.0	0.0	0.0	5.0	0.0	5.0	0.0	0.0	0.0	5.0
GEOTHERMAL		0.0	0.0	5.0	40.0	50.0	95.0	0.0	20.0	0.0	50.0	40.0	110.0
TOTAL PNG		255.0	55.0	464.0	982.0	239.0	1740.0	669.0	878.0	45.0	2252.0	40.0	3884.0

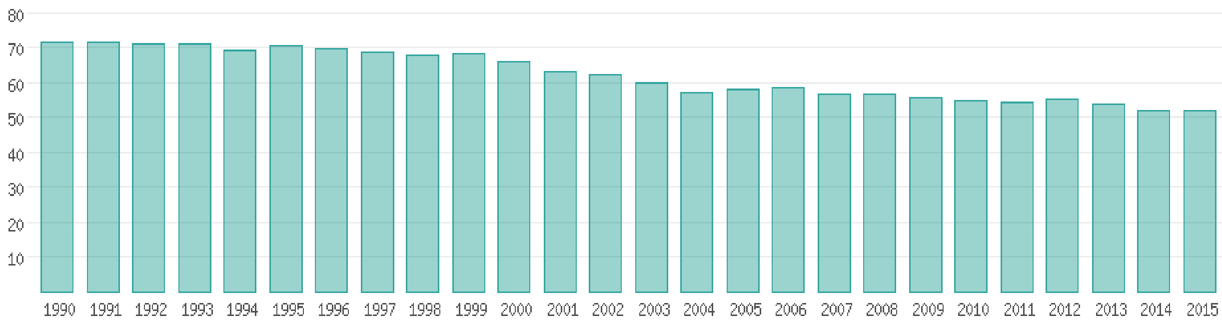


Figure 3.46: Percentage share of renewable energy from 1990 to 2015 (WorldData, 2019)

Impact

Continued economic growth with the increasing exponential population rate in recent years is driving demand for electricity and other energy needs across PNG. This exerts pressure on the capability of the country's primary grid networks. Only around 10-12% of PNG's population has access to electricity, but often those who are connected to a grid still experience frequent blackouts and inconsistent supply. In order to counteract this unreliability, urban areas have considerable self-generation and backup generation capacity, which is expensive and inefficient to operate and maintain by private operators and business houses (Oxford Business Week, 2015).

In recent memory, the national government is trying to roll-out rural electrification programs, yet much of these has not been accomplished fully. In addition to this, provincial governments are responsible for maintaining a number of stand-alone rural generation facilities, some churches also provide electricity to villages that are off the grid and the larger mining and oil and gas sites sometimes provide power to adjacent communities (Oxford Business Week, 2015).

Hence, PPL in partnership with the government has embarked on a number of initiatives intended to extend power access throughout the country, as well as to shore up the existing network to ensure adequate and consistent power supply is provided. These programmes include the ongoing $83m Port Moresby Power Grid Development Project, rolled out with the help of the ADB, and the Ramu Transmission System Reinforcement Project, launched in 2013 in conjunction with the Japan International Cooperation Agency and the Town Electrification Investment Programme (Oxford Business Week, 2015).

A number of new power generation projects are currently in various stages of development, and if completed, would increase current capacity many times over. Numerous hydroelectric power projects are already under way to take advantage of PNG's underutilised hydro resources, estimated by the International Energy Agency at 4200 MW for technical and economically viable resources (Oxford Business Week, 2015).

Tapping into this latent potential is a cornerstone of the government's Strategic Development Plan 2010- 30, which targets a national electrification goal of 70% by the end of 2030. This would require a near quadrupling in total capacity from roughly 500 MW (Oxford Business Week, 2015). Moreover, Exxon Mobil, operator of the PNG liquefied natural gas (LNG) project, and the government signed a memorandum of understanding in January 2015 for the former to supply up to 20m standard cu feet per day of domestic natural gas for 20 years to power a 25-MW thermal plant feeding into the Port Moresby grid. Similar agreements were also signed during the APEC Leaders' Summit in Port Moresby in 2018, by the governments of PNG, Japan, Australia, US and New Zealand to supply 70% of electricity across PNG by 2030.

In spite of the government plans to increase electrification across the country, numerous challenges in PNG have thwarted a smooth rollout of new power infrastructure. While the government has received aid from its partners in various projects, PPL often lacks the resources and funding to carry out the growing list of development initiatives it is tasked with, including the rehabilitation of existing infrastructure to improve reliability, the extension of grids to service the growing urban population and the expansion of disaggregated generation to serve the rural population. (Oxford Business Week, 2015). As a result of outdated and poorly maintained transmission lines and substations, power transmission and distribution system losses account for 20% of the energy PPL handles.

Other contributing factors include difficult geographical conditions, operational issues linked to technical and management capacity, investment disincentives related to the single national tariff structure and high up-front costs for power generation in rural areas. Compounding these challenges is a long-running problem facing PPL in which the state-owned enterprise has been unable to collect large amounts of past-due bills, many of which are for other public firms or large companies that have racked up millions in unpaid charges. (Oxford Business Week, 2015).

The financial support from the development partners is a major step to increasing energy efficiency, demand and supply in PNG to realise the Vision 2050 and the National Development Plan Strategy 2010-2050 for energy efficiency. In addition, the electricity Industry Policy and the National Electrification Roll Out Plan need to be implemented immediately. This is now being supported by the World Bank and the government of PNG and implemented by the Department of Petroleum and Energy to achieve its goals and objectives. Hence the government need ensure PNG triple the current capacity of mixed supply of 800 MW to 2 500 MW by 2030.

Response and Recommendations

Proper assessment and reporting process on climate change impact and adaption, mitigation measures, technology development and transfer must be done. Enabling environments such as technology transfer and financing, improving capacity for institutions, and ensure education, training and awareness raising are important that target vulnerable sectors, ecosystems and infrastructures. Proper development planning is of essence. Set priorities for climate change adaptation and compatible development, and developing financing instruments may ensure PNG become resilient to climate change impacts.

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8.3. THEME 3: FRESHWATER RESOURCE

8.3.1 Overview

The hydrological cycle in PNG is determined by the topography and climatic conditions, which influences the moisture condition throughout the year. For instance, the central mountain ranges provide a rain shadow effect for rainfall patterns experienced around the Port Moresby area, thus producing that distinct dry-wet condition. Consequently, it results in the dry savannah vegetation of the region. The vast open sea of the southern region also influence the trade wind conditions thus influence the savannah/monsoon forest of the South Fly district of Western Province.

Generally, the central Cordirella serves as the major divide causing all river systems to drain either north into the Bismarck Sea or south into the Coral Sea. The northern side of the mainland is mainly drained by the Sepik, Ramu and Markham rivers while the main drainage channels in the southern side are the Fly, Purari and Kikori as well as numerous other smaller rivers (SPREP, 2007). The bigger islands east of the mainland such as New Britain, New Ireland, Bougainville and Manus are drained by several large rivers. The heavy rainfall in the interior of the country, high altitude and steep slopes produce fast flowing rivers with high erosive capacity. Flow rates drop significantly in the lower reaches of the larger mainland rivers where seasonal floods are a normal feature.

According to SPREP (2007), soil water infiltration, soil moisture and groundwater are dependent on rainfall, topography, vegetation cover, soil type and geological conditions, whereas the availability of soil moisture and groundwater is locality based. Groundwater is present in both confined and unconfined aquifers, with the amount and quality varying form one location to another. Alluvial fans in valleys and coastal plains and in close proximity to surface water bodies appear to contain most of the groundwater resources while large limestone areas provide underground channels and storages for groundwater. Many rural communities, including urban dwellers in Papua New Guinea need safer and clean water as their basic human rights. The Agenda 2030 of the Sustainable Development Goal also promotes safer water for the planet's inhabitants.

With increasing human population and impact on the environment, most rivers and lakes are under threats. This is coupled with natural climate change phenomena that affects access to safer clean water as well. This Chapter discusses two indicators: 1) Access to freshwater; and 2) Freshwater quality.

8.3.2 FRESHWATER RESOURCE HIGHLIGHTS

TOPIC	STATUS & TREND	KEY FINDINGS	RESPONSE AND RECOMMENDATIONS
ACCESS TO QUALITY OF DRINKING WATER		60% of the population of 8 million people in PNG (4.8 million people) live without a safe water supply, with PNG having one of the poorest access to clean compared to the rest of the world. The volume of renewable water available per person per year in PNG is 111,762 m^3. Only 40% of PNG has access to an improved drinking water source. Iimproved water sources in rural population and urban population is almost 30% and 90% respectively.	Any future development work on water supply and access to clean and safer water must work toward achieving the WaSH Policy 2015-2030, and other polices such as MTDP3, DSP 2010-2030 and Vision 2050 policies, and improve water quality and accessibility in the country. Capacity building, improve institutions and infrastructure, collaboration, funding, data collection and strategy are vital to achieve the Wash Policy target.
FRESHWATER QUALITY		60% of the PNG's population not only live without a safe water supply but has the poorest access to clean water in the world. The current baseline indicates that only 40% of over 4.8 million rural population have access to safe water. The urban population has 90% access to safe water. Remarkably, about 50% of health and education institutions in the country have access to safe water and improved sanitation services.	Collaborative partnership and working towards achieving the government policies is important to ensure better water quality is distributed to all Papua New Guineas. Institutional capacity building and increase resources would enable better data collection and management as well to improve service delivery

8.4.3 TOPIC/SUBTOPIC: ACCESS TO FRESHWATER

Indicator Definition: Percentage (%) of population having access to safe and clean water

Status and Trend

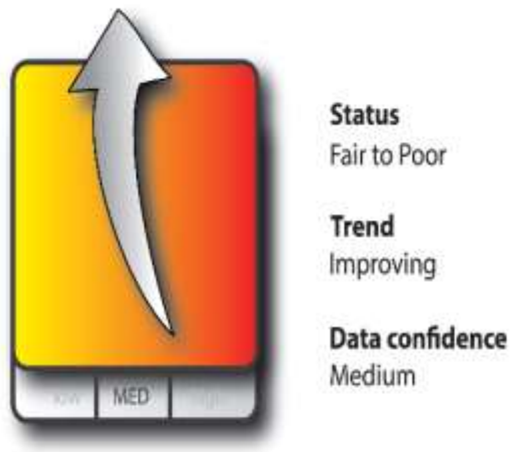

Photo: Lake Kutubu Wildlife Management Area is a major water source for the livelihood of the people

SDG/CBD Targets

SDG:1.4.1, 1.5.3, 3.2.1, 3.3.5, 3.9.2, 6.1.1, 6.3.2, 6.4.1, 6.5.1, 6.6.1, 6.a.1, 6.b.1, 12.1.1, 13.1.2, 17.3.1

Aichi Target: 4, 5, 8, 11, 14

Status and Trend Discussion

PNG is situated in the tropics where high rainfall is often experienced, with rainfall variability experienced in certain parts of the country which experience drier conditions such as Western, Central Gulf, Morobe, and Milne Bay provinces. The rainfall ranges from 1000mmm-8600mm per annum (Bryan and Shearman, eds. 2008). Figure 3.47 and 3.48 shows the rainfall variability and average rainfall across the country. Generally, rainfall is influence by topography, geomorphology of the area, ocean and wind patterns. Although water resources are finite, they are also fragile, particularly in atoll environments, and drier parts of the country. In recent times, water is increasingly under pressure due to the effects of climate change, population growth, urbanisation, economic development, the waste steam and other pressures.

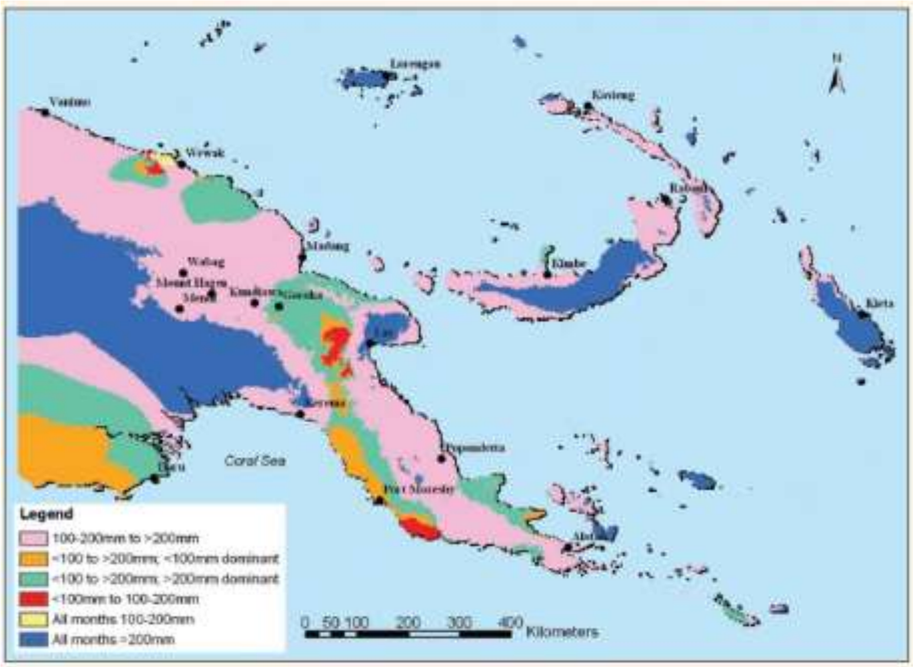

Figure 3.47: Rainfall seasonality across PNG (Bryan and Shearman, eds.2008).

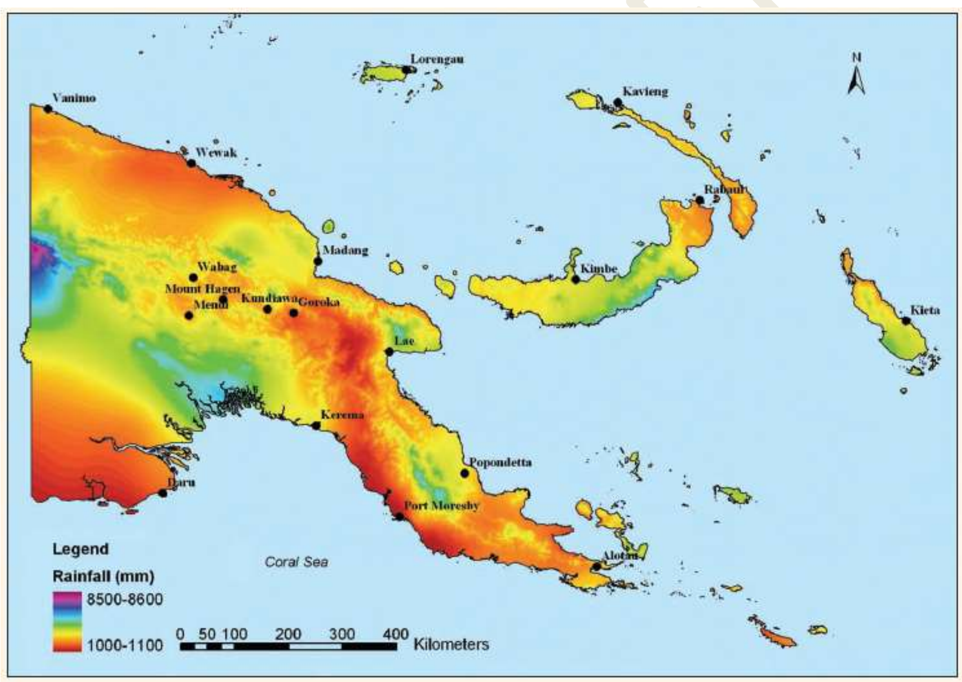

Figure 3.48: Annual rainfall distribution pattern across PNG (Bryan and Shearman, eds. 2008)

Over 80% of PNG's eight million people live in rural areas and the rest live in small urban centers, the majority of these centers have a population of well below 30,000 people. Only Port Moresby and Lae have sizable populations at over 365,000 and 88,000 respectively.

According to WaterAid, almost 60% of the population or 4.8 million people live without a safe water supply, has the poorest access to clean compared to the rest of the world (Kwaeifio-Okai, 2016). The volume of renewable water available per person per year in PNG is 111,762 m^3 (SYB, 2014). Figure 3.49 shows is still PNG is still far behind in improved water sources and accessibility in the world. Only 40% of PNG has access to an improved drinking water source using piped water on premises (piped household water connection located inside the user's dwelling, plot or yard), and other improved drinking water sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection (Richie and Roser, 2019).

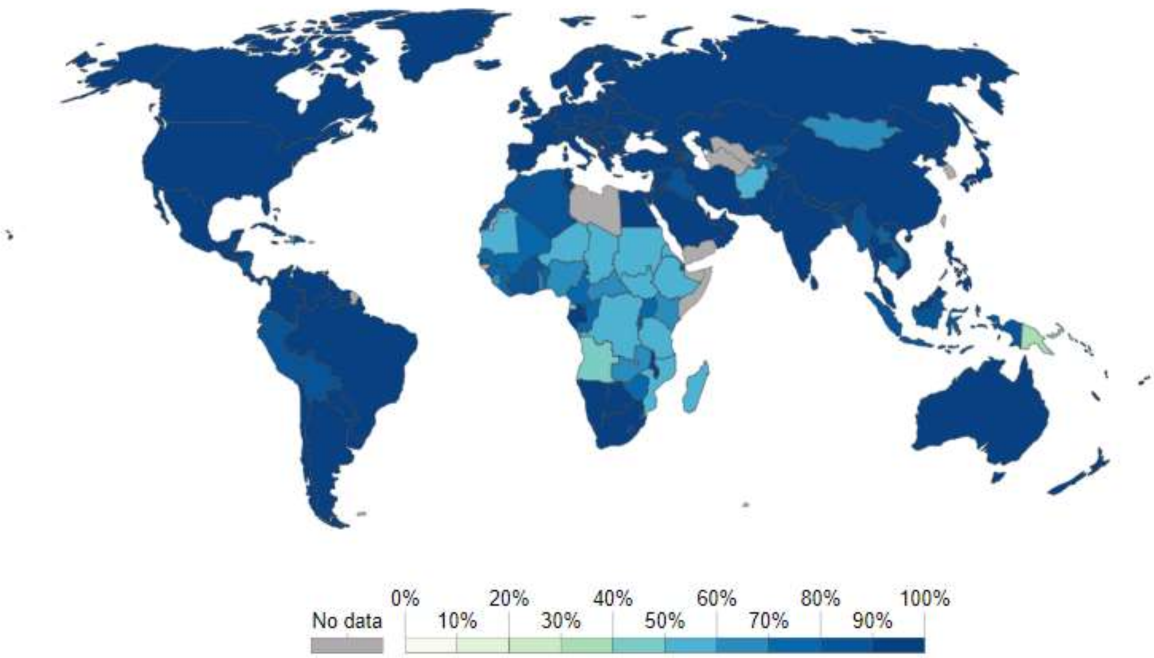

Figure 3.49: Global share of population with access to clean dirinking water in 2015 (World Bank WDI; in Richie and Rossie, 2019)

Water channel in the Kokori River Basin (B. Bito)

In PNG, water is abundant in some places whilst it is a scarce and vital resource in other places where pronounced dry seasons are experience such as in some parts of Western, Central, Gulf, Milne Bay, Morobe, East Sepik and Eastern Highlands provinces. Moreover, PNG also experience climate variability where some parts of the country experience drier conditions with less rainfall than others. Some parts of the country also are indundated with water periodically, seasonally or over long term.

Figure 50 shows these places are found in the major river ctahcment of the country. Hence majority of the people who live in those places, especially rual areas, do not have access to clean water. They either take water directly from the river, streams and lakes for cooking, drinking and washing. Most water used for drinking and cooking are not treated. The main uses of water in PNG is for domestic purposes for washing, cooking, bathing, and aquatic resource gathering in the rural communities (SPREP, 2007). The river systems serves people with water, food and transportation.

The major rivers in PNG also provides easy access to place using the mode for transport that is suitable for each region such as big barges to travel up and down major rivers like the Fly and Sepik or outboard motors, and canoes for travelling in small or big rivers and streams. The local community uses are for food gathering especially for communities who depend on waterways to sustain their living. Edible fish, molluscs and aquatic weeds are gathered from the wetlands all around PNG (SPREP, 2007).

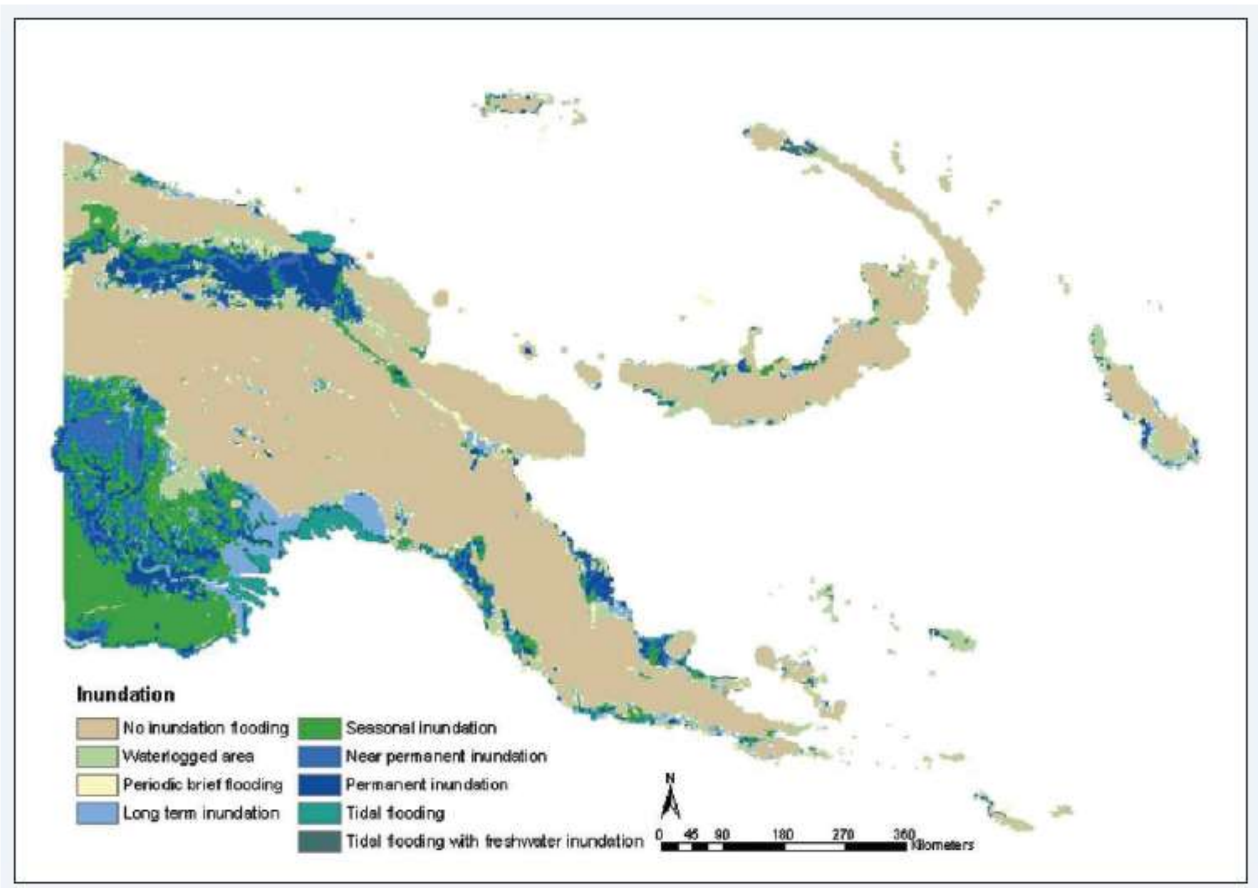

Figure 50: Inuandatration flooding areas of PNG (Bryan and Shearman, eds. 2008)

Little children enjoying their bath in a small stream in Bulolo

The main sources of fresh water in urban areas in PNG comes from rainfall harvesting and groundwater, from major rivers and streams. Despite relatively high rainfall, the limited storage capacity and aging reticulated water system means the public water supply is rationed. Under non-drought conditions (i.e. normal operating conditions), the public water supply operates without rationing (SPREP, 2007). However, there is a need to upgrade and improve the city and urban water systems in order to make water more available in some area where it is needed most. During the *El-Nino* periods in 1987, 1997, and 2015 in Port Moresby for instance, the public water supply was exhausted to the extent where water was rationed during the day and evening to manage and relieve the water crisis. The main sources of water in the urban centres comes from rainwater and groundwater (rivers and streams). In the outer islands, the main water resources are rainwater and groundwater. In the urban areas, the main use for water is for domestic and industrial purposes while other uses of freshwater include hydropower generation, mode for transportation and small scale irrigation (SPREP, 2007).

Figure 3.51 and 3.52 indicates level of improved water sources in rural population and urban population is almost 30% and 90% respectively. Access to an improved water source, rural and urban areas refers to the percentage of the population using an improved drinking water source in their premises. The improved drinking water source includes piped water on premises (piped household water connection located inside the user's dwelling, plot or yard), and other improved drinking water sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection).

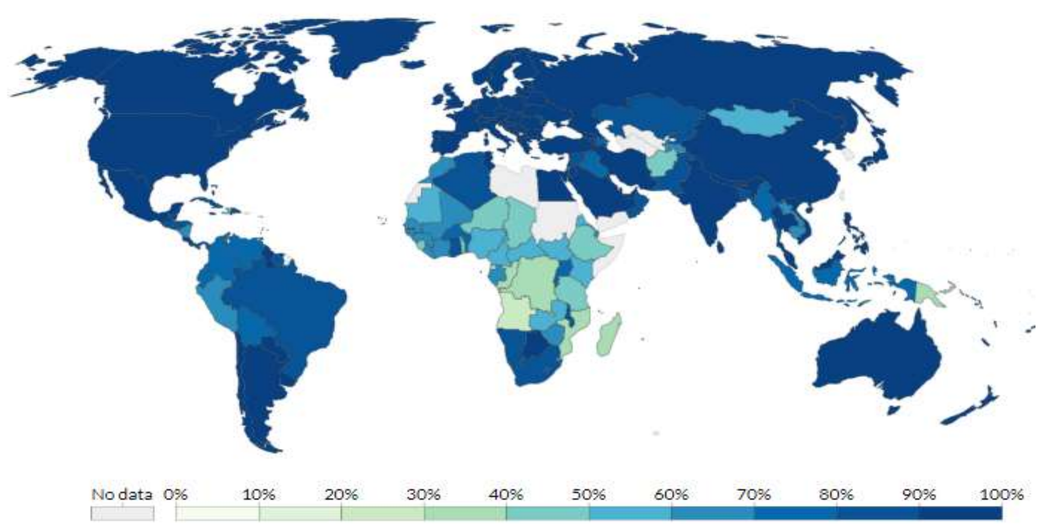

Figure 3.51: Share of access by rural population with imporoved water sources (World Bank WDI; in Richie and Roser, 2019)

Access to improved water across PNG improved slightly between 1990 and 2011, from 33% to 40%. Each year, access to water and sanitation services deteriorates in proportion to the increasing population, meaning that more people are without water supply and sanitation today than they were two decades ago (GoPNG, 2015). The extraction, treatment, and sanitation and distribution of water and collection, treatment and discharge of waste water, are the functions of two state owned utilities provider (Eda Ranu and Water PNG) established under the National Water Supply and Sewage Act 1986. Currently, there are a number of agencies dealing with water supply schemes in PNG where some are privately owned and operated. Water PNG and Eda Ranu has been mandated to build, operate and manage water supply and wastewater treatment systems. In Port Moresby and Goroka, water is managed by the local municipality namely National Capital District Commission and Goroka Town Authority respectively (SPREP, 2007).

Water PNG uses both surface and groundwater sources for supplies for the rest of the 17 Provinces. In the rural communities, several donor funded projects under European Union (EU), Asian Development Bank (ADB), WaterAid, Japanese International Cooperation Agency (JICA), including the national government through local members of parliament and districts at the local level government (LLG) level provides small-scale water supply systems that can be managed by the community. The rest of the rural community depends on rainwater, shallow wells or direct use of streams for domestic purposes (SPREP, 2007).

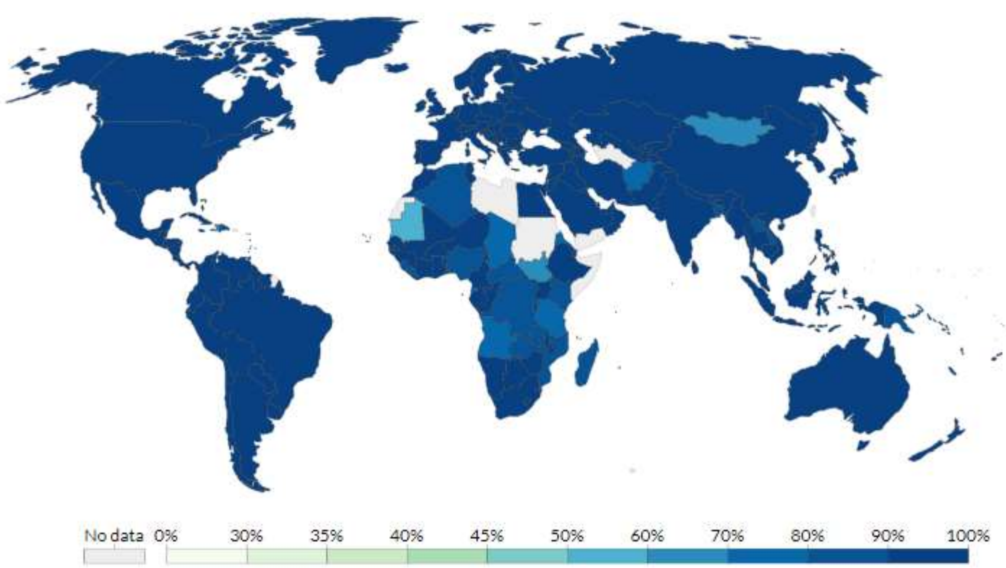

Figure 3.52: Share of urban population with improved water sopurces in 2015 (World Bank WDI; in Richie and Rose, 2019)

Eda Ranu's water supply treatment plant at Mt Eriama outside Port Moresby (Photo by Eda Ranu)

Water PNG is currently operating in only 14 provincial towns of 22 provinces and 6 of 93 district towns. Appendix 4 shows the water supply systems established and managed by Water PNG (formerly PNG Waterboard) are consists of bore water, rivers and borehole. Most of these facilities in the provinces uses submerside pump, solar submerside pump with diesel, gravity feed, river intake, and bore pumps. Their capacity ranges from 0.2 mega litres (ML) per day to 36 ML/day (SOPAC, 2007). GoPNG (2015) states that the standard household piped water has a minimum service delivery norms of 150 litres per capita per day (l/c/d) continuous supply with a service pressure of 60 Kpa; For standpipes and hand pumps, the designs should accommodate for 50 l/c/d with a maximum of 50 users per water point no further than 150m from the household. When rain catchment is used, designs must accommodate for a minimum of 5 l/c/d for drinking water with a maximum of 50 users per water point no further than 150m. The designs for all schemes are designed in such a way that adequate water re-charge is met on a continuous basis.

Most of these water supply stations use either sedimentation or filtration method for water distillation and chlorination. In the mining and oil and gas towns, the water supply systems are operated independently. In some local municipalities and towns in PNG, the water supply is run by private companies and businesses, churches or schools. More recently, ADB and the World Bank is funding the development of major water projects rehabilitation and upgrade in some urban towns and cities in the country such as Goroka and Bulolo.

Industrial usages in most parts of PNG also vary from province to province. In Port Moresby and Lae, the 2 bigger cities, the industrial use is more than 50% of processed town supply. New industrial Projects are coming on-stream such as fish canneries in Madang, Lae, and Wewak would see an increase in water demand (SPREP, 2007). Other uses in the agriculture sector is more in the rural areas with small reticulation systems constructed for both domestic and industrial purposes for coffee, coconut, rubber and oil palm processing. Mini agricultural irrigation systems are also in place especially for agricultural experimental station and research activities including forestry. However the mineral sector for both mining and petroleum take up the biggest portion of water uses for processing, domestic and waste disposal (domestic and industrial including tailings.

Hydropower in PNG has a very big potential when dealing with climate impacts. PNG has big hydropower stations in Rabaul (Warangoi), Kainantu (Yonki) and Port Moresby (Rouna 1 & 3, Rouna 2 and Rouna 4 stations). Aside from these there are small hydropower stations like Aibe Creek (Mendi), Pauanda (Mendi), Ru Creek (Kimbe), Hargy- Bialla Hydro (Kimbe), Yuk Creek (Ok Tedi), PNG Forests (Bulolo); and micro hydro schemes such as those run by the Catholic Diocese that has a number of them throughout PNG. There remains big potential for additional hydropower schemes. More recently, the Chinese government is funding new development of hydropower projects in Ramu 2, Edevu outside Port Moresby while ADB is funding development of Hydropower in Bougainville in Autonomous Region of Bougainville, Kimbe in West New Britain province, and Popondetta in Oro province.

Impact

Water is an important natural asset for PNG and its effective management is vital for PNGs long term sustainable development. Attempts have been made to improve access to water and sanitation have been largely haphazard and uncoordinated. Having access to sufficient safe water is a human rights. With the WaSH Policy 2015-2030, the government is aiming to link existing development priorities ascribed in the Vision 2050, National Development Strategy Plan (DSP 2010-2030, MTDP 3 and the National Strategy for Responsible Sustainable Development (STaRS) directly to an improved service delivery structure and monitoring framework (The Strategy RSD) for the benefit of the people, linking sustainable development activities to clear budgets and monitoring progress against the government's key development objectives (GoPNG, 2015). It establishes clear disaggregated targets for 2030, as well as minimum standards and principles for implementation.

Since their establishment, both two of the PNG's biggest water provider, Water PNG and Eda Ranu, have played a significant role in safeguarding the country's water infrastructure and providing services to the people. Their infrastructures has grown substantially with over 20km of distribution pipelines, 19 treatment plants and 20 distribution reservoirs and standpipes. Water from the treatment plants is distributed across the cities and urban areas by gravity fed bulk supply mains to services those reservoirs, providing over 100 million litres of clean water per day. In 2014, Water PNG was named the "best Performing Large Utility' and 'Most Improved Water Utility during the 2014 Pacific Water and Waste Conference. Water PNG plans to achieve 100% coverage of provincial towns and 85% of all districts by 2050 as spelled out in Vision 2050.

It takes the political will to ensure the above policies comes to fruition in any future development. For the entire population to have access to clean and safe water, the government must align to the current status and pace of development in the different water sub-sectors of rural water, rural sanitation, urban water and urban sanitation in the country. In rural situations, there are currently no systematic or integrated planning or financing mechanisms in place that could provide for comprehensive national planning and decision making, financing and implementation of water and sanitation infrastructure WSSDP ESMF, 2016). On the contrary, infrastructure investment to increase access in urban water supply can be undertaken utilizing the existing institutional, implementation and service provision structure of Water PNG.

Hence, the PNG government has the mandate now to increase access to, and improve the quality of, water and sanitation services to the population of PNG as well as improve hygiene behaviour and practices. It must make available funds to implement or upgrade water supply systems in the country, in both the rural and urban areas though a coordinated approach with development partners and NGOs, to implement or support the implementation of the available policies highlighted above.

A holistic change must need to be undertaken to improve the infrastructure and services. To reach the 2030 water and sanitation targets, an estimated K302 million (US$ 120 million) annual investment in infrastructure, operations and maintenance is required (GoPNG, 2015). Source of funding will come from the public government funds, the private sector, household contributions and international development partners' contribution. In addition, there will be costs for additional human resources in the sector, the majority of which is most likely to be met by recruitment from the private sector.

According to the WaSH Policy, a coordinating national office (National Water, Sanitation and Hygiene Authority or NWSHA) will have to be established at a cost of approximately K1.8 million per annum with an additional K 2.6 million per annum for salaries. The policy also proposed to establish sub-national offices in each province. Each sub-national NWSHA office will cost approximately K500, 000 each, to establish with a further K260, 000 each, per annum in salaries.

Once improvement is undertaken, it is possible that PNG could offer safer and clean water to its citizen thus meeting the standards outlined in the Public Health (Drinking Water) Regulation 1984, adopted from the WHO International Standards for Drinking Water, 1971. This could enable better services and quality of water are provided for its population, including schools, residents and offices. Where an emergency situation has been declared, WHO minimum standards will be temporarily replaced by the Sphere minimum standards for emergencies. The aim of the WaSH policy by 2030:

- 70% of the population in rural areas will have access to a safe, convenient and sustainable water supply;
- 95% of the population in urban areas will have access to a safe, convenient and sustainable water supply; and
- 100% of educational institutions and medical centres across the country will have access to a safe, convenient and sustainable water supply.

Response and Recommendations

Any future development work on water supply and access to clean and safer water must work toward achieving the WaSH Policy and improve water quality and accessibility in the country. Focus should be on building the institutions and establishing district level WaSH planning and decision making entities, before beginning to scale up the pace of infrastructure investment to increase access. There is a critical need for improved capacity to collect, process and analyse hydrological, hydrogeological and meteorological information for the sound management of water resources to cater for its various uses under normal conditions and in times of water related disasters. Other recommendations could include:

- Introduce sound catchment management practices in all watershed areas involving all stakeholders including regulators, developers and communities;
- Establish a system for effective information sharing between CEPA, National Weather Services, PPL & Water PNG on hydrology, climate variability & weather;
- Design and implement a capacity building program to improve coordination with all relevant national and provincial agencies to establish effective disaster warning, preparedness, relief and rehabilitation systems;
- Use appropriate technologies for small islands and remote inland areas, which will withstand prolonged natural disasters such as droughts;
- There should be a clear strategy at the national and local level to enable open participation of all communities in sustainable water and wastewater management; and
- Information on sustainable water use and management should be readily accessible to all sectors of the society and the general public.

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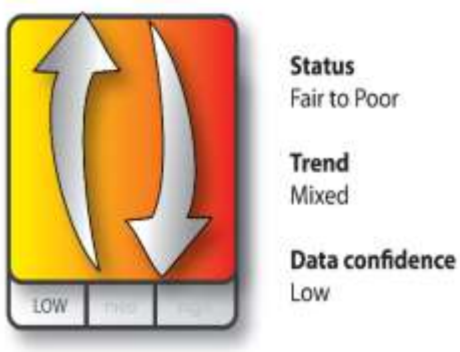
8.4.4 TOPIC/SUBTOPIC: FRESHWATER QUALITY

Indicator Definition: Percentage (%) of access to fresh and quality clean water sources

Status and Trend



Waterfront of Simpson's Harbour, Port Moresby

SDG/CBD Targets

SDG: 1.4.11.5.4, 3.2.1, 3.9.2, 5.1.1, 5.3.1, 6.1.1, 6.3.1, 6.3.2, 6.4.1, 6.4.2, 6.6.1, 6.a.1, 6.b.1

Aichi targets: 4, 5, 8, 11, 14

Status and Trend Discussion

With 87% of the population living in remote and rural areas with little to no modern facilities, PNG struggles with poor water quality and a lack of awareness about basic human health necessities. With very little access to clean water, sanitation is poor, people are becoming more vulnerable to disease water borne disease. As access to safe water and sanitation are vital to the basic health needs, the population in this area is at risk. Poor hygiene leads to poor health and illnesses such as cholera and diarrhoea, which can become sinister. Access to poor WASH facilities in schools and at households level is reflected in the health of the nation.

According to UNICEF, PNG ranks currently at the bottom of all Pacific countries for all WASH related health statistics, with over 6,000 diarrheal deaths per year. In 2009 cholera re-emerged in PNG after 50 years. Unless drastic improvements are made, women and school children will continue to fetch water, especially girls and the government will spend much on health care costs which may well have been avoided with the correct investment in WASH sector.

Areas outside cities and unhabituated areas are less contaminated than urban areas. A study by REM for PNG LNG Project on surface and ground water quality for heavy metal, at Portion 152 outside Port Moresby near Papa and Boera villages, shows some typical rural setting results (REM, 2008). Figure 3.53 shows groundwater samples collected during the field program for laboratory analysis were also tested for a range of parameters for heavy metals in the field using a calibrated electronic meter. Figure 3.54 shows the surface water sampling program was undertaken to assist in developing an understanding of baseline surface water conditions on Portion 152 with respect to heavy metals only. The single surface water sample collected during the field program for laboratory analysis was also tested for a range of parameters in the field using a calibrated electronic meter. By comparing salinity with the WHO guidelines, alone, groundwater sampled from well GW-3 and from the Papa Village well is considered unpalatable. All of the other groundwater samples can be considered to have 'good' palatability. Total Dissolved Substance (TDS) and Electrical Conductivity (EC) are high because it is a big flowing river.

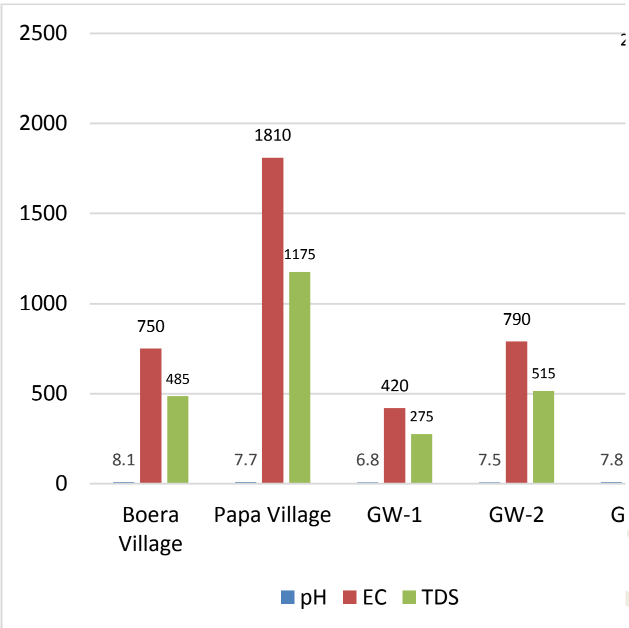


Figure 3.53: Field measured gound water quality data (PNG LNG, 2008)

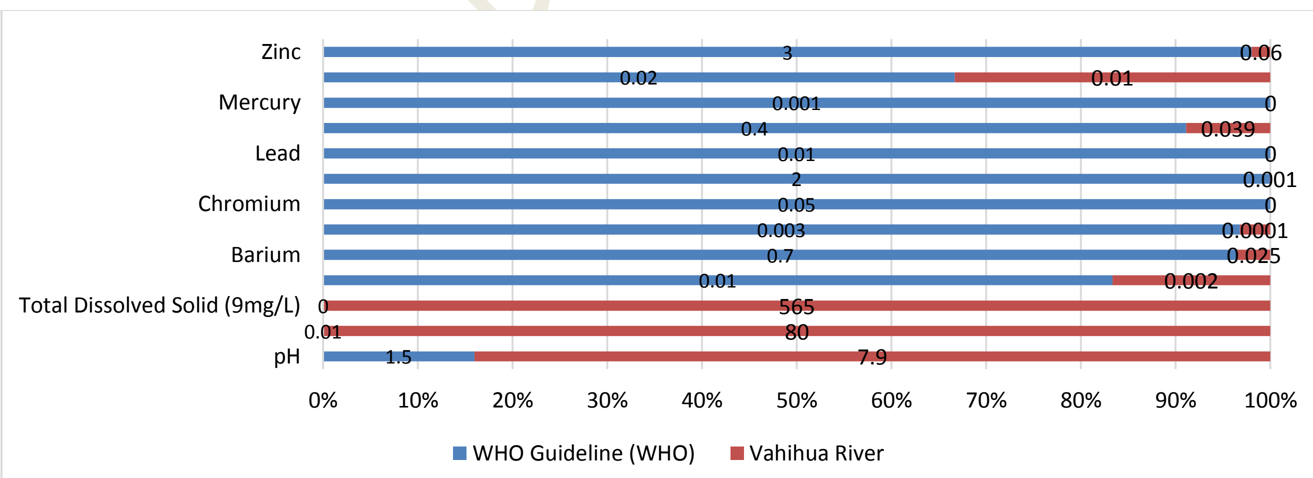


Figure 3.54: Fiedd and laboratory measured surface water quality of Vaihia River measured against WHO 2004 water quality standard (data from PNG LNG, 2008)

Table 3.5: Ground waterquality in Papa and Boera villages measured against WHO 2014 Water standard (PNG LNG, 208).

Parameter	WHO Guideline (2004)	GW-1	GW-2	GW-3	Boera	Papa
Fluoride	1.5	0.1	0.1	0.3	na	na
Arsenic	0.01	0.002	<0.001	<0.001	<0.001	0.002
Barium	0.7	0.02	0.015	0.056	0.001	0.019
Cadmium	0.003	0.0003	0.0008	0.0004	0.00008	0.0003
Chromium	0.05	<0.001	<0.001	<0.001	0.001	<0.001
Copper	2	0.001	0.002	0.001	0.001	0.002
Lead	0.01	<0.001	<0.001	<0.001	0.022	<0.001
Manganese	0.4	0.751	0.312	<0.001	0.013	0.078
Mercury	0.001	<0.0001	<0.0001	0.0003	<0.0003	<0.0001
Nickel	0.02	0.004	0.002	<0.001	0.012	<0.001
Zinc	3	0.088	0.144	0.018	1.04	0.012

Table 3.5 presents reported laboratory analytical data (fluoride and heavy metals) for groundwater samples collected from five locations on and near Portion 152 (three groundwater wells; GW-1 to 3, and two village wells; Boera and Papa). Also presented for comparison purposes are World Health Organisation (WHO) Drinking water Guideline values (2004) for the same analytes. There is better quality groundwater (i.e. lower salinity) in the southern part of the area. Water from this area can be considered potable (less than 1,000 mg/L), but would possibly require some form of treatment to ensure it can be used safely for potable purposes (e.g. to manage possible biological contaminants). It will be important to address the possible sources of lead in groundwater sampled from Boera Village to ensure the Project workforce is not exposed to lead concentrations that may pose an adverse risk to human health.

Near coastal villages, atolls across PNG and low lying areas, increase in water salination is prominent. For instance Lake Murray, has a surface area of 647 km^2 and a high-water convoluted shoreline 2038 km long. It is the largest lake in PNG and exhibits marked seasonal fluctuations in water level. A study by Osbourne et al. (1987) shows the fall in water level of 4 m between April and December 1982 was accompanied by a marked rise in pH (from 5.3 to 9.6), conductivity (from 12 to 100 $\mu S\ cm^{-1}$), total hardness (from 80 to 400µM) and filterable residue (from 11 to 45 mg l^{-1}). In November 1982, maximum production of phyto-planktonic oxygen was 1120 mg O_2 m-3 h-1 at the surface but declined sharply with depth because of light attenuation by suspended solids. It was much higher than that recorded in April 1982 (250 mg O_2 m-3h^{-1}). In low lying areas such as Morehead in the South Fly, people using bore water taste increased salinity content from bore water as a result of tidal influence, especially during high tide. The same could be true for low lying atolls. Severe drought also has the potential to affect water gravity or water potential and water level.

The need for clean and safe water has increased over the years. In some parts of PNG, most people have no access to clean and safe drinking water as per the WHO standard. With the high population growth and declining water coverage rates, over the last two decades, the absolute number of people without access to water supply and sanitation has grown by 73% for improved sanitation and 67% for safe water (Water Aid, 2018).

The MDG targets for water supply and sanitation are out of reach, however there is still chances of achieving the Sustainable Development Goal (SDG) by 2030. Unless there is significant increase in investment and profound sector reforms to address bottlenecks, the ambitious national targets set in the Medium Term Development Plan for the year 2030 and the Wash Policy can be achieved. The presence of *E. coli* in water as indicators of faecal contamination in freshwater bodies are increasing and are associated with a range of possible human diseases.

Though there are lack of data during this write-up, it can be assumed that high levels *of E. coli* can be associated with cloudy water and decreased dissolved oxygen. Household sewage are often discharged into the main storm water drainage which ended up in the rivers and seas, and this is evident through presence of green-blue algae.

Storm water drainage in Port Moresby with growing Blue green algae

According to Water Aid, 60% of the PNG's population not only live without a safe water supply but has the poorest access to clean water in the world. A report on the state of the world's water showed PNG, Equatorial Guinea, Angola, Chad and Mozambique are in the bottom five of a table ranking countries according to the percentage of households with access to clean water (Kwaeifio-Okai, 2018).

Globally, 650 million people are living without an "improved" source of drinking water, which includes public taps, protected wells, rainwater or water piped into households. If the water has the presence of *Escherichia coli* (*E. Coli*), it must not be detected in any 100ml sampled collected as per the WHO Guideline for Drinking Water quality standard. The study also shows the global water and sanitation crisis was not a problem of limited supplies and scarcity but distribution, with government policies being a hindrance.

While the some countries have achieved or made progress in achieving the millennium development goal, by halving the proportion of people without access to safe drinking water by 2015, that target by PNG is still below average. This must be met by 2030 target under the SDG.

In the P'nyang Oil and Gas EIS study for Western Province noted that increasing population in and around rural villages due to project development are likely to increase as a result of in-migration for people seeking employment and other opportunities (Coffee, 2015). No sanitation facilities are available in the area and springs used as water sources have already exhibit elevated faecal coliform levels, above applicable water quality criteria which should not exceed 200 colonies or no change greater than 10% from background levels at any particular time (whichever is greater).

Most rural communities in PNG depend on natural streams and rivers for their use and livelihood. People in rural areas are likely to lead to an increase in unsanitary practices and increased contamination of water sources with human waste. In most rural communities some water are crystal clear compared to others which are high in silt and discoloration. Choices of fetching clean water for drinking and cooking is usually from uninhabited areas or headwaters of streams, rivers and creeks.

A study by Coffee for Freda Copper Mine, situated in the hinterland of West Sepik province shows the developer's plans to build a dam to store its waste ores and produce electricity. The Environment Impact State (EIS) shows groundwater extraction will occur over the lifespan of the mining operations, where the operation is required to depressurise and dewater the open-pit to enable mining to proceed safely and productively (Coffee, 2018). Consequently the surrounding areas will have lowered groundwater levels and an altered hydrogeological regime, with the open-pit acting as a groundwater sink (i.e., point of groundwater discharge). At the completion of mining, dewatering activities will cease and the open-pit void is predicted to fill within three years to form the final open-pit lake in year 33, to the prescribed spill points. The predicted drawdown presented in Figures 3.55 and Figure 3.56 represents the maximum localised drawdown within shallow aquifers in the immediate vicinity of the open-pit. The maximum predicted drawdown within other (deeper) modelling layers will be confined to the main open pit area and is consistent with the final depth of the open-pit below the watertable or potentiometric surface (i.e., up to 500 m).

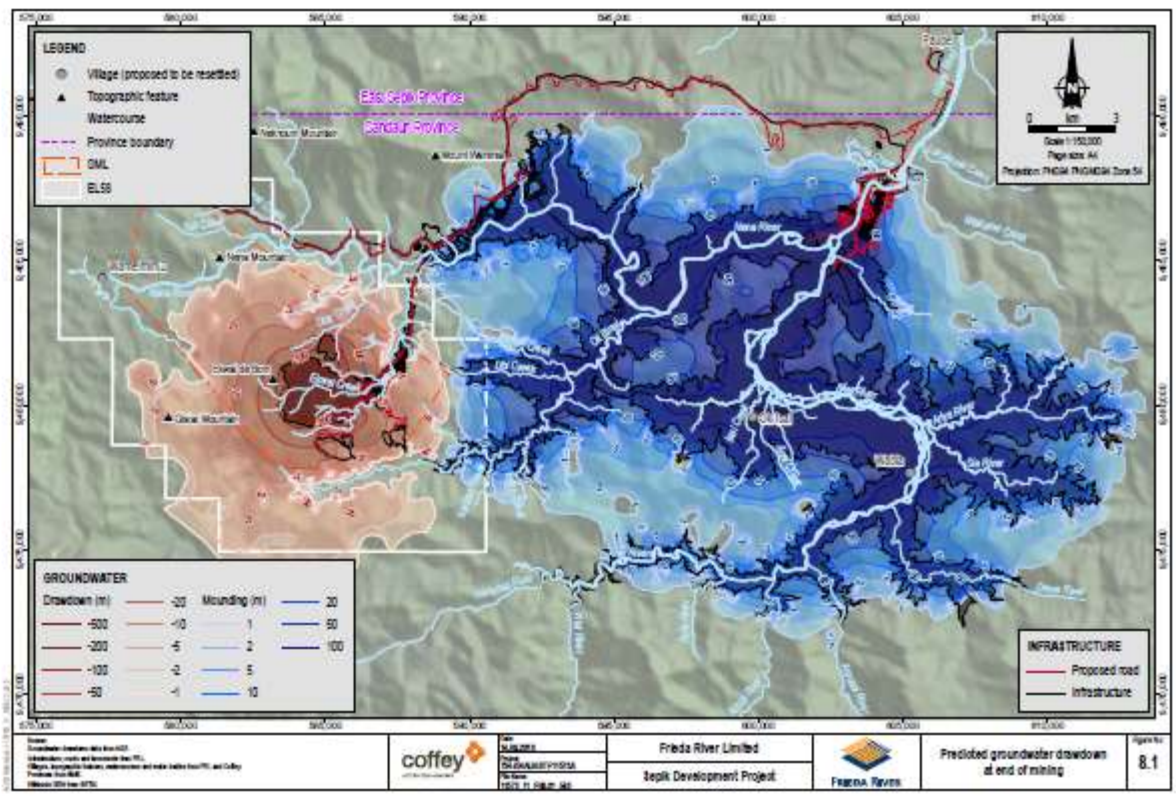


Figure 3.55: Numerical groundwater modelling during the influence of mining operations on groundwater levels during the operation at the closure of mine in year 33(Coffee, 2018.

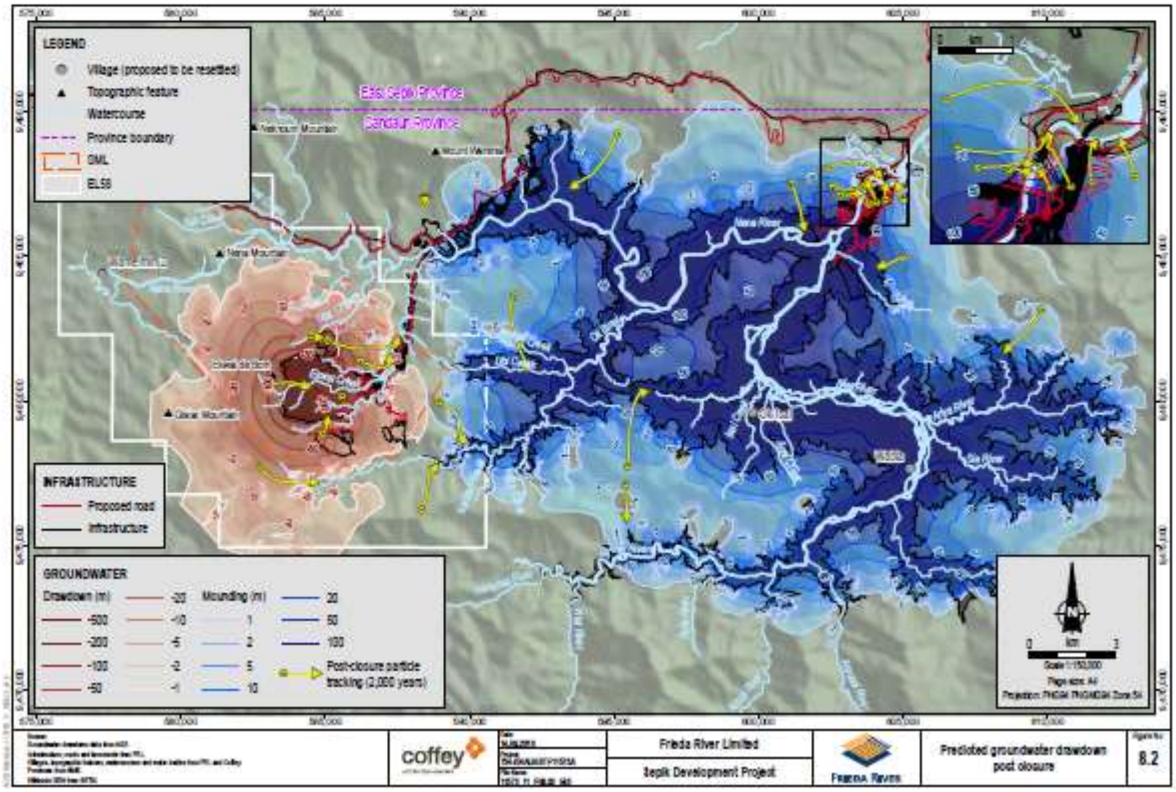


Figure 3.56: Numerical groundwater modelling during the influence of mining operations on groundwater levels after post closure of the operation (Coffee 2018).

The study by Coffee shows that deduced groundwater availability during mine dewatering is predicted to result in reduced baseflow contribution to the major rivers and creeks in the mine area. After approximately two years of mining, reduced groundwater levels that are outside the open-pit footprint are predicted to result in the loss of all baseflow contributions from groundwater (Coffee, 2018). After 33 years of operation, it is predicted the baseflow outside catchments will reduce by 19%. It was argued that these effects may be less noticeable during wet periods where rainfall runoff accounts for a high proportion of stream flow.

However, during dry periods the inverse is true, with baseflow accounting for most of the total stream flow. The zone of groundwater drawdown at the end of mining is likely to remain unchanged after post closure, and groundwater levels within the drawdown zone would undergo a period of flux towards a new point of equilibration.

The above study shows that any development in a catchment area or near a village and town must do proper studies on the hydrology of the area, studying the waterflow of the area to minimise any effects. Hence, protection of the catchment and natural environment is important for the well-being of the people and the environment. Under the Environment Act 2000 and CEPA Act 2014, CEPA has the mandated responsibility of managing the nation's water resources. These legislations are linked to all development planning and natural resource extraction regulatory instruments where various agencies are responsible to minimise or prevent environmental impacts at an acceptable level. However, CEPA's activities are often hampered by lack of resources, ineffective monitoring and enforcement system, and uncoordinated development and land-use planning system in the country.

There is currently little to no hydrological data collection around PNG except in areas with resources development like mining and oil and gas. Hence, improvement in collection and maintenance of raw data from catchment, ecosystems, climate, geography, geology, biodiversity and natural resources must be effectively collected and stored in a reliable database (SPREP, 2007). More recently, CEPA has established an open environmental data Portal launched it in April 2019, with funding from SPREP and UNDP. Hopefully with availability of data, appropriate reports can be produced on timely manners thus promoting transparency. In terms of environment and water, an integrated resource management can be developed using the available data.

During the pre-and post-independence, natural resources data collection across PNG commenced, with the Australian government investing large input of resources into data collection. However, in recent times, reduction in financial resources and capacity has reduced collection of reliable data, which begs the question of how much adequate support should be given to the respective organisations such as Water PNG and CEPA to resume their data collection programmes. According to SPREP, some water resources related data are collected by the National Weather Service (NWS) housed under the National Civil Aviation Authority (NCAA), and the PNG Geological Survey (PNGGS) based at the Department of Mining (SPREP, 2007). Rainfall and climate data is collected by the NWS while PNGGS collects hydrogeological data.

CEPA has an excellent working relationship with the NWS and both organisations share the rainfall data collected under their respective networks, but overtime, the relationship becomes less effective. Although CEPA and PNGGS have worked together on a few assignments, there is still a need to improve and strengthen this connection including exchanging data. Currently, CEPA had developed its Data Sharing Policy 2019-2022 and is working toward sharing data with other agencies through the signing of Memorandum of Understanding (MOU). In the future, it is believe collaborative effort to share cost, information and build working relationship will improve. This is crucial because a complete integrated water resources management plan for a catchment requires data on both surface and groundwater hydrological parameters. Currently, CEPA is in managing all water districts and collect fees from those using the river catchment.

Moreover, a number of natural resources databases have been constructed and developed over the last twenty years. The most widely known is the Papua New Guinea Resource Information System (PNGRIS) developed by University of Papua New Guinea (UPNG), which has grown in scope and utility over the years. It is the first and probably the only database so far to incorporate and integrate a range of ecosystem parameters such as climate and geology (SPREP, 2007). Several information such as CEPA's hydrometric and biodiversity database, Department of Agriculture and Livestock (DAL) land use and soil database, Forest Information and Mapping System (FIMs) from PNGFA, climatic from NWS and geological databases Department of Department of Mining (now MRA) were used to develop the PNGRIS database.

Thus the information contained therein PNGRIS should be used as the basis for integrated catchment management planning. However its full potential may not be harnessed since some custodians of sector specific data are reluctant to allow the inclusion of "their" data due to concerns regarding commercial confidentiality and profiteering from the sale of data by unscrupulous persons (SPREP, 2007).

The continued availability of trained and competent officers in all the disciplines required for integrated catchment management is critical.

Ideally a catchment planning team providing advice to a management committee should be headed by a qualified and experienced catchment planner. A number of trained and experienced CEPA officers in this field have left the public service but the level of replacement and training has been incommensurate (SPREP, 2007). Hydrogeological studies have only been carried out in certain parts of the country, and by different organisations or developers.

There is a great need to carry out detailed groundwater assessments in all the catchments in the country, if the sound integrated management of water resources is to be attained. This is needed because the government is planning to increase its energy output using hydropower generation. Also urbanisation is expanding so too population and development activities thus require reliable data to make decisions and planning. This is because *E. coli* threshold at or below globally accepted standards for drinking and bathing water must be contained at none detectable per 100 mL for both *E. coli* and total coliforms for drinking water, which varies with those of bathing and swimming water.

Thus, the need for some form of routine collection of hydrometric and water quality data is essential which would ensure sound management of water resources is achieved. With lack of data being conducted by relevant government agencies, there is an urgent need to revive and establish a basic representative hydrometric network, taking into consideration the latest technology, as well as installation and operational costs (SPREP 2007). The inclusion of *in-situ* instantaneous measurement of physical water quality parameters would be an advantage.

The surface hydrological data collected by then DEC (now CEPA) is not combined with hydrogeological data for catchment water budgeting and allocation for various uses. At present, limited hydrogeological data is collected by the PNGGS and there is very little interaction between the two organisations in terms of data collection, exchange and analysis. PNGGS also needs the surface hydrological data that CEPA collects and the two agencies should work towards integrating their databases and conducting joint data collection exercises. This collaborative working arrangement could be one way of dealing with the limited annual operational funding allocated to the respective organisations by the government (SPREP, 2007). Funding limitations has drastically reduced the area of hydrometric coverage, therefore a coordinated approach using the land-users in the catchment is currently being promoted.

According to SPREP, in most permitting conditions by CEPA, a permit holder is required to undertake monitoring for various parameters and report at regular intervals to CEPA in compliance to the permit condition. This is when the samples for compliance monitoring are collected in duplicate with one set dispatched to an accredited independent laboratory for analysis. A copy of the laboratory's results is sent directly to CEPA to eliminate suspicion of data tempering. CEPA is also required to undertake compliance monitoring including audit sampling for analysis by an independent laboratory (SPREP, 2007). If there is any evidence of non-compliance, the permit holder is instructed to take corrective actions within a specified time period or face prosecution.

However, this process of undertaking auditing of analysis is not implemented or monitored effectively. All expenditures are now taken by the developer under the User Pay Policy that is practiced and promoted under the Environment Act 2000. The costs for laboratory analysis are very high and CEPA's ability to carry out audit sampling is restricted. Hence, funding for routine compliance inspections is limited and in most cases, permit holders assist with airfares, accommodation, transportation and subsistence expenses for CEPA officers to carry out their duties. This may compromise the work of CEPA and the developer, as this practice may be seen as unacceptable consequently promoting non-conformity and non-compliance by the permitted operation (SPREP, 2007).

Moreover, water quality data is not collected routinely but only in response to pollution complaints, during EIS studies for new projects or during monitoring by the developers. This warrants specific water sampling and analysis exercises to authenticate such allegations and take remedial actions. Under the environmental permitting system of the Environment Act 2000, companies and corporations involved in large-scale natural resources extraction, infrastructural development and specified intervals need to conduct their own water quality testings (SPREP, 2007).

CEPA is supposed to incorporate the information into its database but the current database capacity can only accommodate hydrometric data. An additional difficulty with the hydrometric data is the use of different incompatible database software and until and when this technology is improved, CEPA should be able to store all the data provided (SPREP, 2007). At the time of writing this report, CEPA does not have reliable data but if data is available, they have been kept by individuals because of no data storage system in place. With the CEPA's Environmental Portal, data can be stored easily however, it will take time and effort to address this issue.

Children enjoying water slide at Adventure Park, Port Moresby

Good quality water supplied to the population will enable people to enjoy life. In urban areas like Port Moresby and Lae, people are enjoying clean water facilities and services. This is not so in most rural areas. Though water quality can be suitable, there are lack of data to qualify this statement. There are no community based water quality monitoring programmes but most people in rural communities are well aware of who to approach when they observe changes in water quality or experienced, ill health or sudden and inexplicable threats to life or humans and living things (SPREP, 2007).

Some communities or people are not aware of the right authorities to approach but report matters to their local ward councillors who then takes the matter up to the higher authorities. Consequently, this can lead to huge compensation demands and problems such as the ten year armed insurgency which started in 1989 on the island of Bougainville, caused by disposal of Bougainville Copper Mine tailings into the Guava River and the watershed system (SPREP, 2007). In the Fly River, the burst of tailings dam has resulted in substantial damage to the Fly River System. There were also reported cases of mine waste dumping into the Strickland River system by Pogera Mine in Enga province. These environmental damages and the conflict on Bougainville marked an historical turning point in terms of environmental awareness and management in PNG.

Since many rural communities depend directly on the environment, sometimes people go to the extent of protecting their livelihood. Hence, better negotiations and awareness has to be done to prevent environment damages, confrontation and litigation must ensued when a large development project is undertaken in the country.

On the other hand, while water conservation becomes critical in both rural and urban centres during prolonged low flow and drought conditions, a large amount of wastage can occur as a result of leakage and misuse especially with reticulated systems. During drought situations in urban areas, the service provider normally applies a stepwise response strategy relative to ensure the declining capacity of supply meet demands of the residents and business houses (SPREP, 2007). There are cases of illegal water connection and this often led to reduce water pressure into residential and settlement areas in urban areas. Theoretically, the strategy for drought includes use restrictions accompanied by fines, temporary increase in fees to discourage misuse and rationed distribution throughout the serviced area. In addition, all service providers often undertake regular monitoring and maintenance of reticulated systems in order to reduce forced to restrict potable water usage and use brackish or seawater for non-consumptive purposes.

With regard to water pollution prevention in catchments, CEPA currently has in place a number regulatory tools including water supply watershed protection and codes of practices for municipal solid waste landfills, as well as industrial, logging, agricultural, mining and infrastructure development. CEPA also adapted some international guidelines from the World Health Organisation (WHO), the Australian Environment Standard, ADB Standard, World Bank standards and other globally accepted standards. T

hese standards or guidelines specify implementation of the various activities with respect to erosion control, protection of biodiversity, disposal of solid and liquid waste, air pollution, and noise. Most companies have complied with these requirements but there have been many instances where major destruction of watersheds has occurred. CEPA requires more funding to effectively perform its regulatory duties and it should also devise an effective compliance monitoring strategy with the private sector, other government agencies, and involving landowner and public participation to reduce or manage impacts.

The Environment Act 2000 contains a provision that restricts certain land uses within a surface water catchment or a groundwater bore field to prevent contamination of the water and to conserve water for priority uses during prolonged dry seasons and drought situations. In a surface water catchment, restrictions may be imposed on removal of vegetation, gardening, buffer zones, drainage and waste disposal. Similarly, over a bore field area, vegetation clearance, waste disposal and barriers to effective recharge are the main considerations. This provision is difficult to apply over customary owned land since getting the people's consent is often challenging and a lengthy processes.

In urban areas, such as Port Moresby, discharge of silts and grey water from building road construction and gardening activities by rain into drainage often clogged the drainage thus causing flooding in the city. Also sediments from disturbed and cleared sites mostly ended up in the sea thus affecting mangroves and reefs as in the case for Tuna Bay in Port Moresby.

In a number of cases, watershed protection for water supply purposes has been indirectly secured where landowners have organised themselves and requested the area to be declared Protected Area for biodiversity conservation, maintenance of environmental integrity, prevention of commercial logging and promotion of ecotourism (SPREP, 2007). Thus, public education and awareness and the provision of alternative revenue generation measures is therefore essential to acquiring landowner support and cooperation.

Impact

Delivering water at the right quantity and quality for a given use is a major challenges faced in PNG. In rural areas, only 20% of the population have access to an improved water supply which includes public standpipes, boreholes, protected wells or springs (PNG Waterboard Strategic and Medium Term Corporate Plan 2006). For the rest of the population, water is directly taken from the source.

In the urban areas which PNG Waterboard services, only 91% have access to treated and reticulated water supply but only 60% of these households get piped water directly into their houses. The other 'urban' households are located in squatter and peri-urban settlements where reticulated water is provided at public standpipes and wastewater management is a problem. There are also instances of illegal water connection done in some suburbs and settlements. Most urban centers are equipped with better water supply treatment plants compared to others are are operated by government statutory bodies such as Eda Ranu and Water PNG.

Many rural communities and urban settlements are still living in poor housing conditions. Their state of living, for instance, building permanent house and installed water tanks to capture rain water, is still poor. If they can have proper homes and water tanks, they can be able to have access to better source of drink and cooking water. There are no statistics to show how many people have permanent house and water tanks but it can be assumed it comprised of over 80% of the population. In urban areas, Water PNG and others such as Eda Ranu are using best international standard thus meeting WHO water quality standards for use by residents.

In some localities and urban centers like Goroka, the standards are still poor. More recently in 2019, Goroka water supply was found with high quality of *E. Coli* that leads to typhoid break out.

Moreover, the MTDP3 Goal is to *see "Every citizen and visitor to have access to safe (drinking) water, reliable and affordable sanitation, and hygiene facilities by 2030"*. The WaSH Policy 2015-2030 also looks ensuring water is access by most household by 2030. This policies canvass safe (drinking) water, improved sanitation, and good hygiene as essential features for the country's integral development, yet a very low proportion of the population have access to these essential needs. It is critical that safe water, improved sanitation services, and good hygiene practices must be developed in the country. The current baseline indicates that only 40% of over 4.8 million rural population have access to safe water. The urban population has 90% access to safe water. Remarkably, about 50% of health and education institutions in the country have access to safe water and improved sanitation services (GoPNG, 2018).

These polices also envisage to guide and coordinate the water, sanitation, and hygiene developments, in order to reverse the decline, accelerate access, and to promote long-term change in people's hygiene behaviour. The policy also embarks on promoting equitable access to safe, convenient and sustainable water supply, improved sanitation and good hygiene practices to achieve government's vision of Responsible Sustainable Development.

Water treatment plant operated by Eda Ranu at Mt Eriama, Port Moresby (Photo: Eda Ranu)

While the water resources available in a catchment is initially subject to natural climatic and geophysical conditions, various land uses and waste disposal linked to population growth is also affecting the capacity to supply in terms of quantity and quality to cater for ranges of water uses (SPREP, 2007).

The highly visible impact of mine riverine tailings disposal has in some ways concentrated pollution concerns in this sector, possibly detracting due consideration towards a systematic quantitative analysis of all pollutant types and their causes across the country.

Currently there is no systematic measurement of the volume, extent or composition of pollution in PNG apart from developments that require environmental monitoring such as mines, LNG and agro industry. Without this information it is difficult to prioritise and strategically tackle each pollution concern.

Previously under the former repealed Water Resource Contamination Act, measurements of water quality was done under the former DEC (now CEPA) and other government agencies. Today enforcement is zero to nil. In addition, the government agencies, some of which in the past were monitoring and reporting environmental pollution, no longer have the capacity or recurrent allocation of resources required to fulfill this role. There is also a lack of political support to proactively react to increasing pollution concerns.

Determining the extent and impacts of landfill and effluent disposal on local, riverine inshore and marine systems is lacking by the government along with resultant impacts on its citizens. Similarly there is no systematic monitoring in the food chain for heavy metal accumulation measured against health standards from all known pollution sources. Nor for any other pollution induced or exacerbated health related concerns.

There are few catchments that are directly accessible to the main urban towns and cities in PNG. Thus, the development of these sources to sustain the demand of local municipalities is difficult because pollution to the original source may occur as a result human settlement and increase land-uses in critical areas like at headwaters can deprive other users to benefit from the same source (SPREP, 2007). This is prominent in catchments such as Laloki, Wahgi and Bumbu and other rivers throughout the country because these catchments are often over stressed with poor quality yields and high demand from various users.

Additionally, there are no proper catchment management plans that would dictate the land-use type in the area and equally distribute water resources. There may be exception in logging concession and plantation areas. There is often constant increase in population that allows communities and settlements to move into catchments thus causing stress to environment and water resources.

Clearing of riverbanks are now causing increasing erosion and depositing them into waterways. The other main concern is to develop a policy to regulate activities within critical catchments and provide for equal distribution of the resources to all users.

The low rate of access to potable water in the rural areas, increasing pollution and vulnerability of water resources to natural disasters and climate variation all highlight the critical need for integrated water resource assessment, planning and management. . Frequent water testing by drinking water regulators is critical to determine how the data collected by national service providers or regulators help improve water safety. Figure 3.57 shows the water quality testing and risk management strategy that could be implemented by the water supply operators in PNG to improve water safety and risk management. Appendix 5 water quality and sanitation checklist for PNG by Water PNG Ltd and Appendix 6 shows the checkslist for water supply establishment and where the water is taken from.

Thus an effective inter-sectoral coordination mechanism involving the public sector, private sector, NGOs and landowners must be established in each catchment to ensure that all development and natural resource exploitation activities are undertaken in a sustainable manner (SPREP, 2007). Also a national catchment management strategy must be formulated for professional climatologists, hydrographers, hydrologists and hydrogeologists, who can interact with other experts to devise and implement all-inclusive catchment management plans. There are exisiting water Districts managed under CEPA and this need to be overhauled. Hence, this would allow each individuals or organisations to act swiftly to ensure that any planned activities for the catchment can be sustainably accommodated within the plan.

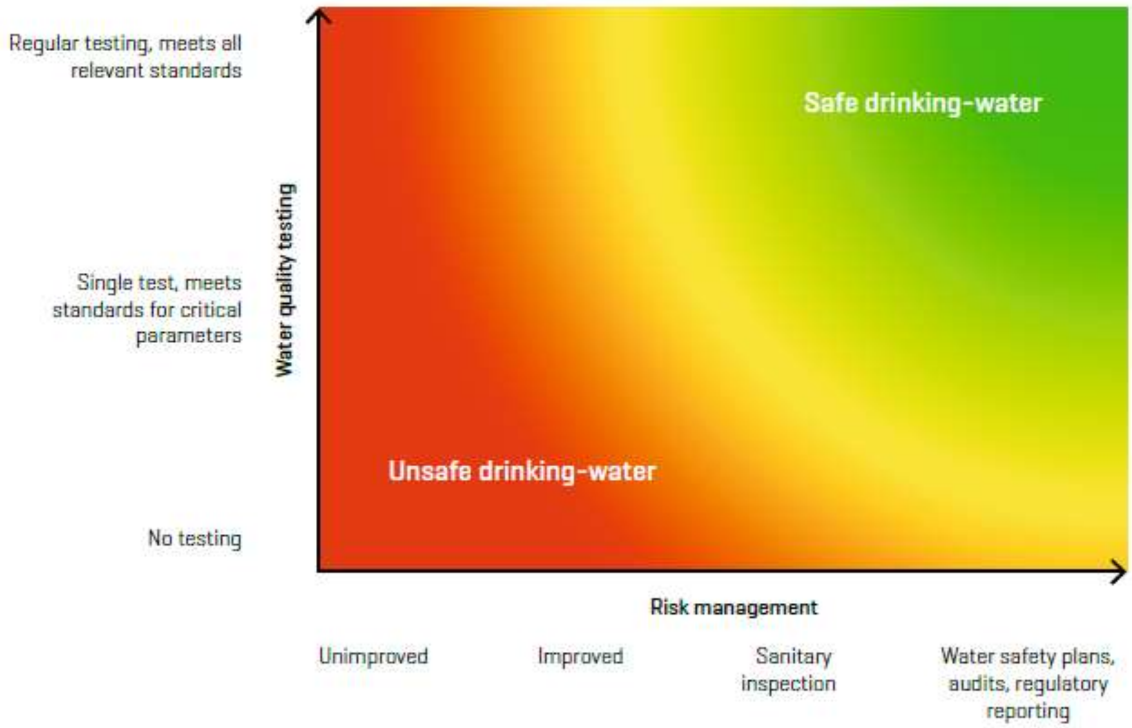


Figure 3.57: Water quality testing and risk management for improved drinking water safety (WHO and UNICEF, 2014)

Response and Recommednations

A close collaboration to work towards achieving the government goals set the premise of PNG to achieve better freshwater quality and services, including protection and management of water catchment. This is because safe and clean water is a universal rights. In order to achieve that, whatever recommendations and steps provided in the Vision 2050, DSP 2010-2030, WaSH Policy 2015-2030 and MTDP3 2017-2022 must be actioned by Water PNG, Eda Ranu and other water supply producers. Collaboration with other government agencies, NGOs and development partners must be achieve to ensure clean water is supplied to residents in both rural and urban areas. Institutional capacity building and increase resources would enable better data collection and management.

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8.5 THEME 4: LAND

8.5.1 Overview

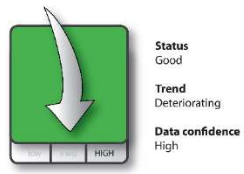
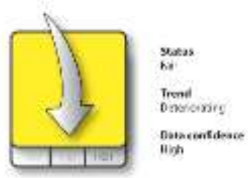
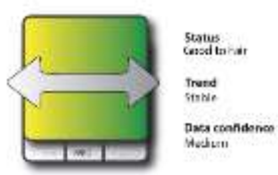
PNG is situated on the Island of New Guinea, the second largest island in the world. New Guinea lies in the Oceania region, in the western Pacific Ocean. PNG shares the common international border with Australia to the south and the Papua province of Indonesia to the West, Palau to the North and Solomon Islands to the east. PNG has a total landmass of approximately 46,514.771 km^2, of which 45,367.224 km^2 comprises of islands land mass while 1,147.547km^2 is sea, where 72% of the landmass is believed to be inhabited (Prais, 2018).

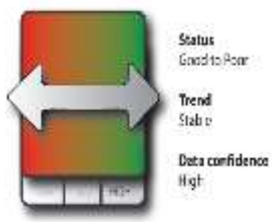
Some reports state PNG has 46,300km^2 or 46.3 million ha of land, with approximately 2 thirds or 75% of it is covered by tropical primary rainforest (GoPNG, 2014; GoPNG, 2018). The mainland comprised of almost 85% of the total landmass. A recent conversation with PNG Forest Authority has PNG covered with 87% of forest cover based on its national definition. The landmass also includes the outlying tropical islands namely New Britain, New Ireland, Manus, Bougainville and about 600 other islands and atolls.

This Chapter covers forest, land under cultivation, wetlands and terrestrial protected areas (marine protected area is covered in the Section 8.6.2). Also this section describes what the PNG government is doing, and what it needs to do to protect its unique ecosystems from further degradation.

8.5.2 LAND HIGHLIGHTS

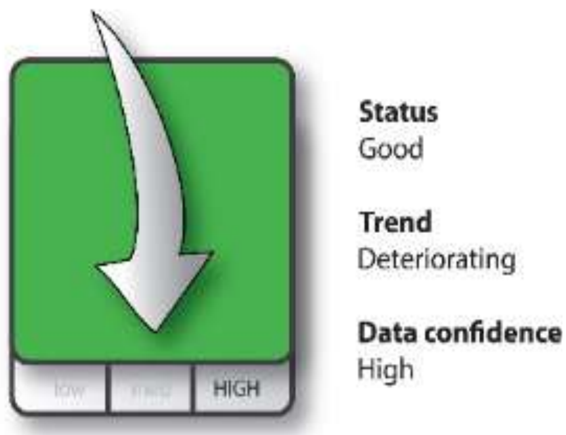
Topic	Status , Trend and data confidence	Key Findings	Response and Recommendation
Forest		PNG has one of the most significant areas of largely-intact tropical forest in the world after the Amazon and Congo Basin. Forests are a vital resource for the local population. Though the forest is huge, it undergoes disturbances from either natural or man-made causes. Currently, the forest facing acute and imminent threats from human activities. The National Depletion rate for forest in 2016 is 9% and the government through the MTDP III aims to reduce the depletion rate to 5% by 2022.	There is need to improve forest governance and compliance. There is a need to improve forest governance and compliance. Also ensure the National Land use Policy clearly demarcates zoning of different land-uses with that of forestry into national land-use plans.
Land under cultivation		85% of PNG's population live in rural areas and agriculture is the mainstay of PNG. A population increase and demand for agricultural products increases, forest cover and wetlands have been converted to cropland with some form of cultivation.	A national sustainable land-use plan and mapping of all potential arable land is required. Also better farming practices must be implemented through the Department of Agriculture and Livestock (DAL). More awareness also need to be conducted on better farming practices.
Wetland		PNG has 2 declared Ramsar sites in Tonda WMA and Lake Kutubu WMA, managed by local communities, yet poorly managed. Overall, there is a net increase in wetland areas while changes has also become prominent in some ecosystems caused by natural or human induced impacts.	Lack or no management plans, no sustainable funding, poor capacity and lack of resources has affected management of wetlands.

Terrestrial Protected Area		A total of 59Protected Area had been established since 1962, yet are not effectively managed. Currently a draft PA Bill is under development and yet to be endorsed by NEC and enacted in parliament. Thus more work needs to be done to achieve the target of 20% of PNG land and marine being conserved by 2020. Currently only 4% of PNG is formally conserved.	Better Protected Area management, strengthening of environment laws and regulation, sustainable financing, capacity building, enforcement and monitoring, and training is needed to improve PA management and its effectiveness. There is potential of doing *ex situ* conservation of threatened and endangered species as well.

8.5.3 TOPIC/SUBTOPIC: FOREST

Indicator Definition: Percentage (%) of native tree cover of total land area

Status and Trend




Tropical flooded lowland rainforest, Ramu River, Mandang Province

SDG/CBD Targets

SDG: 13.2.1, 13.3.2, 13.a.1, 15.1.2, 15.2.1, 15.3.1, 15.4.1, 15.4.2, 15.5.1, 15.6.1, 15.7.1, 15.8.1, 15.9.1, 15.a.1, 15.b.1

Aichi: 1, 2, 5, 7, 11, 12, 13, , 14, 15, 16

Status and Trend Discussion

The Food and Agriculture Organisation (FAO) of the UN define a forest as "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than10 percent or trees able to reach these thresholds *in situ*". It does not include land that is predominantly under agricultural or urban land use. This definition is still contested however until recently, PNG Forest Authority (PNGFA) adapted its version as "land that is bigger than 1ha with trees height above 3m, having 10% canopy cover" (GoPNG, 2017). To PNG's standard, this definition of forest cover is still disputed because PNG is known for its thick dense forests with big trees and diverse species. PNG's forest also comprised of 12 distinct forest types with carbon-rich lowland forest constituting intact tropical forest of 50% of forest area (Shearman et al. 2008). PNG have iterates that currently about 87% of the land is covered by forest based on the above definition.

PNG's land is distinguished from lowland comprising of beach and wetland to high mountainous and rugged high altitude country and valleys flats. These geological features and mosaic of habitats have helped shaped the rich biodiversity of PNG. PNG's forest also falls within the world's moist tropical rainforest zone yet there may be distinct forests types found within such as beach, mangrove, grassland and savannah, swamp, lowland, montane, hill and alpine forests. With PNG's rugged terrain, with the forested area stretching from sea level to an altitude of over 4,000m, the forest types vary from mangrove forest, swamp forest and lowland rainforest to lower montane forest, upper montane forest, and dry evergreen forest (ITTO, 2018).

PNG has one of the most significant areas of largely-intact tropical forest in the world after the Amazon and Congo Basin. Forests are a vital resource for the local population, particularly in the remote rural areas of PNG, where almost 80% of the population live. Forests provide, medicine, food, fibre, building materials, and support a variety of wildlife and ecosystem services. Though the forest is huge, it undergoes disturbances from either natural or man-made causes, thus facing acute and imminent threats from human activities such as agriculture, logging, shifting cultivation, mining, urbanisation, and oil and gas (Bito and Petit, 2016).

Ideally one can say most forest in PNG are not in a climax state but are a result of major natural disturbances such as wind throw or cyclones, natural death and gap formation, fire, landslides and volcanic activities that evolved through time. Most forest situated near villages have undergone some form of disturbances through subsistence gardening and fire through time as well.

A study by Shearman et al. (2008) using landsat imagery and GIS shows there is an estimated 29 million hectares of forested land remaining in the country for logging. This is a decline from the 33 million hectares estimated in 1975. The study also shows that the loss of some 4 million hectares over a 30-year period was partially attributed to shifting cultivation, conversion of forested lands to agriculture, logging, urban development, fire, infrastructure development, mining developments, and various natural disasters.

Figure 3.58 shows the forest cover loss estimated by the Global Forest Watch between 2001 and 2017. There was an increase in forest cover losses through time with the highest loss encountered between 2014 and 17 and this may be attributed to increase forest conversion from SABL agriculture projects. In addition, the area and number of timber concessions had increased over the years from an area of a little over 1,000 hectares in 1940 to over 11 million in 2009 (Shearman et al, 2008; FAO 2009).

Figure 3.59 shows the number of forest concessions in PNG (World Bank, 2001). The number of timber concessions has increased substantially since 1950s when the first logging operation began in Bulolo. Most of these concessions are either under the old Timber Rights Purchases (TRP) and Local Forest Area (LFA) or the Forest Management Area (FMA), with most TRPs either expired, renewed or are replaced by FMA or Timber Authority (TA) as per the Forestry Act 1993. More recently, some forest operations licenses comes under the Forest Clearance Authority (FCA) which cater for agro-forestry projects.

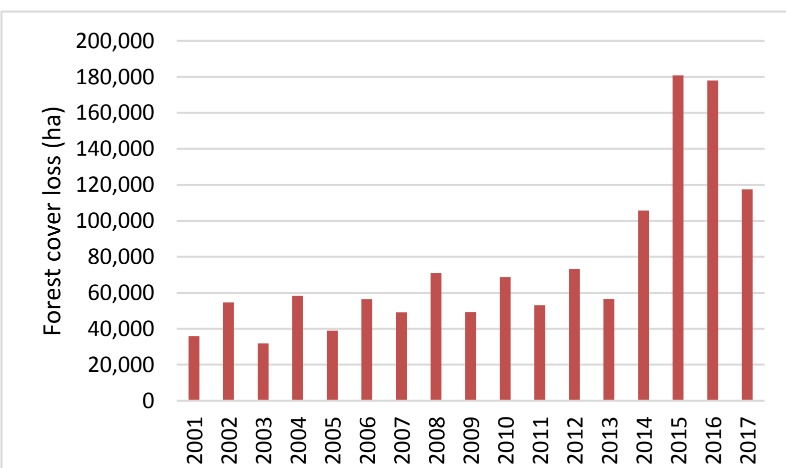


Figure 3.58: PNG's forest cover loss between 2001 and 2017 at 30% (Glbal Forest Watch)

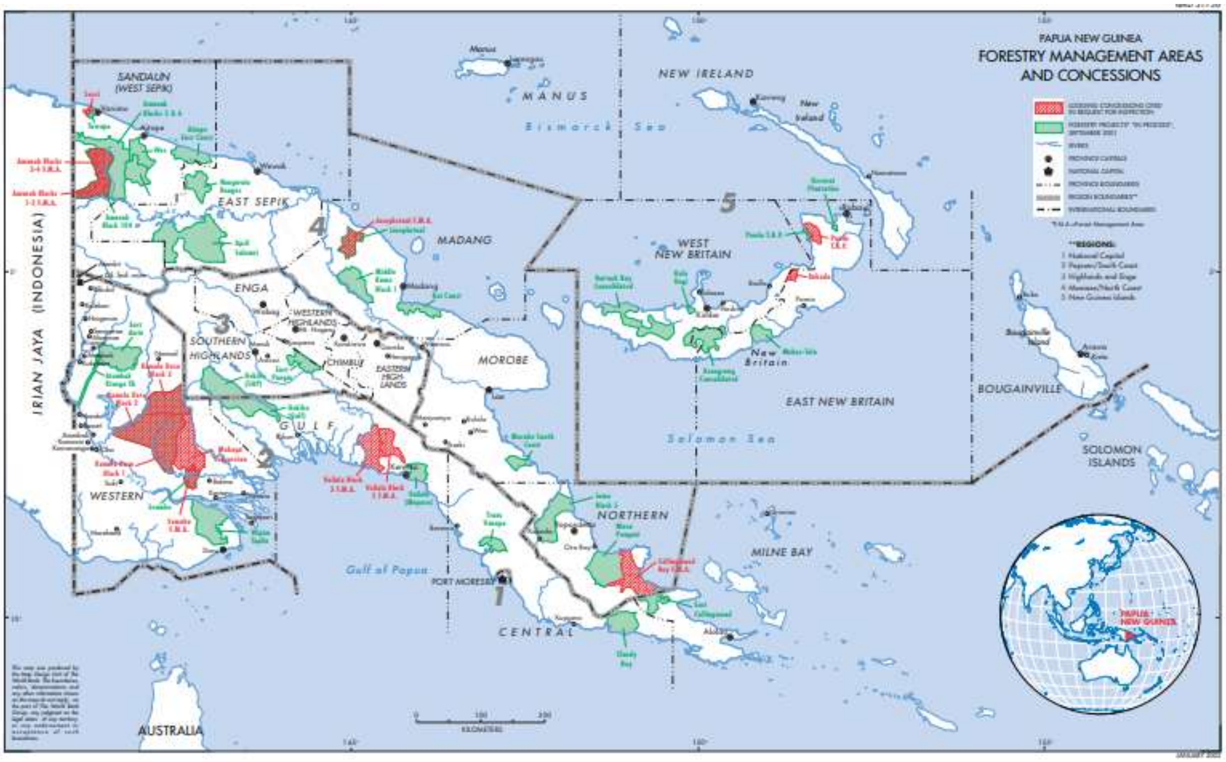


Figure 3.59: PNG's Forest Management Areas and logging concessions in PNG (World Bank, 2001). The Red shaded area was visited by the World Bank for review while the green shaded are forestry projects. Note: Some of these concessions have expired while others have been renewed, including additions of other Agroforestry projects.

Another study shows that of the 465 147.71 km^2 of land in PNG (i.e. 114, 754.7 km^2) constitute of water bodies and 45,367,224 km^2 total land area, with approximately 2 thirds (75%) of it is covered by primary tropical rainforest (Prais, 2018). In 2000, 370,629 km^2 of land were covered by trees and by 2015, it was 376,679 km^2. Over 15 years, between 2000 and 2015, a net land cover change of 6,050 km^2 was recorded, with 21.950 km^2 of forest increase. The forest area increase for 2015 is due to results attained from the 2012 probably because of increase forest cover from plantations or regeneration. The JICA-PNGFA project currently operating in PNG with the state of the art forest monitoring system found lack of deforestation using GIS & RS software. The national forest definition discussed above may have influence the increase of forest area because some vegetation types have fallen within the definition threshold.

The above studies indicate that increasing global demand for agricultural commodities, especially palm oil and timber products, has prompted a rise in deforestation rises, with over 4 million ha of forest land cleared under Special Agriculture and Business Lease (SABL) agreements between 2003 and 2010. SABLs are based on a lease-lease-back arrangement, whereby customary landowners form an Incorporated Land Group (ILG), register their land for development and lease it to the government. The government then leases the land back to the ILG, which sub-leases it to a company to develop and manage (Filer, 2012).

Such rapid increases in forest clearance for agriculture are also likely to continue in a country with the current population growth rate of over 3.2% per annum and the increasing global demand for agricultural commodities and forest products. Currently only 4% of land area is dedicated to agriculture with an estimated 30%

is considered suitable for agriculture (Bito & Petit, 2016). On the other hand, the PNGFA estimates approximately 60% of the total area of the country is covered by natural forests, of which 52% are considered production forests (for timber and other products), and 48% are for conservation because of inaccessibility for timber extraction or other ecological constraints (Bito & Petit, 2016). Thus it is estimated that each year 50,000-60,000 ha are cleared permanently with 50% for agriculture, 25-30% for industrial logging, and the rest for infrastructure. However, up to 100,000 additional hectares are affected by selective logging (Mogabay, 2019). Figure 3.60 shows the different land constraints that restrict suitability of land to forestry and agriculture activities.

Logging and agriculture (subsistence and commercial) are the major land-uses in PNG that are causing significant changes to forest cover. The study by Shearman et al. (2008) using remote sensing indicates that commercial logging, subsistence agriculture and fire are the major drivers of forest change across PNG between 1972 and 2002. Forest and land-uses sector accounts for 90% of PNG's total greenhouse gas (GHG) emission.

The major drivers of deforestation and forest degradation comes from large-scale industrial logging, large-scale clearance for agricultural commodities and small scale clearance for gardens and subsistence agriculture, coupled with the rapid rising population at a growth rate of 3.1% (GoPNG, 2018c). This spatial analysis suggests that the annual rate of deforestation and degradation across all regions in PNG over the 1972-2002 period was 1.4% and 24% for all primary forest (Shearman et al. 2008). In 2014 there were 278,767 km^2 of closed canopy rainforest in PNG, and about 13% of them had been logged at least once since 1972. Moreover, between 2002-2014, almost 4.1% of forest was cleared or logged (Bryan et al., 2015). This means a total of 3752 km^2 of rainforest was deforested and 7705 km^2 of previously unlogged forest was degraded through logging.

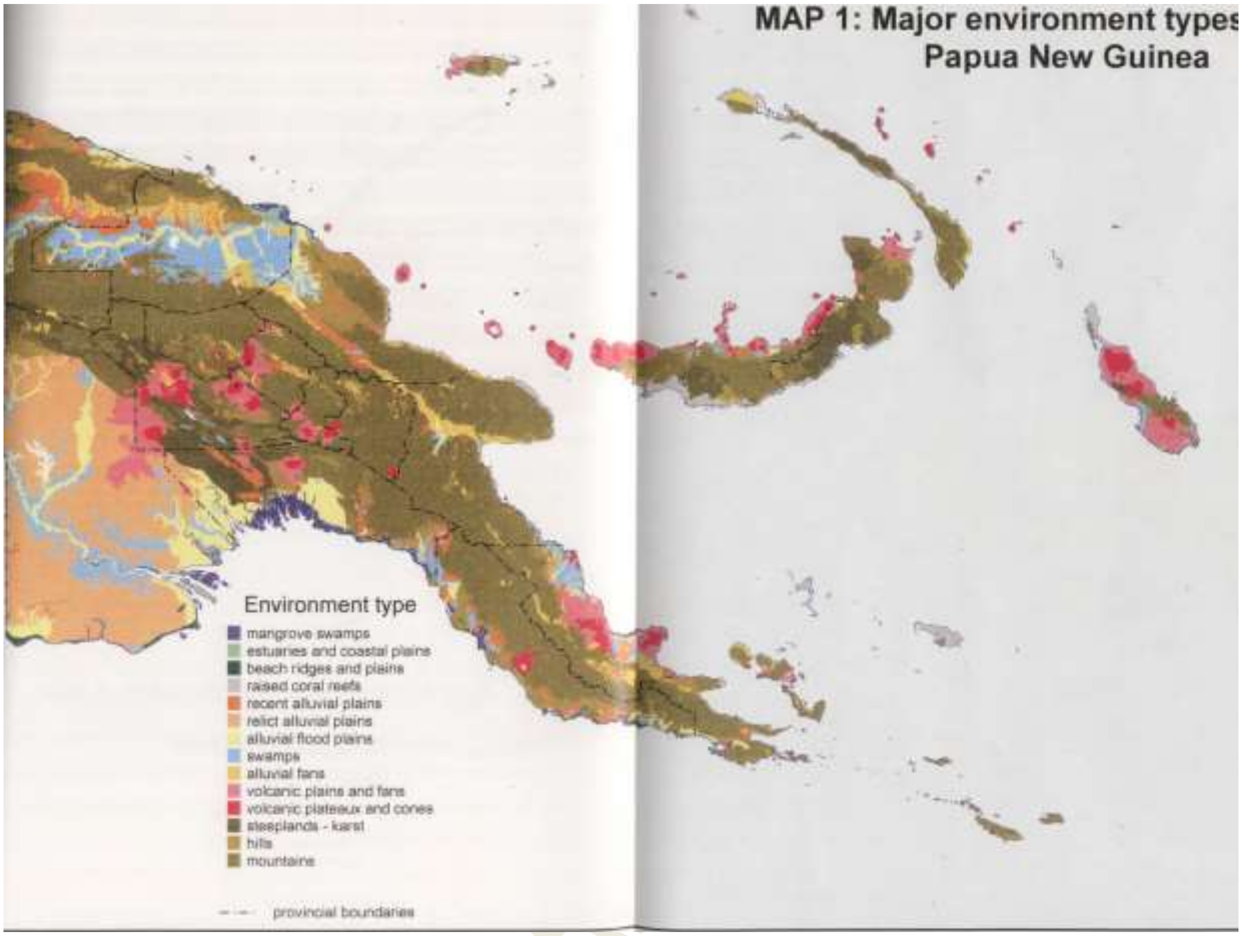


Figure 3.60: Major environment types in PNG (Trangmar et al., 1995)

The increasing forest and agriculture land-uses are also contributing to loss of species, ecosystem and carbon. For the later, the forest sequester the carbon dioxide (CO_2) emitted into the atmosphere. Figure 3.61 shows between 2001 and 2015 deforestation was 161,528ha and forest degradation was 2,427,987ha, with emission of 5mt CO_2e- and 25mtCO_2e- respectively (GoPNG, 2017).

Most CO_2 emissions in deforested areas come from family agriculture with 55%, followed by commercial agriculture, mainly palm oil with 26%, forest conversion to other use with 13% and forest conversion to other agriculture use with 6%. On the contrary, forest degradation is commercial logging the major emitter of CO_2 with 98.1% while 1.9% comes from other sources namely small scale logging, gardening, and fire.

Impact

Agriculture is a mainstay of the PNG economy and thus represents an important area for economic growth and stability. As such there is a need to ensure that continued agricultural development not only supports economic growth and poverty alleviation, but is also socially and environmentally sustainable. This is particularly important if the country is to meet its objectives under the Vision 2050 development strategy, including that of becoming carbon neutral by 2050. Other polices such as MTDS III and StaRS will determine the preservation and sustainable management of PNG's forest.

Overall PNG's forests were being cleared or degraded at a rate of 0.49 % per year in 2014, a deceleration compared to the 1972-2002 period.

Logging increased after small agriculture business lease was introduced where almost 38,242 km^2 of SABL land were awarded. In a recent assessment, it was found that the picture is quite different where most forest are still intact. Despite the losses, Vision 2050 to establish 800,000 ha of forest plantation by 2050 with PNGFA estimates that around 60,000 ha have been reforested with a further 20,000 ha prior to be planted by 2030.

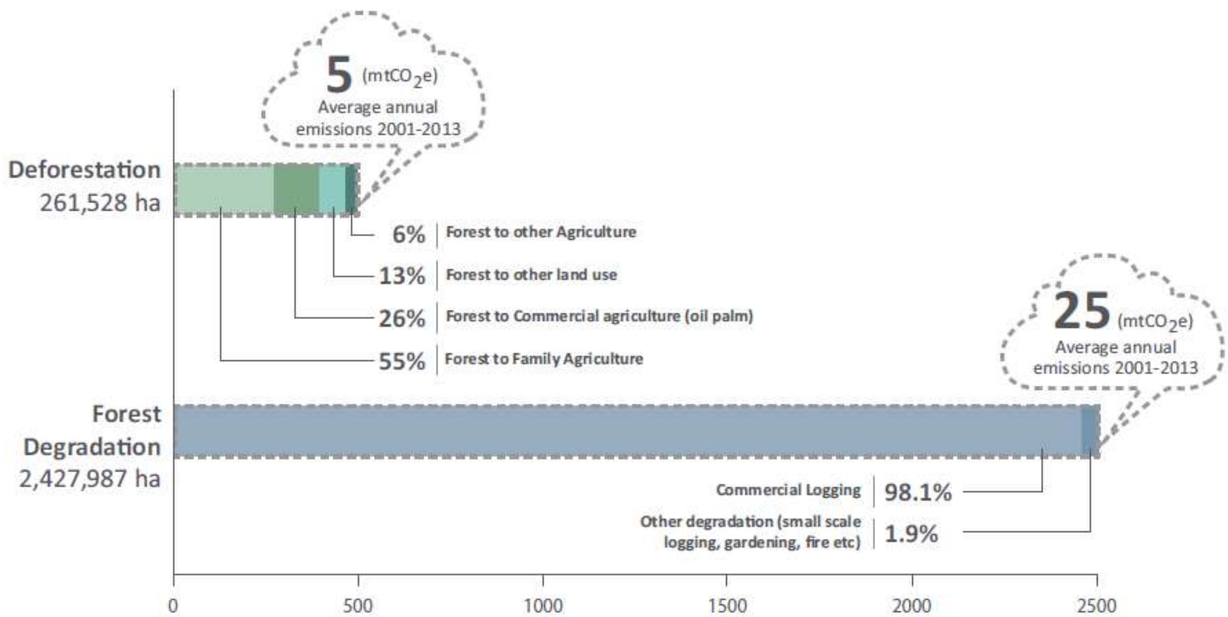


Figure 3.61: Thousands of hectares of forest impacted between 2001-2015 as PNG Forest Reference Emission Level (GOPNG, 2017)

The increasing forest losses and forest degradation will continue become a major topic of discussion over time because PNG is now at a cross road for sustainable development. If PNG is not resilient to managing its land and forest sustainably, it will loss many of its unique resource in term of cultural and biological diversity it is renowned for. Other environment services provided by the forest will also be affected, thus affected the lives of the majority of the rural population who depend on those resources for their livelihood and sustenance. In terms of species survivorship, destruction caused by humans coupled with other impacts coming from climate change will also affect the ecosystem and the rich biodiversity PNG has.

Response and Recommendations

The National Depletion rate for forest in 2016 is 9% and the government through the MTDP III aims to reduce the depletion rate to 5% by 2022. There is a need to improve forest governance and compliance. Also ensure the National Land use Policy clearly demarcates zoning of different land-uses with that of forestry into national land-use plans.

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8.5.3 TOPIC/SUBTOPIC: LAND UNDER CULTIVATION

Indicator Definition: Percentage (%) of total arable land that is under cultivation and agricultural use.

Status and Trend

Aerial Photo of palm oil plantation, Solomon Islands

SDG/CBD Targets

SDG: 1.1.1, 1.4.11.4.2, 1.a..1, 1.b.1, 2.1.1, 2.1.2, 2.2.1, 2.2.2, 2.3.1, 2.4.1, 8.1.18.2.1, 8.3.1, 8.4.1, 8.4.2, 9.1.1, 9.2.1, 9.4.1, 9.5.1, 9.b.1, 12.1.1, 12.2.1, 12.4.1, 12.5.1, 12.6.1, 12.a.1, 13.1.2,13.3.1, 13.b.1,15.1.1, 15.1.2, 15.2.1, 15.3.1, 15.8.1, 15.9.115.a.1, 15.b.1

Aichi Target: 1, 2, 3, 4, 5, 7, 8, 9, 13, 16

Status and Trend Discussion

PNG constitute of 1% of the earths landmass, with majority of Papua New Guineans live in rural coastal and highlands village hamlets and communities. That is, over 85% of PNG's population live in rural areas and agriculture is the mainstay of their livelihood (NSO, 2011). Almost 97% of the land in PNG is owned by customary land owners whereas the other 3% is owned by the government and private individuals or businesses. In the chapter on Culture and Heritage, more will be discussed on traditional land ownership.

Apart from forestry activities, agriculture has contributed significantly to PNG's economy between 25 to 40% GDP over the past 40 years and around 85% of the population are dependent on agriculture. Agricultural commodities (e.g. palm oil, coffee, cocoa, coconut) provide the key sources of agricultural export revenue and employment. The subsistence agriculture provides for the livelihood and sustenance of the people, with additional crops sold at the market for cash.

Figure 3.62 shows that most land used for agriculture are mountainous and population density is quite high in those regions with five basic landforms being prominent in PNG. These landforms determine the suitability of both commercial or subsistence agriculture and they are (Burke and Harwood eds., 2009: 1)

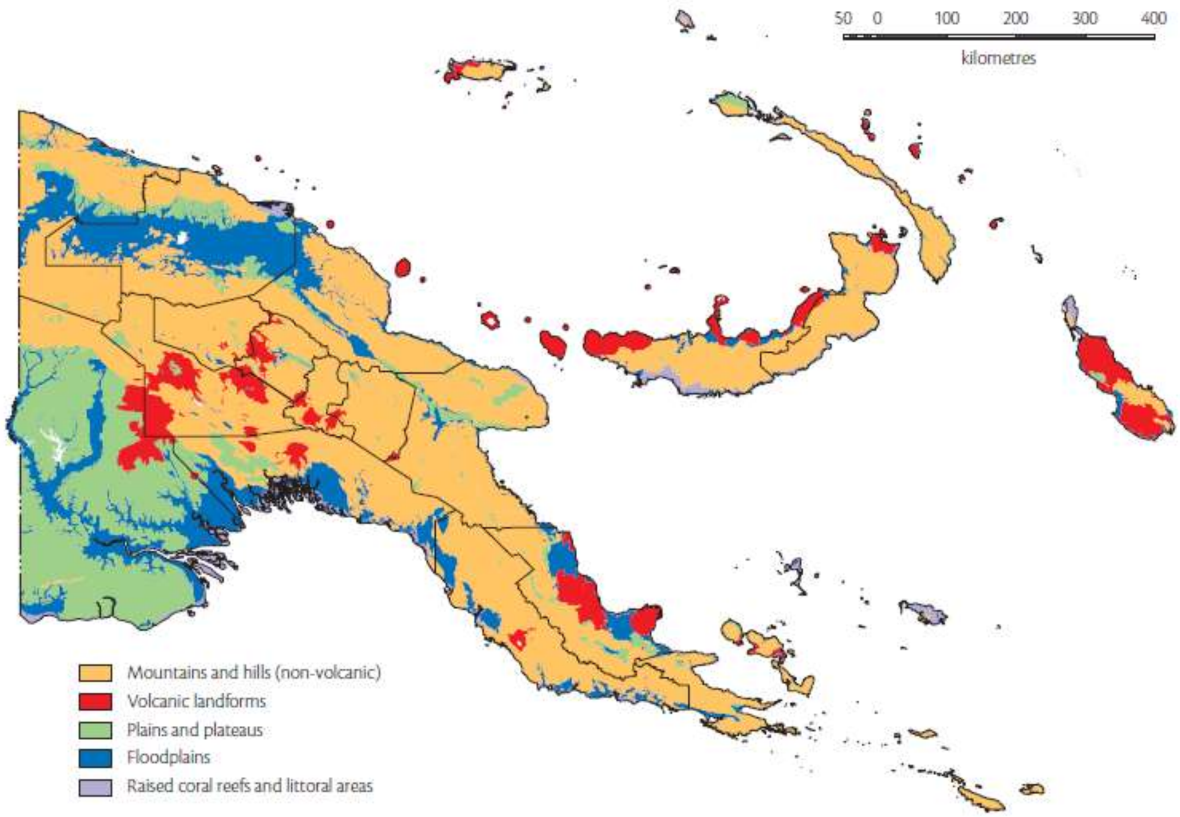

Figure 3.62: Landform where agriculture activities are centered (Burke and Harwood, eds., 2009)

Mountains and hills (not of volcanic origin); 2) Landforms of volcanic origin (including volcanic foot slopes and plains); 3) Plains and plateaus; 4) Floodplains; and 5) Raised coral reefs and littoral areas (beach ridges, tidal flats, mangrove swamps and other coastal features). Almost 52% of the total land area of PNG is mountains and hills; with 19% is plains or plateaus; 18% is floodplains; and a smaller proportion is of volcanic landforms or raised coral reefs and littoral areas.

Figure 3.63 shows the land that the people use land based on altitude and this depends on the province where agriculture is prominent. Figure 3.64 and 3.65 shows elevation and slopes of the entire country where most of the middle part of the mainland and outer islands are steeper as distance from the coast increase inland (Bryan and Shearman eds. 2008). According to Burke and Harwood (eds., 2009), the provinces with the greatest proportion of total land area comprising mountains and hills are Enga (91%), Eastern Highlands (90%), East New Britain (83%), Simbu (79%), Central (78%) and Morobe (77%). Almost two-thirds (63%) of the land used for agriculture in PNG is on mountains and hills; 12% is on volcanic landforms; 11% is on plains and plateaus; and 9% is on floodplains.

Furthermore, the provinces with the greatest proportion of land used for agriculture on mountains and hills are Eastern Highlands (91% of land used for agriculture), Enga (90%), Simbu (86%), Madang (76%), Sandaun (76%), Morobe (76%) and Gulf (75%). On the contrary, volcanic landforms used for agriculture are most important in the AROB Province, where 61% of land used for agriculture is of volcanic origin. There is also a significant landform for agriculture in Oro (46%) and Southern Highlands provinces (32%).

Although 59% of the land used for agriculture on plains and plateaus is in Western Province, much of this land is used at very low intensity. Provinces where a high proportion of land used for agriculture is floodplain are East Sepik (22%), Central (22%), Oro (16%), Gulf (16%) and Sandaun (14%). The coastal landforms used for agriculture are most important in the Islands Region and in Milne Bay Province.

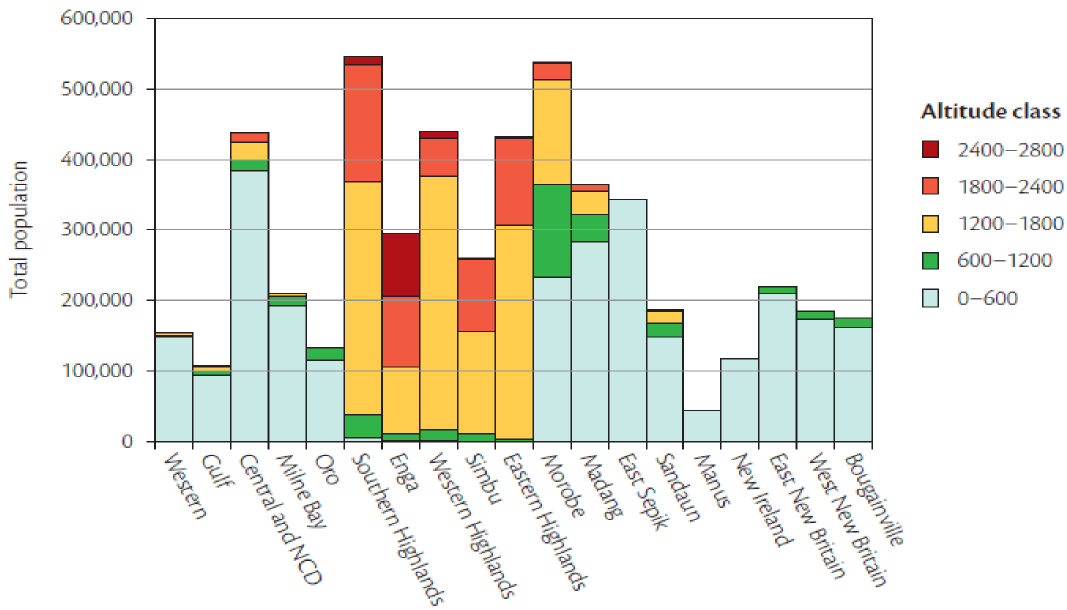

Figure 3.63: Land used by people for agriculture by altitude and province (Burke and Harwood, eds., 2009)

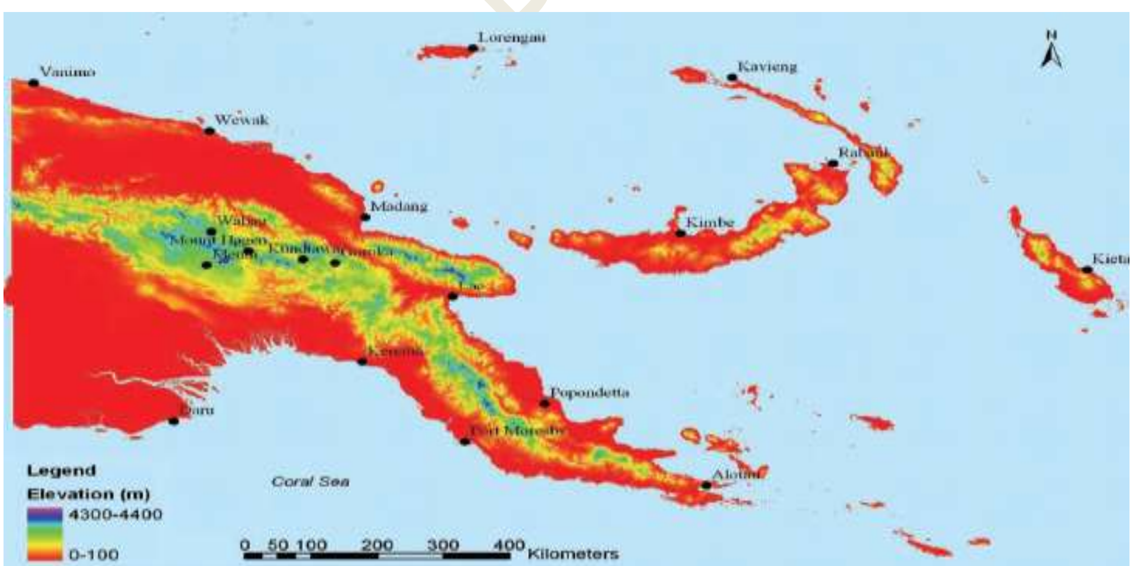

Figure 3.64: Elevation layers of PNG showing one class per 100m increase in altitude (Bryan and Shearman eds. 2008)

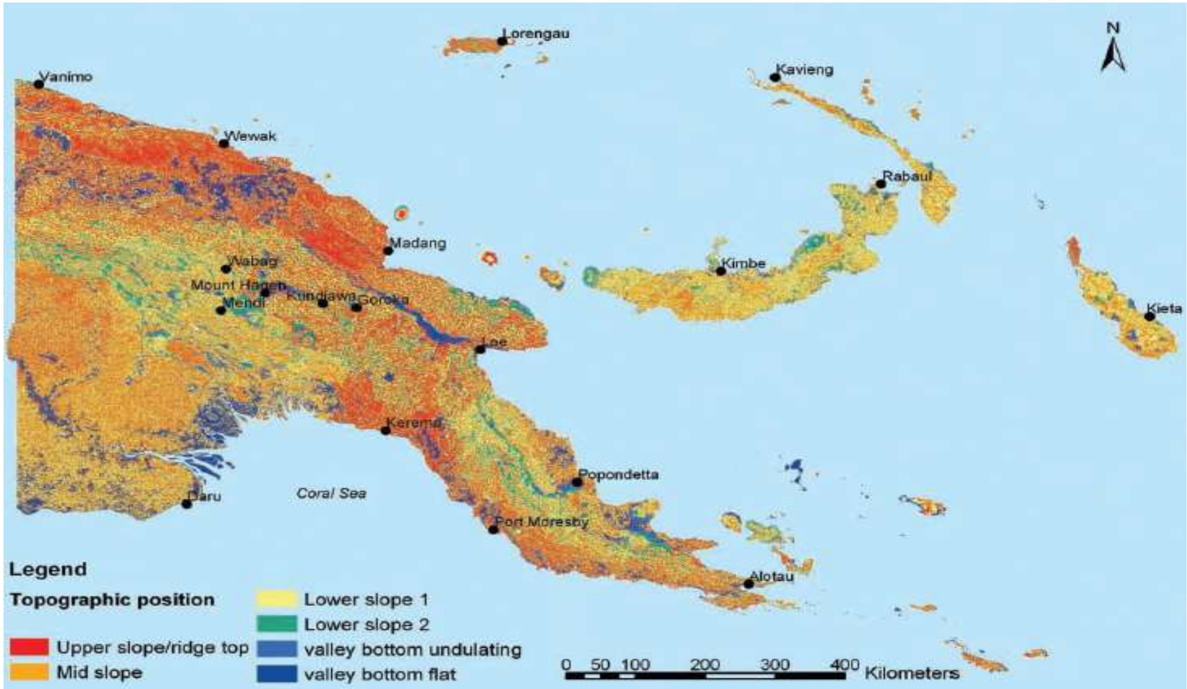

Figure 3.65: Topographic position map of PNG (Bryan and Shearman eds., 2008)

Burke and Harwood (eds. 2009) iterates that approximately half of the population of PNG live on mountains and hills; 17% live on volcanic landforms; 13% on plains and plateaus; and 9% on floodplains. For raised coral reefs and littoral areas – the landform that makes up the smallest area of PNG (only 4%) – it support 11% of the population). PNG landforms with the highest population densities on land used for agriculture are raised coral reefs and littoral areas (70 persons/km^2). Population densities on volcanic landforms average 50 persons/km^2 and on plains and plateaus are around 40 persons/km^2. Population densities are lowest on mountains and hills. The population densities are the driving force behind different land uses and intensity in PNG.

Figure 3.66 shows the different land distribution based on altitude (temperature), soil water and inundation. These basically influence the intensity and occurrence of agriculture activities in PNG. The lowland comprised of 66% compared to high altitude with 44%. In terms of soil water deficit, only a smaller portion of 8% experience strong spoil water deficits (e.g. Markham valley, Wau-Bulolo, Western Province, Central Province and parts of Gulf, East Sepik, Oro and Milne Bay Provinces.

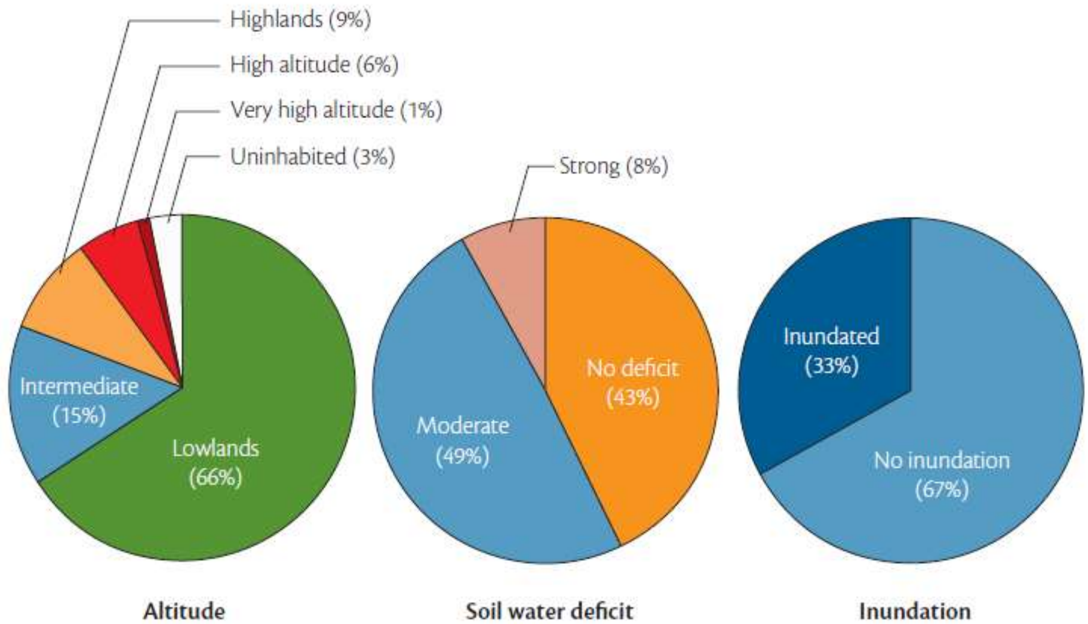

Figure3.66: Proportion of the total land area by altitude (temperature), soil water deficit (rainfall deficit) and inundation classes (Burke and Harwood, eds., 2009)

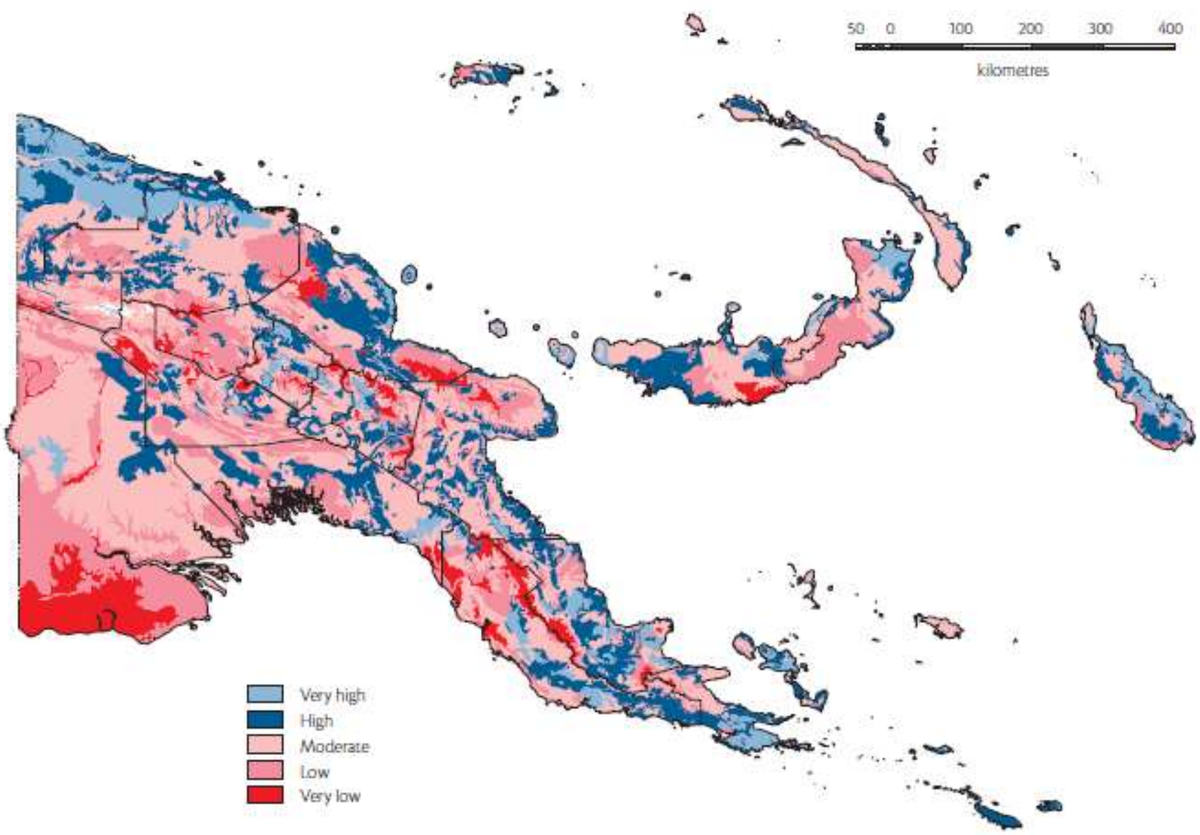

Figure 3.67: Land quality (Burke and Harwood, eds., 2009)

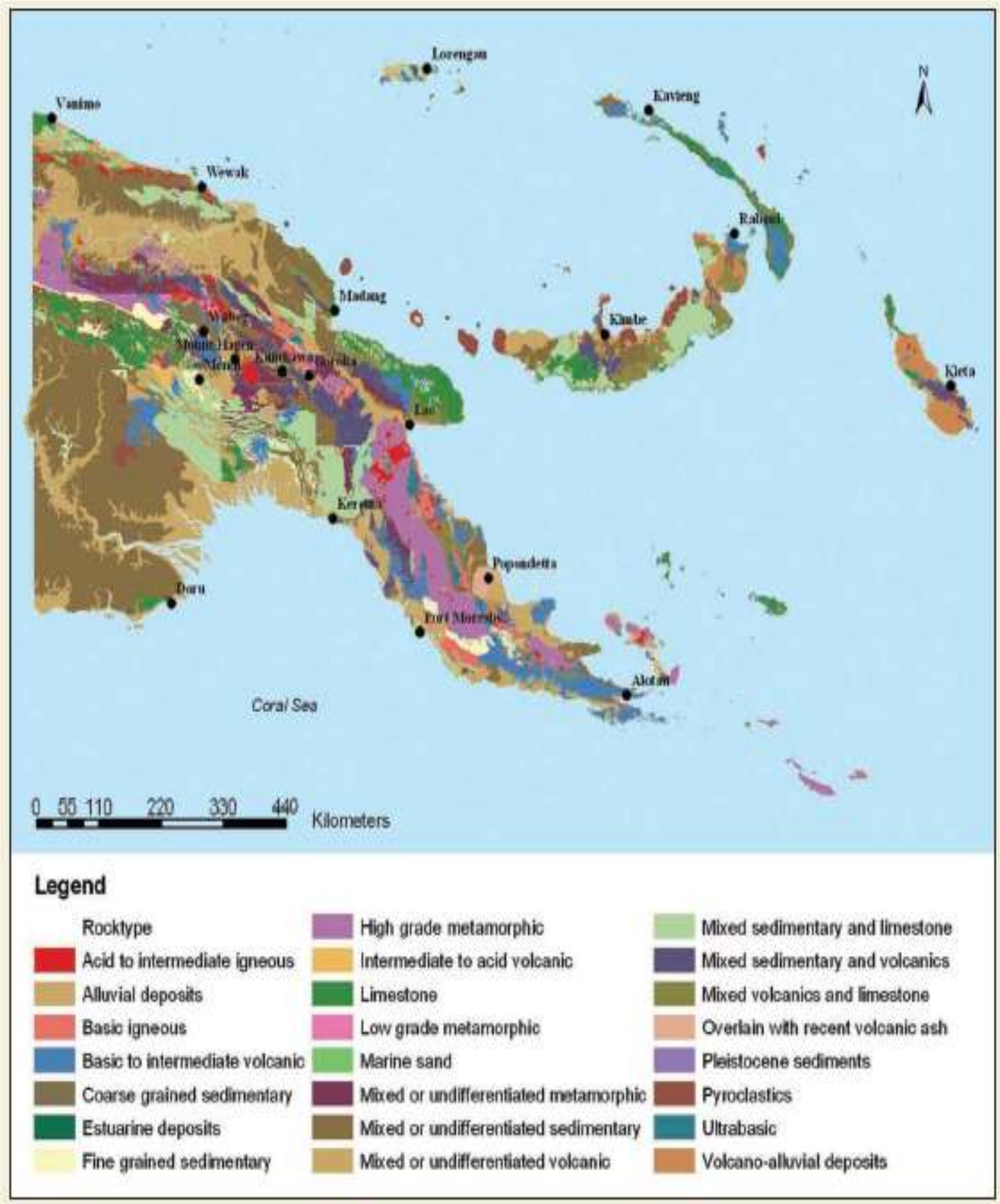

Figure 3.68: Rock types in PNG (Bryan and Shearman eds., 2008)

Figure 3.67 shows high quality soils of volcanic origins are scattered across PNG, with poor quality common in Western, Central, Madang and Morobe and across the highlands region. These soil quality can be determined by the parent rock. Figure 3.68 indicates different rock types across PNG. According to Burke and Harwood (eds. 2009), more than 70% of the total land area in PNG is of low or very low quality and is not occupied by people while 20% of the total land area is of moderate potential and only 7% is of high or very high potential. It was argued that most people in PNG produce food from land of moderate to low quality because almost 80% of the population occupies land of moderate or lower potential. On the other hand, only 20% of the country's population occupy high or very high quality land.

These high quality land is often associated with volcanic landforms or with land of volcanic ashes or tephra origin. Of the estimated 983 000 people who occupy high and very high quality land, almost 30% live in either East New Britain Province or Western Highlands Province. A further 12% live in East Sepik Province and 10% live in Sandaun Province. Of the estimated 2.8 million people who occupy very low or low quality land, 24% live in Morobe Province or Southern Highlands Province and a further 18% in Eastern Highlands or Enga provinces.

People are not evenly distributed over poor and good quality land, but are concentrated on better quality land. Average population densities on high and very high quality land are between four and eight times those on poor quality land (Burke and Harwood eds., 2009).

The government of PNG has a long-term strategy to develop by 2030 a "*world-class agricultural sector"* and tis may led to Increase in agricultural production (Bito and Petit, 2016Though are ambitious expansion plans for palm oil, coffee, cocoa, copra, spices and rice as spelled out in the government plans, there may not be expansion for other commodities except palm oil sector. The Palm oil industry is focused on increasing production through expansion of the area under cultivation, and represents the most significant threat to levels of forest cover. Indeed, the area under cultivation estimated at 150,000 ha is already set to more than double in the short-term based on expansion of existing projects thereby to increase by 10-fold to 1.5 million ha by 2030 (Bito and Petit, 2016).

Oil palm also has important opportunity costs: (i) it reduces the diversity of crops in the oil palm area, as it does not allow for companion planting and encourages wide scale land clearing; (ii) the land clearing introduces soil erosion and siltation of rivers; and (iii) several forms of chemical pollutants are introduced, most notably fertilisers, which cause serious water pollution (Anderson, 2006). Promotion of quality for cocoa, coffee and other commodities will occur, hence acquisition and use of new areas may be limited. On the other hand, subsistence agriculture may increase given the rapid increase in population.

Figure 3.69: Logging concessions and SABL lease areas in PNG (ACT Now)

Impact

The number of agriculture land available is low at 30%, only 4% has been utilised because of constraints such as swamps, mountains, weather and edaphic factors that influence land suitability for agriculture. Burke and Harwood (eds., 2009) reported the available land for agriculture was 25%. In 2000, a total of 62,801 km^2 of cropland was available and in 2015 about 56,732 km^2, indicating a net change of -6,069 km^2 over 15 years (Prais, 2018). The UNCCD report by Prais iterates that tree cover areas change to grassland, cropland, and wetland was about 108 km^2, 3,010 km^2 and 20 km^2respectively, with the highest loss experienced in cropland. This depicts increase agriculture activities, mainly in commercial plantations and shifting cultivation.

Conversion of tree-covered area also change over time. Figure 3.69 shows almost 5.2 mil ha of forests have been earmarked for agriculture development overlaped most logging concessions. This would contribute to increasing deforestation and natural loss of forests, and other environmental values such as species, habitats and cultural heritage of local forest communities. Currently, SABL projects are under moratorium but if in operation will reduce a substantial forest cover in temrs of area.

The trend of tree cover loss see it was declining at 2,279 km^2, moderately decline by 17,745 km^2, under stressed by 53,421 km^2, stable by 269455 km^2 and increasing by 21,950 km^2 (Prais, 2018). The increase may be a result of regeneration from logging, growth of crops such as oil palm or bush fallow activities. With increasing population and global demand for agriculture commodity, land and forest conversion to agriculture (both subsistence and agriculture) in PNG has increased substantially. A reduction of -6.069km^2 of forest cover was encountered as well where forest has been converted to cropland, depicting a net area change of 3.010 km^2 (Prais, 2018).

In addition 85km^2 of wetland has been converted to cropland, however, conversion of wetlands is stable at 29 km^2, 35 km^2 is stressed, 9 km^2has moderately declined, and 1 km^2 is declining. This result shows there is an increasing conversion of wetland to cropland by 10 km^2. All in all, 9.820km^2 of crop cultivation has occurred and most likely to increase into the future as population increases, coupled with government driven policies for increase agriculture activities and unsustainable land-use and poor agronomy practices.

Response and Recommendations

A national Land-use plan and mapping of all potential arable land must be documented and better farming practices be implemented through the Department of Agriculture and Livestock (DAL). More awareness also need to be conducted on better farming practices.

Reference

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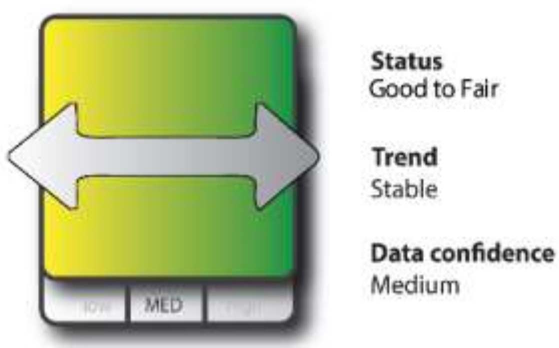
8.5. 4 TOPIC/SUB-TOIPIC: WETLANDS

Indicator Definition: Percentage (%) cover of wetlands and mangroves

Status and Trend




Underground Rivers, Pomio, East New Britain Province (Source: unknown)

SDG/CBD Targets

SDG: .1.1, 1.2.1, .1.4.2, 1.5.3, 2.1.2, 2.2.1, 2.2.2, 2.3.2, 2.4.1, 12.2.1, 12.4.1, 12.5.1, 12.8.1, 12.a.1, 13.1.2, 13.2.1, 13.3.1, 13.b.1, 15.1.1, 15.1.2, 15.2.1, 15.3.1, 15.7.1, 15.8.115.9.1, 15.b.1

Aichi Target: 1 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 14

Status and Trend Discussion

The Ramsar according to Article 1 of the Convention states that "wetlands are areas of marsh, fan, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres" (Ramsar Convention Secretariat eds. 2016). Hence, wetlands are a wide variety of inland habitats such as marshes, peatlands, floodplains, rivers and lakes.

Wetlands also have coastal attributes such as saltmarshes, mangroves, intertidal mudflats and seagrass beds. Wetlands also include coral reefs and other marine areas not deeper than six metres at low tide, and can be man-made wetlands as well such as dams, reservoirs, rice paddies and wastewater treatment ponds and lagoons.

Wetlands play important functions because of various interactions within or among the physical, biological and chemical components of a wetland that enable the wetland to perform various important functions it is known for. Some of these functions are water storage; storm protection and flood mitigation; drought buffering; shoreline stabilization and erosion control; groundwater recharge and discharge; water purification; retention of nutrients, sediments, and pollutants; and stabilization of local climate conditions, particularly rainfall and temperature (Ramsar Convention Secretariat eds. 2016).

Wetlands frequently provide important economic benefits, including water supply (quantity and quality); fisheries (over two thirds of the world's fish harvest is linked to the health of wetland areas);food; agriculture, through the maintenance of water tables and nutrient retention in floodplains; timber and other building materials; energy resources, such as peat and plant matter; wildlife resources; transport; a wide range of other wetland products, including herbal medicines; and recreation and tourism opportunities. It is estimated that more than a billion livelihoods worldwide are wholly or largely dependent on wetlands (Ramsar Convention Secretariat eds., 2016).

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. Ramsar (eds., 2016) recognises five major wetland types are: 1) **marine** (coastal wetlands including coastal lagoons, rocky shores, seagrass beds and coral reefs); 2) **estuarine** (including deltas, tidal marshes and mudflats, and mangrove swamps); 3) **lacustrine** (wetlands associated with lakes); 4) **riverine** (wetlands along rivers and streams); and 5) **palustrine** (meaning "marshy" – marshes, swamps and bogs). The wetlands of PNG are diverse ranging covering both marine and terrestrial habitats. The biggest man-mad wetland in PNG is the Yonki Dam and Sirunumu Dam that generates electricity.

Figure 3.70 shows most inundated areas are found near river tributaries and estuaries, mainly around the Fly, Sepik, Ramu and Purari, and Kikori Rivers, with other minor ones found elsewhere across PNG. This cater for most wetland environment comprising of undifferentiated swamps, fans, floodplains, estuaries, and mangrove swamps, which are either on coastal flats and river valleys or in highlands of PNG.

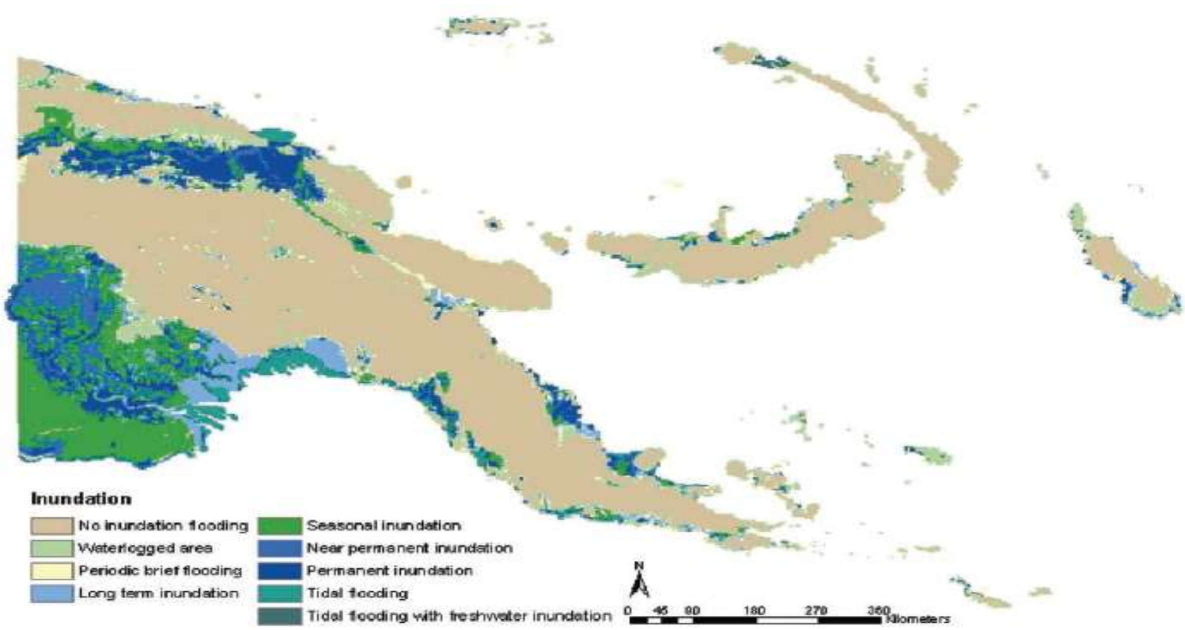


Figure 3.70: Inundation classification of PNG (Bryan and Shearman eds. 2008)

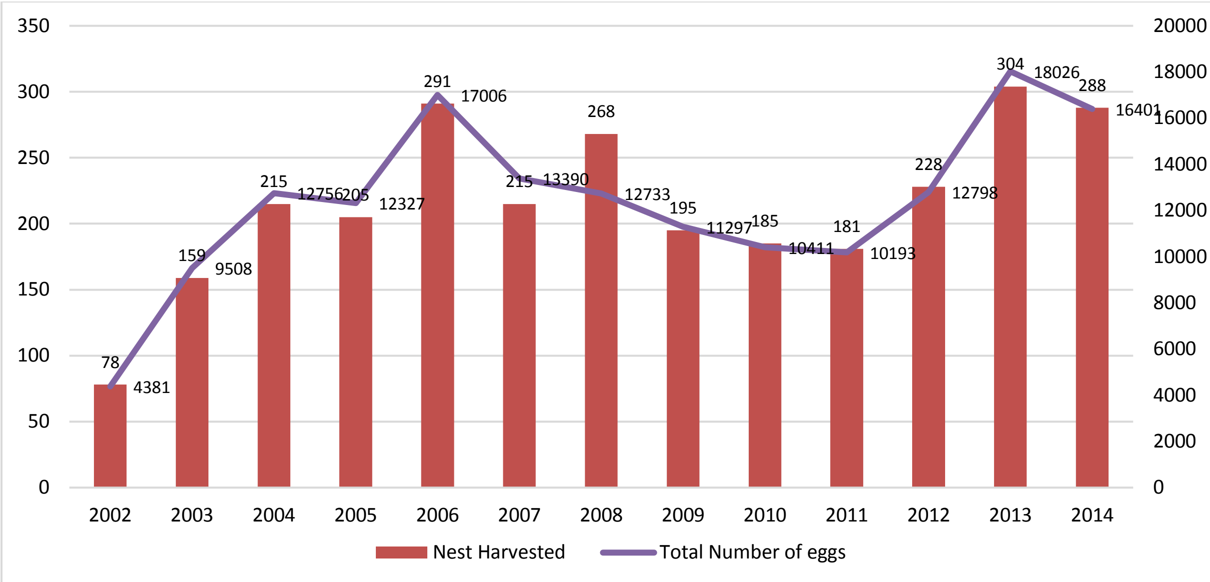


Figure 3.71: Wild crocodile egg harvest and production for the period 2002-2014 (Solmu et al., 2014; cited in GoPNG, 2016)

Wetlands and mangroves provide ecosystem services other ecosystems do not provide (e.g. nurseries for economically important fish species, natural flood mitigation and water filter systems). They also support plants and animals not found in other ecosystems. Most importantly, the wetlands provide habitats for wildlife and food and materials for local people who have their livelihood thrive on this ecosystems. They are provide flyway for migratory species, contains high and endemism, biodiversity, has extensive mangrove habitats, provide important food sources such as sago swamps and habitats from fish, are biologically significant for lake systems, and provide income generation for local communities. The Fly River system in Western Province, is the largest river in the country and has the most diverse freshwater fish fauna in Australasia (Swales, 2002). The river and its floodplain wetlands support local artisanal/subsistence fisheries and a limited regional commercial fishery.

For instance, crocodile harvesting for skin and eggs provide a lucrative business for local riverine and wetland communities. In the Sepik River wetland areas, a total of K100, 000 plus are injected into the community annually by the buyer, Mainland Holdings Limited which has a hatchery and crocodile rearing facility in Lae. It visits communities annually and conduct nests surveys and purchased eggs from locals. It also conduct awareness on sustainable harvest in partnership with CEPA. Figure 3.71 shows the wild crocodile eggs harvest and production for both *Crocodylius novoguineae* and *C. porous* *b*etween 2002 and 2014 in the Sepik wetlands (GoPNG, 2017). In 2002 there were 78 nests harvested but this increased to 288 nests in 2014. The total number of eggs harvested also increase substantially over the 12 years from 4381 eggs in 2002 to 16,401 eggs in 2014.

There are periods where egg harvesting are high probably because of sustainable harvesting practices that enable more eggs to be sold or there is an increase in demand by the buyer, particularly in 2004, 2006, 2008, 2013 and 2014 compared to other years. There are years where harvesting is low probably because of less reproduction, clutches and nesting activities by female crocodiles or increase predation by human and other wild animals and chances of survival by eggs. Ecosystem services are important and globally provide at least US$ 33 trillion worth of services annually, of which about US$ 4.9 trillion are attributed to wetlands (Ramsar Convention Secretariat eds., 2016).

In the late 1980's, barramundi was ranked fourth in terms of both total fish production and foreign-exchange earnings (Opnai & Tenakanai, 1987; cited in Swales, 2002). In 1995, the barramundi catch represented ~80% of the total weight of commercial seafood sold in Daru, near the mouth of the Fly. Thus the fishery is important to coastal communities not only in Western Province but other parts of PNG as well because it involves many local fishers and generates cash for people in areas with few alternative sources of income.

Currently, there are 33 wetlands identified in the directory of the Asia Wetlands. Only two of these wetlands are recognised protected area under the Ramsar Convention as wetlands of significant importance and comprised of 590,000ha. The first Ramsar site is Tonda Wildlife Management Area (WMA) comprise of 590,000ha of wetlands, mangroves, tidal river reaches, savannah, littoral and monsoon forests. It is located in the south-western corner of the Western Province and is contiguous with Wasur National Park of Indonesia. The Tonda WMA is the largest protected area PNG and is managed by the local communities through the WMA committee It is an important wetland for over 250 species of resident and migratory water birds. Most of the World's population of little curlew (*Numenius minutus*) stage on the plains during migration. The area also provides habitat for birds-of-paradise and brolga (*Antigone rubicunda*) and other unique biodiversity.

The WMA also provides many essential environment services such as food and materials for local people's livelihood because most communities are living semi-nomadic lifestyles and trade with whatever they get from their environment across the border in Indonesia. In addition, Tonda WMA is also listed under the World Heritage tentative listing of UNESCO in 2006, including the Sepik wetlands and the Kikori River Basin which Lake Kutubu WMA is part of.

The second Ramsar site is the Lake Kutubu WMA which comprise of 4924ha of lake, aquatic and lowland forests. Lake Kutubu is the largest perched lake in PNG and situated in the highlands at 800m and is the second largest lake in PNG after Lake Murray in Western Province. The lake has a catchment area of 4,924 hectares, is about 19 kilometers long and 4 kilometers wide at its widest point, and has a maximum depth of about 70 meters (Osborne & Totome, 1992; cited in Exxon Mobil, 2012). Twelve of the 18 species of fish in Lake Kutubu are endemic, the highest level of lacustrine endemicity of any lake in the New Guinea–Australian region. Five of these endemics comprise up to 40 percent of the artisanal fishery and subsistence fish catches in the lake (Enesar, 2005; cited in Exxon Mobil, 2012) and provide an important source of dietary protein for the local communities residing within the lake's catchment.

These two recognised WMAs are protected under the Fauna (and Protection Control) Act of 1969 are of important biological values, species richness and endemism. However, this Act has been repealed by the CEPA Act 2014 and more recently will come under the Locally Managed Area (LMA) under the proposed Protected Area Bill Act 2018 which is currently been drafted and waiting for enactment by Parliament to become a law. The National Policy on Protected Area (2014) also recognised the conservation of wetlands in general.

Generally the overall Management Plan (e.g., feasibility study on the ecosystems values and services that are already present), review and update biodiversity Information were done by NGOs back then but most information are scattered or need update. In a recent assessment of protected area using the METT analysis developed by WWF, issues of social and economic values, invasive species, threats from hunting, fishing, climate change and other threats, and sustainability and management of both PAs was done with other 51 PAs (Leverington et al., 2017).

It was concluded that many criteria for effectively managing PAs need to be done to remedied or improve management effectiveness of all PAs including these two WMAs.The study also indicates that most PAs, including those two Ramsar sites are poorly managed, lacked resources and capacity and have no sustainable fiancé mechanisms.

According to the PNG Ramsar report to COP 13 (GoPNG, 2018), CEPA is finalizing the designation of the Upper Sepik River Basin as PNG's 3rd Ramsar Site. CEPA is also working to prepare Bootless Bay nomination before November 2018 but this was delayed due to some situations beyond CEPA's control. Other Activities CEPA is working on is to prepare Lake Kutubu and Tonda Ramsar Information Sheets' update and to provide support to the Ramsar Advisory Mission (RAM) on building capacity of CEPA to work with oil and gas industry. CEPA is also working towards identifying potential Ramsar Sites that will be able to accommodate for other initiatives, e.g., ecosystem-based disaster risk reduction, World Heritage Sites and others.

Mangrove ecosystems are unique because they are highly productive areas, and are important socially, economically and biologically. Tens of millions of people in the tropics and subtropics depend on mangrove forests, which provide ecosystems services such as wood and non-wood forest products, dyes, medicines, livestock feed and honey. Mangroves provide habitats for different organisms, including endangered species as well. They serve as a valuable nursery to many shrimps, crustaceans and molluscs, and act as a breeding and feeding ground for many commercially important fish species.

Moreover, mangroves maintain water quality and clarity, filtering pollutants (including heavy metals) and trapping sediments. Mangroves also help prevent erosion by stabilizing sediments and protecting the coast, especially during surge storms, hurricanes and tsunamis.

Mangrove forests are distributed in the inter-tidal region between the sea and the land in the tropical and subtropical regions of the world between approximately 30° N and 30° S latitude. Furthermore, the global distribution of mangrove forests is believed to be delimited by major ocean currents and the 20° C isotherm of seawater in winter. The forests are typically distributed from mean sea level to highest spring tide (Giri et al. 2010). Most mangroves grow in harsh environmental conditions such as high salinity, high temperature, extreme tides, high sedimentation and muddy anaerobic soils.

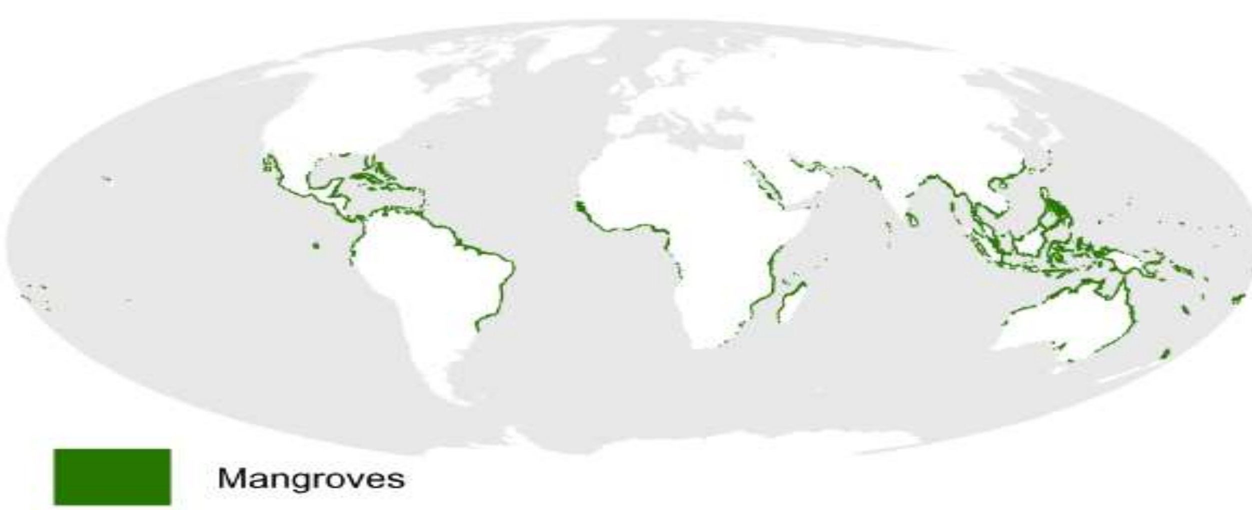


Figure 3.72: Global mangrove forest distribution (Giri et al. 2011)

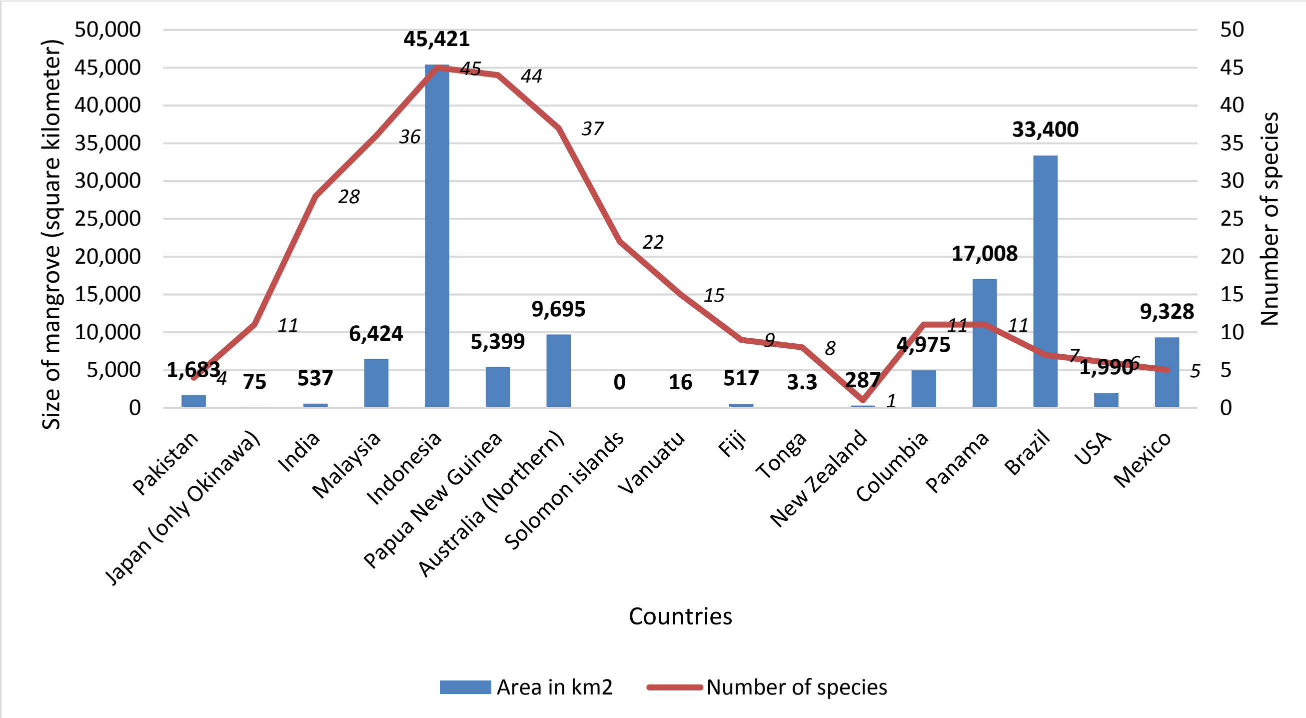


Figure 3.73: Size of mangroves in 17 top mangrove countries and the number of species (Giri et al. 2010)

The mangroves ecosystems are common occurrence in PNG's coastal regions, with particularly extensive stands in and around the deltas of major rivers, especially along the southern and northern coasts. Figure 3.72 shows the distribution of mangroves globally (Giri et al., 2011). Figure 3.73 also shows the sizes of mangroves across the top 17 mangrove countries. The species diversity of mangroves are high in the Southeast Asian region, including PNG and Australia, with PNG having the second most highest species diversity in the world after Indonesia with 44 species (Giri et al. 2010). No data for the size of mangrove forest for Solomon Islands was available, hence it was recorded as zero. The mangrove stands' close-knit lattice of aerial roots stabilizes the mud and silt sediments they inhabit, and provides sheltered environment in which silt deposits predominate. It is also the breeding ground for fisheries and other marine life, and provide protection from storm surges, high waves and erosion (ADB, 2014).

Mangroves are growing in 123 tropical and subtropical countries but only 73 species have been recognized as "true" mangroves. However, over 20% of mangrove habitat have decline in last 19 years due to conversion and coastal development, which is 3-4 times faster than terrestrial forest types because of lengthy recovery periods required by mangroves (ITTO, 2010). It is estimated that roughly between of US$2,000-9,000/ha/year have been derived from mangrove habitats.

PNG's major mangrove habitats are associated with the country's major rivers, including the Markham, Ramu, and Sepik Rivers along the northern coastline of the PNG mainland. On the southern coast the Fly, Kiokori, Purari, and smaller rivers such as the Brown and Vanapa rivers, and the Kemp Welch River (Paijmans and Rollet 1977, Petr 1983, Bualia and Sullivan 1990, Pernetta and Osborne 1990, Woodroffe 1992; cited in Giri et al., 2010). Giri et al. (2010) states that PNG's mangrove forest cover is ranked 8th in the world in terms of forest cover, comprising of

3.5% of the global total or 480,121 km^2. PNG's mangrove is also has about 57.6% of the total cover area in the Oceania region. In terms of species diversity, PNG has about 33-44 species, covering an area of 5,399km^2. There are some arguments that there are only 37 species of 'true' mangrove species in PNG.

PNG is also a globally important flyover for winter wading birds and its wetlands and shores provides important stop-overs. BirdLife International categorised PNG under the East Asia-Australian Flyway for. Every year winter experienced in either north or south of the temperate climatic areas instigates mass migration of birds to escape winter and to breed and feed in warm climatic areas such as PNG. Curlews, water birds, kingfishers, kookaburras and other birds often frequent the Tonda WMA annually. Some winter wading birds come to Tonda WMA as far as Siberia. Moreover, wetlands around the Sepik and Port Moresby also receive visitors from far lands as well. Hence, PNG wetlands provide ideal habitats for these birds.

Figure 3.74 is the East Asia-Australian Flyway and PNG is an important destination in the global migratory route for winter wading and shorebirds.

Figure 3.74: The East Asian-Australasian Flyway showing the sites with internationally-significant counts of at least one species of Migratory Shorebird (Bamford et al., 2008).

In conclusion, the mangrove and wetland ecosystems are faced with chronic threats from development activities footprints, including rising population and increasing demand for fuel wood and timber from logging and local users. There are also threats from climate change such as flooding and drought, invasive species, anthropogenic fires, sedimentation from upstream and mining and agriculture run-off. Consequently, these effect can have an effect on the environment, biodiversity and people's livelihood. Hence, it is important to maintain or manage the long-term sustainability of various environmental services that the local communities enjoy or depend upon for their livelihood.

Aquaculture

Aquaculture is a new fish farming practice introduced in PNG. It is still predominantly artisanal where subsistence pond culture of introduced fin fish are reared.Wtare can be extracted from main streams and creeks. These low level input systems are sustainable if returns for labour are favorable. Acording to NFA, in 2010, there were an estimated 10,000 inland aquaculture projects in PNG with an estimated value of PGK10 million (www.nfa.gov.pg). Generally, most freshwater fished are fished from rivers, streams and lakes using modern and traiditional methods and amount caught is still unknown.

The Papua New Guinea *National Aquaculture Development Policy* 2004, has visions that envisage to see sustainability and appropriate aquaculture activities are conducted to;

- Establish aquaculture as a viable business industry by facilitating and supporting the private sector to establish economically, socially and environmentally sustainable aquaculture ventures, with NFA facilitating development when appropriate;
- Ensure food security is promoted by producing sufficient fish or fish products to feed the people of PNG; and

- Integrate aquaculture with agriculture by encouraging farmers to adopt subsistence/artisanal aquaculture into their existing agriculture options.

Impact

In 2000, 15,068 km^2 of land cover was under wetlands and by 2015, 15,316 km^2 was covered in wetland, depicting a net area change of 248km^2. Land cover area change from tree covered areas, to grassland, to cropland and to wetlands were 20 km^2, 2 km^2 and 184km^2 respectively whereas from wetland to wetland is 14, 907 km^2. There was also conversion of 85 km^2 from wetland to cropland. Personal encounter in Tonda saw wetland declining due to vegetation changes and human and natural induced impacts affecting the local hydrology patterns, ecology and ecosystem (Prais 2018).

All in all the wetland is net productivity is declining at 284 km^2, moderately declining at 1,413 km^2, is under stressed at 3,325, is stable at 8,205 km^2 and increased at 961 km^2. There is an increasing conversion of wetland to cropland by 85km^2 between 200 and 2013. There is a decline in land productivity as land were converted declining by 1 km^2, moderately declining by 9 km^2, under stressed by 35 km^2 and stable by 29 km^2(Prais 2018). Mangrove ecosystems are, fragile and it is estimated that over half the world's mangroves have been lost in recent times. Capacity and resource constraints are affecting the implementation of the Ramsar Convention and management of many wetlands in PNG, including climate resilience and response. Therefore, annual visit for technical and administrative support by the government or partners are crucial for the management of these fragile ecosystems.

Response and Recommendations

International organisation partners should assist with documenting and preparing integrated land use and management plans for Ramsar sites, conduct assessment or survey of biodiversity inventory, invasive species, potential disaster risks from extractive industries.Recommendations from the UNDP report on Protected Areas identified several issues and challenges including in PAs such as no management plans, no sustainable funding, poor capacity and resources affecting management of wetlands. These must be addressed profusely. Also coordination of quarterly reviews and national updates will be a way forward to improving linkages and identifying gaps with other MEAs.

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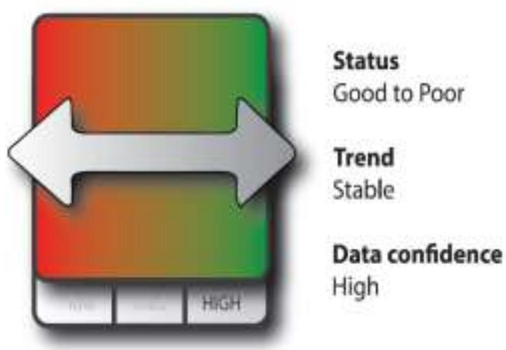
8.5.5 TOPIC/SUBTOPIC: TERRESTRIAL PROTECTED AREAS

Indicator Definition: Percentage (%) of area of land formally protected for conservation

Status and Trend



Varirata National Park overlooking Port Moresby (A. Frazer)

SDG/CBD Targets:

SDG:1.1, 1.2.1, .1.4.2, 1.5.3, 2.1.2, 2.2.1, 2.2.2, 2.3.2, 2.4.1, 12.2.1, 12.4.1, 12.5.1, 12.8.1, 12.a.1, 13.1.2, 13.2.1, 13.3.1, 13.b.1, 15.1.1, 15.1.2, 15.2.1, 15.3.1, 15.7.1, 15.8.115.9.1, 15.b.1

Aichi target: 1, 2, 3, ,4 5, 6, 8, 9, 11, , 12, 14

Status and Trend Discussion

Formally recognized protected areas are listed with the national PNG agency of the Conservation and Environment Protection Authority. In 2019 a Protected Areas Register with associated data for each PA has been established within CEPA. A METT (Management Effectiveness Tracking Tool) analysis of these protected areas was also completed and reported to the authority in 2017. Combined these represent the most definitive current record of protected areas as recorded in the yet to published 2019 6th National Report to the Conservation on Biological Diversity (in press).

Many of the customary 'protected' areas, both terrestrial and marine, that are not formally recognized, such as sacred 'tambu' sites, some of which cover extensive areas i.e. mountain summits have not been accounted. It is considered that as custom is dynamic, the future use of these areas is subject to change, however such areas have been recognized within the draft of a *Protected Areas* BilProtected areas are at established to protect biodiversity and ecosystem values from resource extraction and unsustainable harvesting. Approximately 2.5 million hectares (4%) of the total land and seascape of PNG are allocated for protection. Although there is no clear legal national definition of protected areas, consequently the extent of protected areas is much disputed. Figure 3.75 shows the status of protected areas in PNG. Approximately 2.5mil ha or 4% of the land and seascapes are formally protected. There are additional area of 14.5 million ha that are of interests for conservation as well. Some PAs have under dispute with 17,226ha, still under draft for gazettal with 53,366ha, 39,794ha is under voluntary conservation and 575040 ha is proposed for conservation.

There are also unknown number of PAs with 28,186ha while 19730ha are no longer active, The reason for the latter is because of lack of presence of CEPA on site or local people have convert PA into other uses that are of much benefit to them. Figure 3.76 shows the location of the Protected Areas in the country. Majority of the PAs are terrestrial based while only a minority are marine. Some terrestrial PAs also covers aquatic and parts of marine. The figure also indicates proposed, drafted, disputed idle, unknown or new area of interest sites. Figure 3.77 shows shows the priority areas done using Maxzan with 31 being marine and 49 being terrestrial, where 71 areas of Interest are critical for immediate conservation in the future (Vanessa et al., 2017), with 17 areas of land and sea are priority areas for immediate conservation.

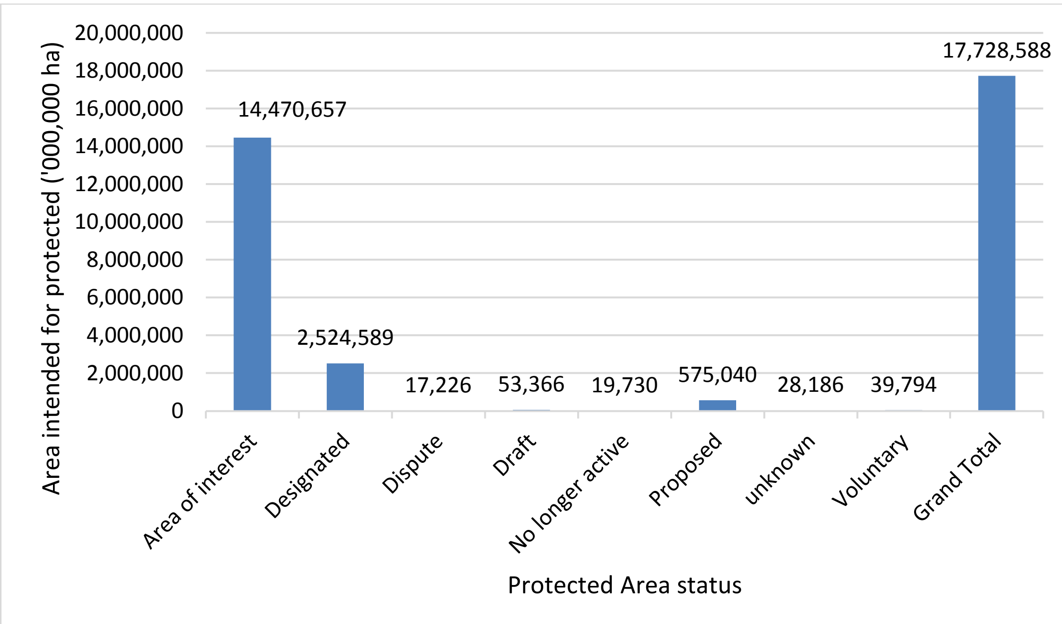


Figure 3.75: Status of Protected area in PNG and their sizes (CEPA, 2019)

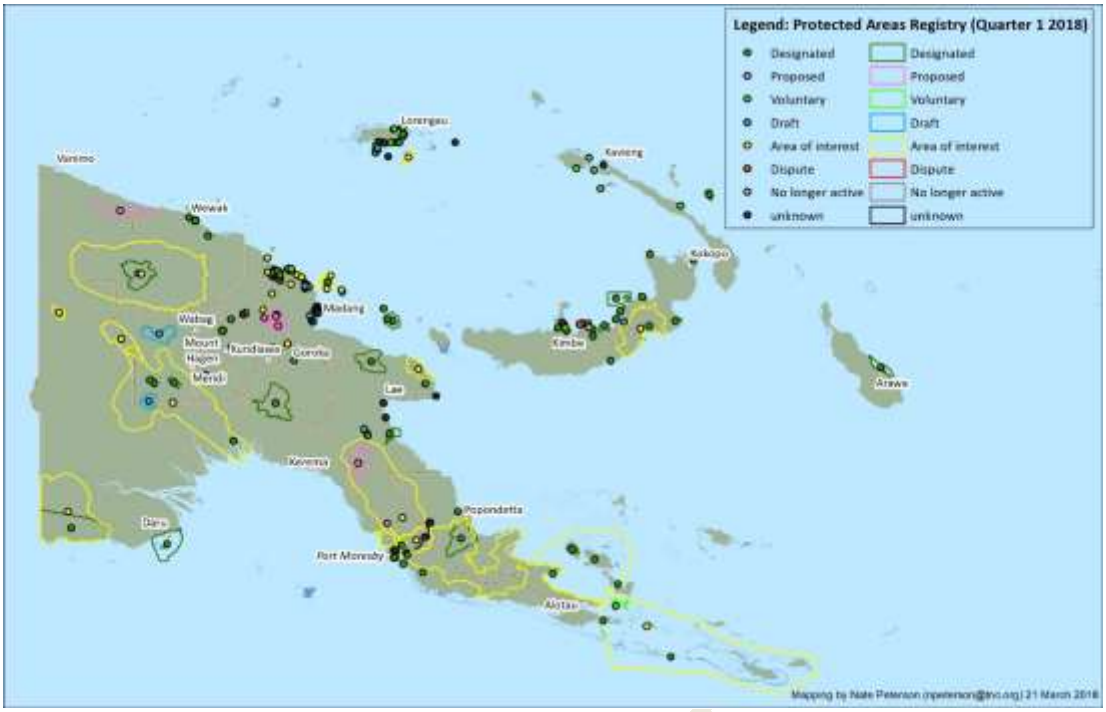


Figure 3.76: Map of Protected Areas in Papua New Guinea (CEPA, 2018)

Figure 3.77: 71 areas of Interest (AOIs) being subset of the conservation assessment priorities identified as areas critical for immediate conservation attention (Vanessa et al. 2017)

1 Adelbert Range, RRE, 2 Baining, 3 Bali Witu Islands, 4 Bootless Bay, 5 Buang, 6 Circular Reef, 7 Coastal Pomio, 8 Coastal West New Britain, 9 Crater Mt, 10 Cromwell Range, 11 D'Entrescascau Islands, 12 East Cape, 13 East sepik WHA, 14 Eastern Fields, 15 Galley Reach, 16 Gasmata, 17 Goaribari Island, 18 Gulf, 19 Hindenberg Wall, 20 Island chain northwest of Manus, 21 Jaba River, 22 Kandrian Coast, 23 Kimbe Bay, 24 Lake Trist, 25 Lihir, 26 Long Island, 27 Madang Lagoon, 28 Manus, 29 Manus neighbouring islands, 30 Mid New Ireland, 31 Mt Balpi catchment area, 32 Mt Bosavi, 33 Mt Elimabari, 34 Mt Gahavisuka, 35 Mt Micheal, 36 Mt Murray / Mt Giluwe, 37 Mt Puru, 38 Mt Simpson and Damen, 39 Mt Sisa, 40 Mt Strong, 41 Mt Suckling, 42 Mt Thompson, 43 Mt Whilhelm, 44 Murdogado Square, 45 Murik Lakes, 46 Musa Plains, 47 Musau Group of Islands, 48 N Huon Coast, 49 Nakanai, 50 NI east islands, 51 North Owen Stanley, 52 Northern New Ireland, 53 Orangerie Bay, 54 Pirung Eight Islands, 55 Pocklington Reek, 56 Proposed Whale Sanctuary, 57 Scotchio, 58 Sea Abyss (plains and hills), 59 Sea basin and plateau, 60 Southern New

Ireland, 61 St Georges Channel, 62 Table Bay, 63 Tewae, RRE, 64 Tonda, 65 Torokina Caves, 66 Vakuta Island, 67 Vitiaz Strait, 68 Vokeo Island group, 69 Waters north of Kavieng, 70 Wewak coast, 71 North Coast Madang, 72 Whiteman range, 73 Woodlark Island, 74 Yela Islandipsum

Furthermore, not much of the land and seascape of PNG is under conservation. Figure 3.78 shows only 4% of PNG is under conservation while majority of the land or sea are not. Nonetheless, there are some form of voluntary conservation areas practiced in forest activates namely buffer zones and traditional taboo or cultural sites. Figure 3.79 shows the breakdown of the PAs into marine, terrestrial and both marine and terrestrial. Terrestrial PAs are the largest with 84% (1,639,863.81ha), followed by terrestrial-marine with 14% (273,839.25ha) and marine with the lowest portion with 2% (45,417ha).

Figure 3.80 shows that since 1962 when the first PA was established the progress of formally gazetting PAs has been very slow. Since the first Park was established in 1962, the number of Protected Areas had increase significantly to 45 PA in 2000, 57 in 2009 and 59 in 2018. The slowdown in PA establishment was because most PA work were promoted by NGOs in the 1990s and 2000s, with limited lead by government agencies.

Despite the challenges to establish PAs in PNG, studying the management effectiveness of PAs would bring to light the condition of PAs in PNG. In 2006, the WWF's Rapid Assessment of Protected Area Management (RAPPAM) found many flaws and issues in the management of PAs. The results shows most PAs were below operational and management standards, hence are not effective (Chatterton et al., 2006). Overtime, their values have diminished, except few that are managed by continuous funding were exception. More recently, Leverington et al. (2017) used the WWF Measuring Effectiveness Tracking Tool (METT) for Protected area for 58 PAs and found deduced that most PAs have not improved or are worse than recorded in the 2006 RAPPAM report, having limited progress. Only four PAs are rated as undergoing very good progress with 5% while 3 PAs with 7% are having good progress but with some concern. Moreover, 14 PAs or 24% are experiencing some progress, but have major management issues while 37 or 64%) indicate poor management or management have not being established at all. Protected Areas are important in PNG because of their natural cultural and socio-economic values, hence the study was timely but results indicate appalling state of PAs for their values, benefits, threats and management effectiveness.

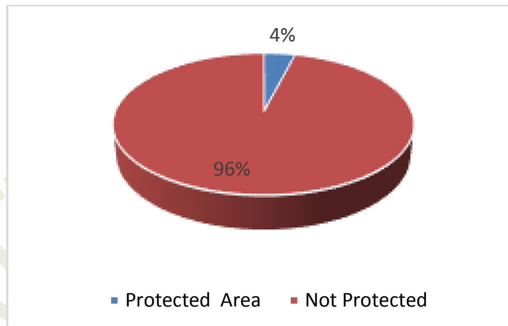


Figure 3.78: Percentage of Protected Area (CEPA, 2019)

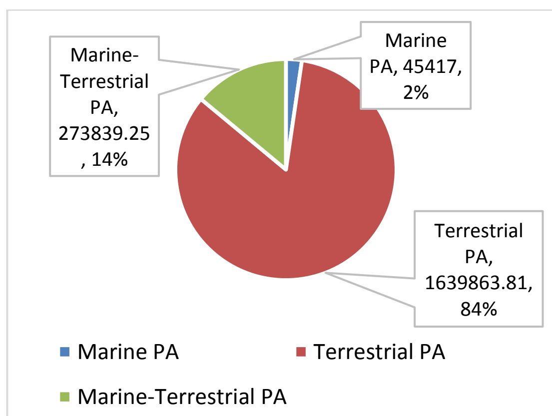


Figure 3.79: Protected area by ecosystem types (CEPA, 2018)

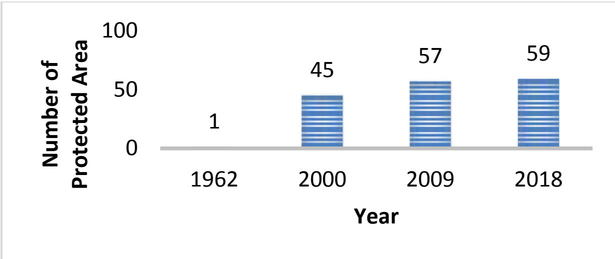


Figure 3.80: Protected Area recognised by the government since 1962 (CEPA)

Figure 3.81 depicts the benefit and importance of conserving the environment in PNG. The study of Management Effectiveness of Protected Area in PNG using the METT Analysis tool developed by WWF shows Protected areas are protected because of their natural values with 36%, socio-economic values with 34% and cultural values with 30% (Leverington et al., 2017). Many protected areas in PNG contain most of the three high values discussed above where those interviewed see PA as an important site for protected. The importance of PAs to people were very high as per respondents' feedback in the 58 PAs when consulted.

Figure 3.82 shows almost 74% of the respondents during the METT analysis exercise thinks PA is of very high value, 10% think its of high value, 9% think its of medium value while 7% thinks PAs are of low value. That is, 75-100% of the dependence recon PAs are important followed by 50-75% saying its importance is high, followed by 25-50 respondents saying it is of medium importance while <25% said it is of low importance. It is apparent that Papua New Guinea's (PNG's) major asset is its wealth of environmental resources (Swartzendruber, 1993).

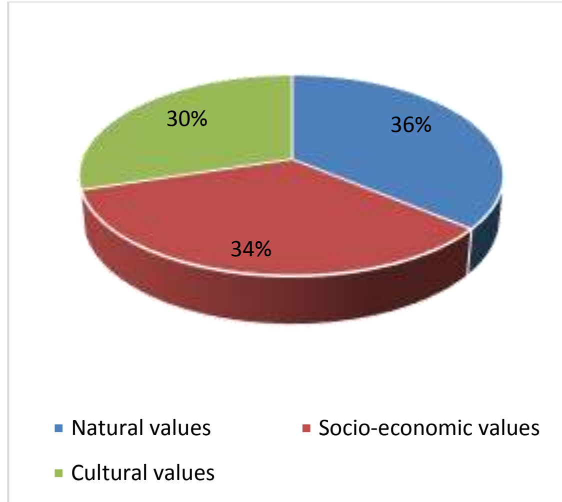


Figure 3.81: Overall benefits importance of ratings for PNG protected Areas (Leverington et al. 2017)

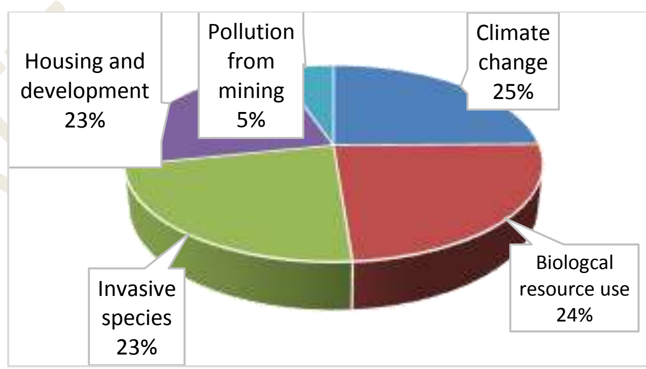


Figure 3.82: Protected Area values used for establishing Protected Areas in PNG (Leverington et al. 2017)

The study also found that there was increasing threats within and outside the PAs. Most Protected areas are located in remote areas of PNG, except few. These PAs are under humorous threats from both natural and human activities. In terms of natural threats, (Leverington et al. (2017) recorded that almost 93% PAs the 58 PAs assessed using METT analysis have experienced threats coming from climate change, especially temperature extremes, prolong droughts, increasing severe storms and flooding, shifts in habitat changes and changes in seasonal patterns may affect food security and long-term sustainability. In addition, 90% of PAs of threats within PAs come also come humans who uses the biological resources for their personal use or consumption and for trade. An additional 86% of PAs received threats from housing and development, associated with rising population that exert pressure on the resources and environment. This happens because most Papua New Guineans are closely associated with their land for resource extraction and uses. Finally, there is another 20% of PAs currently under threat from pollution and mining activities that is severe to human health and environment.

Figure 3.83 shows 25% of the respondents see climate change as the biggest threat to PAs, followed by 24% responding that use of biological resources are threatening PAs. Moreover, 23% of the respondents sees invasive species PAs while another 23% see housing and development as the major threat to PAs respectively. Only a minute 5% see pollution from mining is threatening PAs in the country.

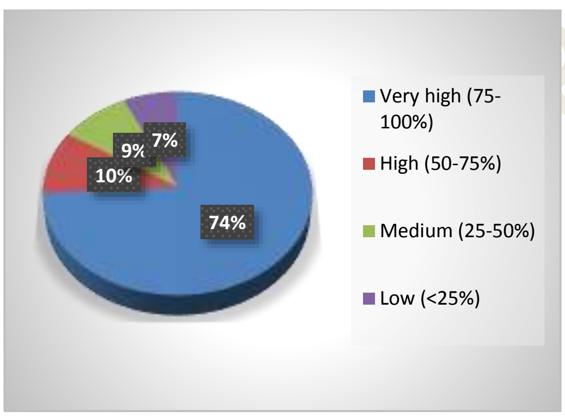


Figure 3.83: Percentage of threats faced in Protected Areas (Leverington et al., 2017)

In terms of the management of PAs in the country, management is very poor or lacking with only few PAs managed given availability of sustainable funding from donors (Leverington et al., 2017). Issues of lack of resources, training, finance, skills and capacities, no management plans, to name a few were prominent.

Figure 3.84 indicates management and effectiveness of PAs in PNG has little or no progress with 64%, 24% with some progress but with high concern, 7% very good and 5% of PAs are in good progress but with some concern. The minority of PAs are function well because of availability of funding and training and this are common with donor funded PAs. Majority of the PAs are managed by local people where so many issues are encountred during the METT analysis (Leverington et al., 2017).

Consequently, the above METT analysis study can be assimilate that having less effective PA management, lack of funding for sustainability and government support, most PAs would lose their species, carbon stock, cultural, social practices and other intrinsic and extrinsic values. Almost 71% of PAs have their values in good to very good condition comprising of only 45% of the land area while only 53% experienced decline in some important values. This shows that the state of the PAs are declining, hence, need more attention than ever before. All in all, PA has immerse benefits to the local communities and the public at large as depicted in 58 PAs that were assessed (Leverington et al., 2017). For further reading on Protected area in PNG, see Leverington et al. 2017).

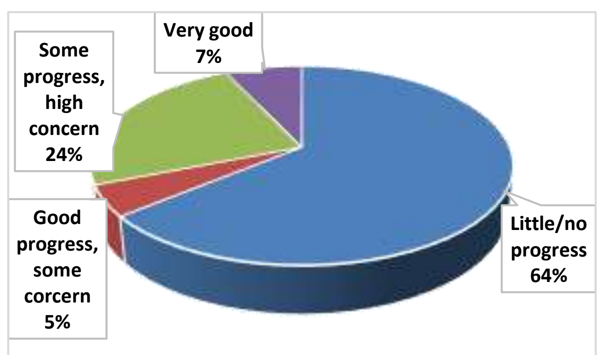


Figure 3.84: Overall progress in management effectiveness of Protected Areas in PNG (Leverington et al. 2017)

Impact

PNG is at the juncture of development and must begin conserving its critical biodiversity or important ecosystem functions for the good of landowners and local communities who are dependent on their natural resources for sustenance and other environmental services. Given the wave of protruding pressures and threats on resources created by industrial development, rising population, increasing demand for goods and services and other activities that may affect the biodiversity and their ecological functions, protection of those biological and cultural assets cannot be compromised.

The PNG's policy on Protected Area provides guidance on managing and establishing PAs in PNG. The policy was required to be evaluated over time to improve PAs effectiveness and management over time. Between 2016-2017 CEPA in collaboration with UNDP conducted an evaluation to find remedial solutions of issues affecting PAs, hence the Protected Areas Policy Implementation Plan (PAPIP) 2018-2028. The PAPIP also provides guideline for organisations, agencies and resource-owning communities to work toward harmonising PNG's efforts to develop new and sustainable protected areas in PNG (GoPNG and UNDP, 2018).

The PAPIP complements the vision of the PNG Policy on Protected Areas (PPA) which states *"Our protected area system across land and sea safeguards our precious and outstanding natural and cultural heritage. Together, we manage these areas effectively for all the people of Papua New Guinea."* The PAPIP also complements the Convention on Biodiversity (CBD) which sees PNG is committed that by 2020, 20% of the total landmass (17%) and seascape (3%) is under some form of conservation. Currently roughly 839,955ha or 3.98% of the landmass of PNG are designated protected area, with an addition area of 11, 461,208ha of the land mass (24.8%) are of interest and the coverage of marine is either still low or not documented well (CEPA, 2019).

The 1993 USAIG funded conservation Needs Assessment (CAN) highlighted many issues regarding conservation of PNG's biodiversity and natural resources. Swartzendruber (1993) highlighted key recommendations for urgent need in building stronger relationships between landowners and others who are involved in natural resource use and management, conservation, and research, including government, NGOs, the private sector, and scientists. The report also identified some important biodiversity high priority areas including 42 terrestrial areas and 13 wetlands, 30 coastal and marine ecosystem, 5 watershed, 5 critical watershed areas and 16 major geographical unknown areas. WWF international has also identified 200 areas of global significance in terms of biodiversity and ecosystem values and species diversity and endemism around the world. PNG has about 9 ecoregions totalling 30,946,356ha comprising of swamps, rivers, marine, savannah, islands, mountains and hill ecosystems. These ecoregion's habitats or ecosystems need to be prioritise and managed under some form of conservation as well. Howevere, they are too broad and and was recently redefined by CEPA in priorities sites for conservation, comprising species, endemics, threatened and of high biodiversity values (Adams et al., 2018)

In 2014, the Protected Area Policy (PAP) sets out a clear vision for the establishment of a protected areas network (PAN) which includes Special Management Areas, Community Conservation Areas (CCA), Locally Managed Marine Areas (LMMA) and national parks (GoPNG and UNDP, 2018). This policy spells out the intention to protect both the biological and cultural diversity which are significant natural assets to PNG, and at the same time looking at ways to harness payment for environmental services. The reason for the latter is becase managing PAs in PNG is often challenging. Almost 97% of land in PNG is either communally owned by clan or group of clans and are important custodians of the natural resources including biodiversity. The fate of the biodiversity and conservation of their resources is in their hands. Without sound alternative and tangible development, their land can be easily be swapped for other development. The same applies to marine environment where sea owners have their customary rights within the 2 nautical miles.

Reponse and Recommendations

A draft PA Bill is under development and yet to be endorsed by NEC and enacted in parliament. More work needs to be done to achieve the target of 20% of PNG land and marine being conserved by 2020. Better Protected Area management, strenghtening of environment laws and regulation, sustainable financing, capacity building, enforcement and monitoring, and training is needed to improve PA management and its effectiveness. There is potential of doing *ex situ* conservation of threathend and endangered species as well.

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8.6 THEME 5: MARINE AND COASTAL

8.6.1 Overview

Aerial view of Wewak, East Sepik Province.

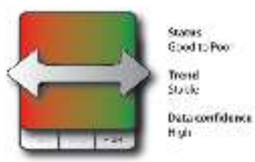
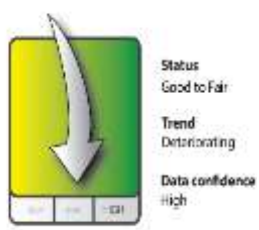
PNG has a total sea area of 11, 475. 47km^2 with the total Exclusive Economic Zone (EEZ) is about 2,437.480km^2, and a total coastline length of 17,110km. (GoPNG, 2011). The ADB report on coral triangle mentions the EEZ is 3.12 km^2 while GoPNG (2018) recorded the EEZ with 2.4 million km^2 in extent, which is the largest and more productive in the Western and Central Pacific Ocean and the second largest in the world (ADB, 2014). The marine environment is still intact but is gradually degrading because of anthropogenic pressures and climate change impact.

PNG lies 6 degrees South and 143 degrees East of the equator. PNG occupies the eastern half of the island of New Guinea, and is a geomorphological diverse country in the South-West Pacific Ocean. PNG contains four large provincial islands and over 600 smaller islands expanding over 800,000 square km^2 of ocean. The total land area of the country is 46.9 million hectares (ha), with 5,152 km of coastline with more than 13,840 km^2 to 40,000 km^2 of coral reefs. The country is home to at least 500 species of stony corals, 1,635 reef-associated fish species, 43 mangrove species, and 7 seagrass species.

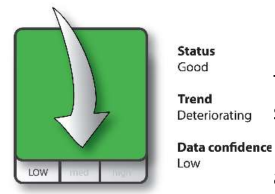
With the vast EEZ PNG has, it is also rich in marine life which enhance local community livelihood. In the offshore environment, fish such as tuna are harvested commercially. While inshore reef fish, clams, beche-de-mer, baramundi, shell fish and other species are harvested. Only a small portion of the marine environment are conserved legally. Coral reefs which is one of the most important ecosystem and natural resources, housed a rich species diversity, including megafauna, an important indicator for reef's health. High species diversity indicates the coral reef ecosystems are intact and healthy. With increasing population and anthropogenic pressures, many urban and rural atolls, reefs, and lagoons are threat and some species are endangered and threatened from extinction with the livelihood of communities who rely on for daily subsistence needs are at stake.

In commercial fishing, by-catch are threaten many IUCN listed species such as sharks and turtles which play a critical role in regulating the reef ecosystems. In this Chapter, Offshore marine environment and fish biomass, Inshore marine environment and fish biomass, Marine managed areas, Endangered marine species, Live coral cover and Lagoon water quality are discussed.

8.6.2 MARINE AND COASTAL HIGHLIGHTS

Topic	Status, Trend and data confidence	Key Findings	Response and Recommendation
Offshore Marine Environment and Fish Biomass		The catch of major tuna species from PNG waters between 2012-2014 averages around an estimate of 500,000 tonnes or 11% of the global catch, and 20% of the WCPO catch. The export value of tuna from PNG to all countries averages around US$230 million and to Europe averages around US$ 120 million. Around 18% of the global tuna stock is found in the PNG 2.13 mil km^2 EEZ. The Tuna industry employs approximately more than 15,000 local people and fishing operators are both foreign and domestic operators.	New innovative approaches must be adapted to improve PNG's fishing industry's performance. Hence, planning, trainings, awareness, research, collaboration and enforcement are needed.
Inshore Marine Environment and Fish Biomass		Marine resources are important source of economic livelihood, income and protein for majority of coastal communities in PNG. Accurate estimates of subsistence fisheries landings are lacking, with estimated annual coastal subsistence fisheries catches ranging from 20,600 tonne to 30,000 tonne. In the coastal and islands areas of PNG, estimates of fish consumption range from 4.8 kg/capita to as high as 24.9 kg/capita. Marine fisheries are an important but underdeveloped sector in PNG and from 2000 to 2006, official statistics indicate that the fisheries sector contributed an average of 2.3% to national Gross Domestic Product (GDP).	Promote sustainable harvesting practices and adequate conservation strategies for endangered or useful marine species. Also more collaboration, research and capacity building to enhance proper data are collected and analysed. More awareness raising are needed country-wide.

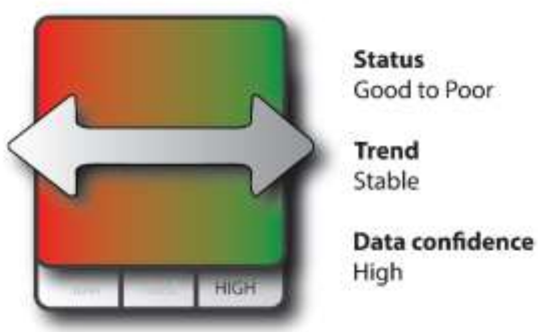
Marine Managed Areas		PNG has a total water body area of 11,475.47 km^2. Its exclusive economic zone (EEZ) is about 3.12 million km^2 and is s the world’s second largest (ADB, 2014). The country’s sparsely distributed population of only 8 million makes PNG’s population density of approximately 9 people per km^2 the lowest in the South Pacific. A total of 59 Protected Areas is recognised in the country covering 2.5 million hectares (4%). The Terrestrial Protected areas (PA) are the largest with 84% (1,639,863.81ha), followed by terrestrial-marine with 14% (273,839.25ha) and marine with the lowest portion with 2% (45,417haThere are 54 marine MPAs and 45 Terrestrial-Marine MPAs. The Marine Protected Areas (MPA) has 4 areas of interest and 12 areas are designated, 1 is under dispute, and another being drafted.	More awareness and funding, including sustainable projects are needed for community driven LMMAs to meet the 20% of the country PA target by 2020. Priority seascapes investment plans needs implementation. Development of management plans, a separate marine policy on seascapes and Implementation are needed.
Endangered Marine Mammals, Rays, Sharks and turtles		PNG is a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, hence must ensure that international trade in specimens of wild animals and plants does not threaten their survival. PNG also has Acts of parliament which also enables CEPA to govern all CITES species trade and export and protection of IUCN redlist species. Over 237 marine species are currently under threaten from extinction.	Collaborative work with research is necessary and access to data must be made available to assess the status of marine biodiversity and their environment. Also public awareness is vital including data storage. Training of monitors with appropriate skills are vital.
Live coral cover		PNG has the second largest EEZ in the world covering 3.12 million km^2. Its marine and coastal ecosystems have approximately 13,840 km^2 of coral reefs (0.44% of the EEZ), 4,200 km^{2}of mangrove swamp forests, and extensive seagrass beds. The country is home to at least 500 species of stony corals, 1,635 reef-associated fish species, 43 mangrove species, and 7 seagrass species. These are now under threat from population and human activities plus global warming effects	Collaborative work must be promoted to conduct monitoring of reefs state, cover and species over time. This require capacity building and training, improve budget and resources, including state of the art research equipment that provides reliable and up to date information.

Lagoon Water Quality		Marine lagoon water quality and urban ports are declining in quality, however there is limited data to substantiate this statement. Increasing urbanisation and resource extraction from mining, logging and agriculture activities are escalating the problem, rivers are discharging tonnes of sediments into lagoons that now buried important habitats for corals. Pollutants and heavy metals are also being discharged into the lagoons and sea thus affecting the pristine and health of the lagoon. Increasing boat, ship movement and oil spills plus discharges from the nearby industries are contributing to the degradation of lagoons.	More water quality tests and research must be conducted through collaboration and partnership, and improving resources, capacity and facilities. Appropriate land uses, coastal zone management planning and better sustainable development practices upstream must be promoted. Protection and rehabilitation of degraded habitats is necessary to preserve threatened habitats.

8.6.3 TOPIC/SUBTOPIC: OFFSHORE MARINE ENVIRONMENT AND FISH BIOMASS

Indicator Definition: Volume catch of identified indicator species

Status and Trend



A fishing trawler in the PNG Waters (Photo by NFA)

SDG/CBD Targets

SDG: 14.2.1, 14.4.1, 14.6.1, 14.7.114.a.1

Aichi target: 1, 6, 10, 11, 12,18, 19

Status and Trend Discussion

The Pacific islands region, comprising of 22 islands States, has an area of more than 27 million km^2 and is dominated by the Pacific ocean. The ocean has significant geological, biodiversity, habitats and ecosystems, climate and social and cultural diversity. The tropical fishery is one of the major contributing sector to the local economies, including food security and livelihoods. Majority of the coastal and island communities in PNG and the pacific island countries depend must on the ocean for their sustenance, subsistence livelihhod and economic wellbeing.

PNG is a member of the Western and Central Pacific Fisheries Commission (WCPFC), a regional entity comprising of countries in the Pacific, including Australia, New Zealand, US, South Korea, Japan and the Philippines. PNG is also a member of the South Pacific Forum (SPF). These member countries ensure fishing is sustainable following protocols agreed by the member states. Most of PNG's fisheries data collected by PNG National Fisheries Authority (NFA) staff and observers on shipping boats and canneries are shared with the South Pacific Commission (SPC) and WCPFC.

Figure 3.85 shows the country specific EEZ of each WCPFC countries. PNG has about 3.12 million km^2 and is s the world's second largest (ADB, 2014). Within these EEZ, licenced fishing boats from various countries fish, including boats for canneries based in PNG. These companies pay fees to the government of each country, including PNG. There are instances that some 'blue fishing boats' from other countries such as Taiwan and Vietnam come into the PNG EEZ and fish but escaped without paying and fees to NFA. There are cases of confiscation and impoundment of blue boats caught in PNG waters in Daru, Milne Bay and the waters of Manus and New Island province. However, boarder surveillance in PNG is still poor.

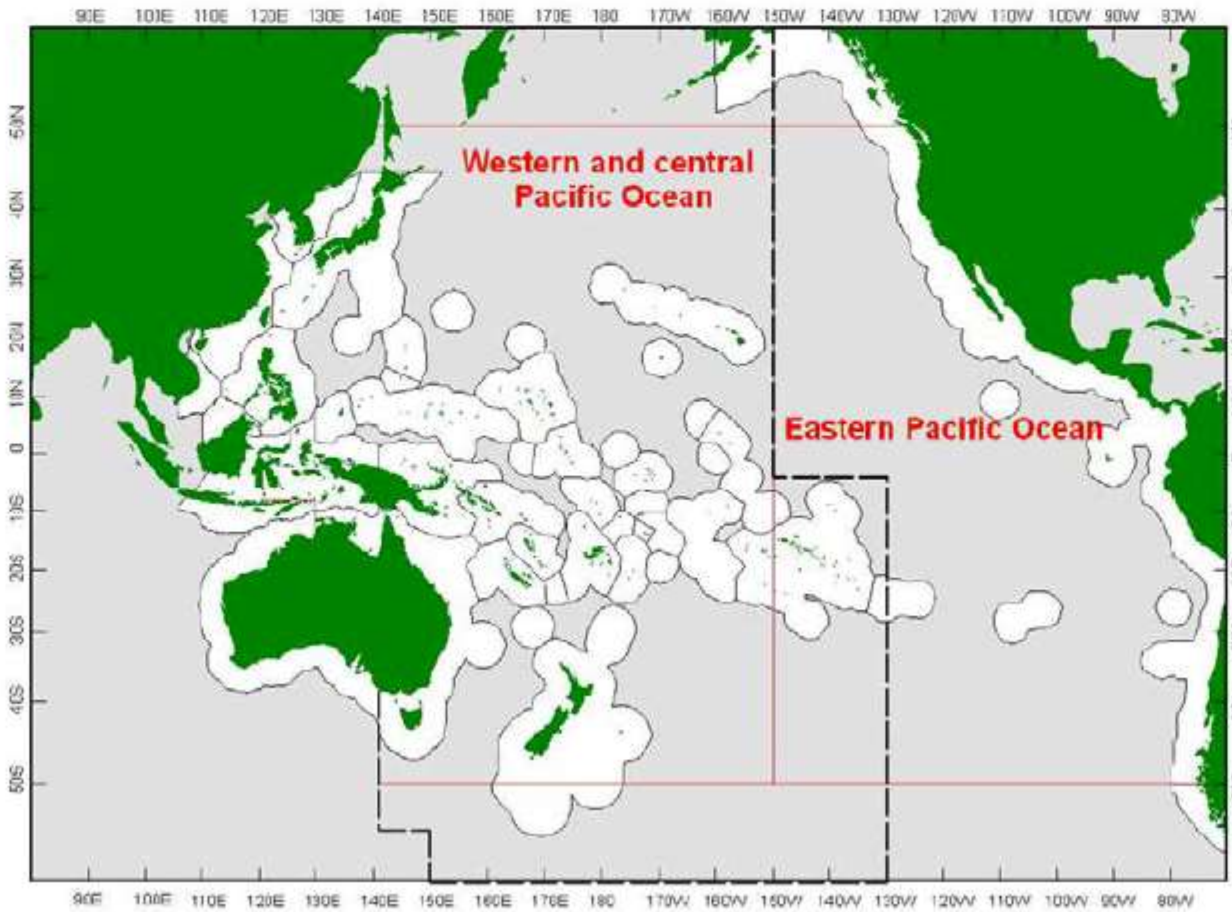


Figure 3.85: The western and central Pacific Ocean (WCPO), the eastern Pacific Ocean (EPO) and the WCPFC Convention Area boundary. Note: WCP-CA in dashed lines (WCPFC, 2018)

In addition, there are often trading occurring at high seas where small fishing vessels transfer or trade the fish caught onto mother boats, thus are unaccounted for or not processed onshore. With this issue becoming prominent, an inter-sessional working group (IWG) was established by WCPFC to review the Compliance Monitoring Scheme (CMS-IWG) to develop a revised CMM for the CMS for consideration (Campling et al., 2018). The Secretariat at WCPFC reported to TCC that 55% of vessels registered on the WCPFC record of Fishing Vessels are authorised to tranship in the high seas (2,193 out of 3,997 vessels from 10 CCMs, as of 30 August 2018, and around 80% of which are longliners).

The tuna industry is the largest renewable natural resource sector in PNG. Around 18% of the global tuna stock is found in the PNG EEZ. In the 1980, PNG depends much on access fees but today, significant downstream processing still occur. Annually, three-quarter of a million tonnes of tuna caught in PNG waters but most of these landed in other countries for further processing. The Pacific Tuna Forum estimates the raw value of PNG’s annual catch at about US$1.5 billion per annum and says this figure could more than double if more value-added activities were implemented. Indeed, PNG has a long-term goal of processing in-country 100% of the tuna catch from within its EEZ.

The main commercial tuna and billfish species caught in the Central-Western pacific region are Albacore (*Thunnus alalunga*), Bigeye (*Thunnus obesus*), Skipjack (*Katsuwonus pelamis*), Yellowfin (*Thunnus albacares*), Black marlin (*Makaira indica*), Blue marlin (*Makaira nigricans*), Striped marlin (*Tetrapturus audax*) and Swordfish (*Xiphias gladius*). The WCFPC, through their member countries, are obliged to compile estimates of key shark species caught as by-catch. Some of the shark species are also covered in the longline fleet Data Table include blue shark (*Prionace glauca*), silky shark (*Carcharhinus falciformis*), oceanic whitetip shark (*Carcharhinus longimanus*) and mako sharks (*Isurus* spp.). Catches of other species not covered explicitly, and discards of any species are not considered in their report.

Hence, some observer data are sometimes used to better estimate by-catch and discards in the longline and purse seine fisheries (e.g. Peatman et al., 2018a, and Peatman et al., 2018b; cited in WCPFC, 2018). Yellowfin Tuna is one of the main species caught in the PNG waters.

A school of Yellowfin tuna (Photo by NOAA Fisheries)

The main industrial fishing methods used in the WCPFC region for fishing activities include longline, pole-and line, purse seine and troll, but some domestic fisheries elsewhere such as Indonesia and the Philippines employ several other methods. Driftnet fishing for albacore in the South Pacific Ocean ceased in 1991. Any individual fleets operated by a country using driftnets are generally flagged to that nation and those vessels considered to be 'chartered' (WCPFC, 2018). Tuna fishing in PNG national waters are caught by purse-seine and longline. The longline and handline vessels fish exclusively in PNG waters while the purse-seine sector is a mixture of both domestic and foreign access vessels (PNGFA, 2018). PNGFA iterates the domestic sector have PNG flag vessels and PNG chartered vessels (locally-based foreign) which support processing facilities onshore in PNG.

According to NFA, annual catch is usually about 150,000mt to 200,000mt per year but it is estimated that the resource can sustain much higher annual catches of 250,000mt to 300,000mt per year. The potential market value is about K1billion depending on the commodity price. Catch from PNG waters accounts for 20-30% of the regional catch and is about 10% of the global catch. There is now concern that yellowfin and bigeye tuna may be nearing its overfished state (http://www.fisheries.gov.pg).

Another report states that the global catch of major tuna species is around 4.5 million tonnes, with more than 55% of the catch comes from the Western and Central Pacific Ocean, comprising of around 2.5 million tonnes. The catch of major tuna species from PNG waters between 2012-2014 averages around an estimate of 500,000 tonnes or 11% of the global catch, and 20% of the WCPO catch (NFA, 2015). The report states that between 2012 and 2014, the export value of tuna from PNG to all countries averages around US$230 million and to Europe averages around US$ 120 million. The Tuna industry employs approximately more than 15,000 local people. Export value in 2012 was about K200 million, a 100% increase from K100 million in 1999, which excludes catch by foreign vessels that pay access fees and take fish to overseas processors (http://www.fisheries.gov.pg). Overall, the total average market value for PNG's fisheries catch is estimated at PGK 350-K400 mil annually.

In addition, SPC reports that the PNG's top primary sector exports comprise of wood, fats and oils, coffee tea and spices, meat and seafood and cocoa in descending order. Wood which surpassed fats and oils as PNG's top primary sector export in 2013 and reached a high of USD 990.1 million in 2014 (Hughes and Kamea, 2015).

Fats and oils exports have been gradually declining since 2011 and reached a low of USD 569.5 million in 2014. Coffee, tea and spices exports have also been declining and reached a low of USD 200.8 million in 2014 whereas exports of meat and seafood preparations, and cocoa fluctuated between USD 100 million and USD 200 million.

WCPFC (2018) reports that in 2018, the total catch estimate of 2017 by PNG purse seine vessels was 280,255 metric tonne (mt). The report iterates that a total of 64 vessels in the PNG national fleet (both PNG Flag and LBF vessels) were active in the WCPFC Convention area, with an estimated overall effort of 8,468 fishing days. Moreover, only a total estimated catch of 1,390 mt was from the domestic tuna longline vessels fishing in 2016, where a total of 22 vessels were actively fishing in PNG waters, with an estimated effort of 37,030 hundred hooks being used. Estimated catch by foreign vessels fishing under bilateral and multilateral access agreements in PNG waters in 2016 was 117,867 mt, with and estimated effort of 3,647 fishing days recorded.

Most of the catch (99%) is attributed to the purse-seine fishery. Purse-seining started in PNG waters in the early 1980s and has since intensified, with the 2010 catch being the highest on record (702,969 mt). The longline fishery started even earlier than the purse-seine fishery, originally only as access by foreign fleets. But in the mid-1990s a policy on domestication enabled the fishery to be a national activity only, hence doing away with access by foreign fleets (NFA, 2018).

The major tuna products exported overseas are fresh chilled, canned, fishmeal and frozen tuna. Chilled tuna is air freighted to the sashimi market in Japan, Frozen tuna is exported to Philippines and Taiwan, and Canned tuna are exported mainly to USA, Germany and Great Britain (NFA, 2018). A small quanty of Canned tuna is exported to the Melanesian Spearhead Group countries, and fishmeal to Australia and Japan. NFA iterates that more than 10,000mt of canned tuna is annually consumed locally.

Processing of tuna in the RD Tuna Cannery, Madang Province (Photo by: RD Tuna)

PNG is striving towards building its fishing industry; therefore fishing licenses are linked to onshore investment. At full capacity PNG is looking to processing all fish caught in PNG waters. The rights to fish in PNG are also linked to onshore investment. The industry provides a substantial employment for local people. Much of growth in the fisheries sector is taking place in Lae, Morobe province, where four companies such as Majestic Seafood and Nambawan Seafood for export markets, while International Food Corporation and Frabelle is processing for domestic and international market (Frabelle is also processing mackerel).

Another two exiting cannery in operations are one in Madang operated by RD Tuna for dometic markets and the other in Wewak operated by South Sea Tuna for loining. Roughly five plants are planned or under negotiation for Malahang in Lae, another 10 processing locators in Madang under the Pacific Maritime Industrial Zone (PMIZ) and one in Manus province.

Purse seine and Longline fishing records between 1993 and 2017

Table 3.6 shows the annual catch estimates and effort (metric tonne, mt) for the PNG purse seine fleet inside and outside of the PNG waters in the WCPFC Convention Area for 2013-2017. Figure3.86 shows the average annual catch estimates and effort inside and outside of WCPFC convention area. The average catch effort is 8420 fishing effort days, which steadily increased over the years but peaked significantly in 2013 and 14 for LPFV boats with 7770 and 6043 fishing days respectively. Skipjack caught have an average of 74,299 mt and 99,941mt within and outside PNG waters respectively.

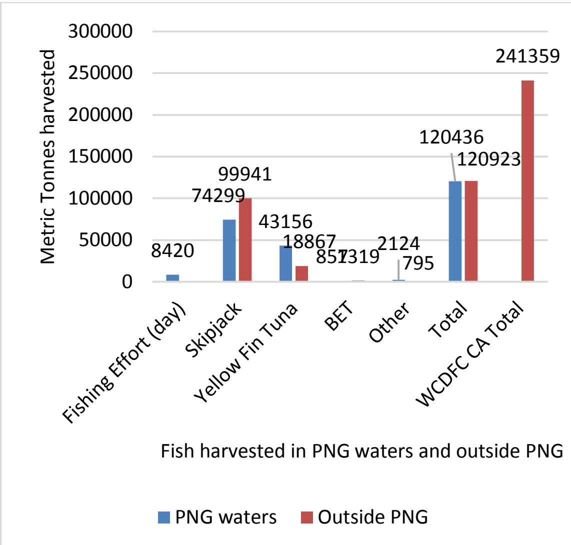


Figure 3.86: Average annual catch estimates and effort (mt) for the PNG purse seine fleet inside and outside of the PNG waters in the WCPFC Convention Area for 2013-2017 (PNGFA, 2018)

There was an average of 43,153 mt and 18,867 mt of Yellowfin tuna fished within and outside PNG waters PNG respectively, Bigeye tuna (BET) had 857 mt and 1319 mt respectively, and Other species with 2124 mt 795 mt respectively. All in all, a total average of 120,436 mt and 120, 923mt were fished in comparison to the WCPFC member country's total of 241,359mt over 5 years.

Figure 3.87 and Table 3.7 shows catches in tonne (t) for Bill fish, Bigeye tuna, Yellowfin tuna and Albacore tuna from longliners in PNG between 1993 and 2017. The catch was high for Yelowfin and Albacure followed by Big eye and Bill fish respectively. In 1993, the total catch was 8t but reached a peak of 712t in 1999. In 2000, the total catch was 1,240 tonnes and increased to 4622t in 2004 but drops again to 3124t in 2008. It boundced back in 2009 to 4315t but drops again until 2011 where it reached a peak of 4,746t. The lowest catch tonnage was in 2016 with 986 yone but improved in 2017 to 2,086t.

Over 25 years, Yelowfin contributed about 66.24%, followed by Abacore with 19.2%, Blue Marlin with 2.68%, Black Marlin with 0.96%, Striped Marlin with 0.4% and Swordfish with 1.76%. In 9 years of recoding shark by-catch, Blue Shark has 31%, Silky Shark has 10%, OCeaniuc Whitetip with 12.8%, Mako Shark with 56.4% and others with 0.72%.

Figure 3.88 shows catches from pole-and-line vessels increased for Skipjack from 2,345t in 1970 and peaked in 1974 with 40,214 t but declined again in 1975 from 15,625t and reached a peak of 45,760t in 1978. The catch declined to its lowest in less than 2,473 t in 1984 and rose to 8,370t in 1985. There was no record in 1982 and 1983. Yellowfin catch increased from 74t in 1970 and peaked in 1976 with 8,563t, then dropped to 930 274 t in 1984 and peaked again in 1985 with 930t.

Table 3.6: Annual catch estimates and effort (mt) for the PNG purse seine fleet inside and outside of the PNG waters in the WCPFC Convention Area for 2013-2017.

Year	Vessels Category	Effort (Fishing Days)	SKJ (MT)		YFT (MT)		BET (MT)		OTH (MT)		TOTAL (MT)		WCPFC CA Total
			PNG Waters	Outside PNG	PNG Waters	Outside PNG	PNG Waters	Outside PNG	PNG Waters	Outside PNG	PNG Waters	Outside PNG	
2013	PNG Flag	2058	21,520	1,054	14,787	404	417		237	2	36,961	1,459	38,420
	LBFV	7770	79,890	66,394	27,741	7,349	287	266	6,602	114	114,520	74,122	188,642
2014	PNG Flag	2150	28,929	9,529	14,846	1,024	279	46	117	0	44,172	10,599	54,771
	LBFV	6403	44,719	87,866	18,643	7,413	334	694	93	670	63,789	96,644	160,433
2015	PNG Flag	3143	13,087	60,086	10,862	8,410	181	488	1,138	1,382	25,267	70,367	95,633
	LBFV	3243	21,927	54,394	13,531	14,340	516	750	1,842	1,585	37,815	71,068	108,884
2016	PNG Flag	4530	30,895	69,478	18,739	16,330	579	1,321	196	91	50,409	87,220	137,629
	LBFV	4335	51,665	43,237	40,266	12,003	584	904	106	23	92,621	56,168	148,788
2017 (Provisional)	PNG Flag	4327	29,512	66,367	17,900	15,599	552	1,262	188	87	48,152	83,315	131,467
	LBFV	4141	49,352	41,301	38,463	11,466	557	864	101	22	88,473	53,653	142,126
Average		*8,420*	*74,299*	*99,941*	*43,156*	*18,867*	*857*	*1,319*	*2,124*	*795*	*120,436*	*120,923*	*241,359*

Table 3.7. Number of vessels active and catches (tonnes) for Papua New Guinea longliners (WCPFC, 2018)

YEAR	VESSELS ACTIVE	ALBACORE		BIGEYE		YELLOWFIN		BLUE MARLIN		BLACK MARLIN		STRIPED MARLIN		SWORDFISH		BLUE SHARK	SILKY SHARK	OCEANIC WHITETIP	MAKO SHARK	OTHER	TOTAL
		CATCH	%	CATCH	%	CATCH	%	CATCH	%	CATCH	%	CATCH	%	CATCH	%	CATCH	CATCH	CATCH	CATCH	CATCH	CATCH
1993	1	0	0	0	0	8	100	—	—	—	—	—	—	—	—	—	—	—	—	—	8
1994	4	0	0	0	0	30	88	1	3	1	3	1	3	1	3	—	—	—	—	—	34
1995	11	6	3	19	11	149	84	1	1	1	1	2	1	—	—	—	—	—	—	—	178
1996	7	38	16	13	5	184	77	—	—	2	1	1	0	—	—	—	—	—	—	—	238
1997	8	101	18	56	10	389	71	2	0	1	0	—	—	2	0	—	—	—	—	—	551
1998	28	104	16	42	7	481	75	5	1	2	0	3	0	4	1	—	—	—	—	—	641
1999	36	129	18	60	8	490	69	17	2	9	1	1	0	6	1	—	—	—	—	—	712
2000	39	159	13	187	15	844	68	26	2	4	0	7	1	12	1	—	—	—	—	1	1,240
2001	40	124	5	240	11	1,812	80	48	2	7	0	13	1	22	1	—	—	—	—	1	2,267
2002	39	142	6	318	14	1,738	76	49	2	7	0	13	1	22	1	—	—	—	—	—	2,289
2003	40	857	27	390	13	1,747	56	66	2	10	0	18	1	30	1	—	—	—	—	2	3,120
2004	41	1,681	36	399	9	2,318	50	113	2	23	0	14	0	73	2	—	—	—	—	1	4,622
2005	46	2,256	56	237	6	1,222	30	144	4	53	1	11	0	98	2	—	—	—	—	—	4,021
2006	35	1,811	41	216	5	2,139	49	95	2	41	1	15	0	80	2	—	—	—	—	—	4,397
2007	21	1,598	46	111	3	1,539	44	109	3	36	1	14	0	82	2	—	—	—	—	—	3,489
2008	17	464	15	201	6	2,259	72	98	3	17	1	4	0	81	3	—	—	—	—	—	3,124
2009	29	906	21	128	3	2,714	62	43	1	96	2	17	0	79	2	38	207	28	99	—	4,351
2010	27	883	24	39	1	2,147	59	151	4	36	1	11	0	93	3	41	178	17	74	—	3,661
2011	35	305	9	39	2	2,303	69	262	8	16	0	11	0	125	4	36	148	11	64	7	3,350
2012	36	811	17	119	3	2,961	62	247	5	37	1	11	0	177	4	33	213	21	93	1	4,746
2013	15	261	13	32	2	1,041	52	153	8	29	1	3	0	114	6	33	213	21	93	—	2,015
2014	12	323	12	52	2	1,568	60	153	6	29	1	3	0	114	4	33	213	21	93	—	2,624
2015	20	345	27	15	1	891	69	11	1	13	1	9	1	2	0	8	—	1	8	1	1,288
2016	15	80	8	86	9	728	74	44	4	39	4	—	—	6	1	1	—	—	—	2	986
2017	15	689	33	47	2	1,249	60	13	1	65	3	11	1	6	0	1	—	—	1	2	2,086

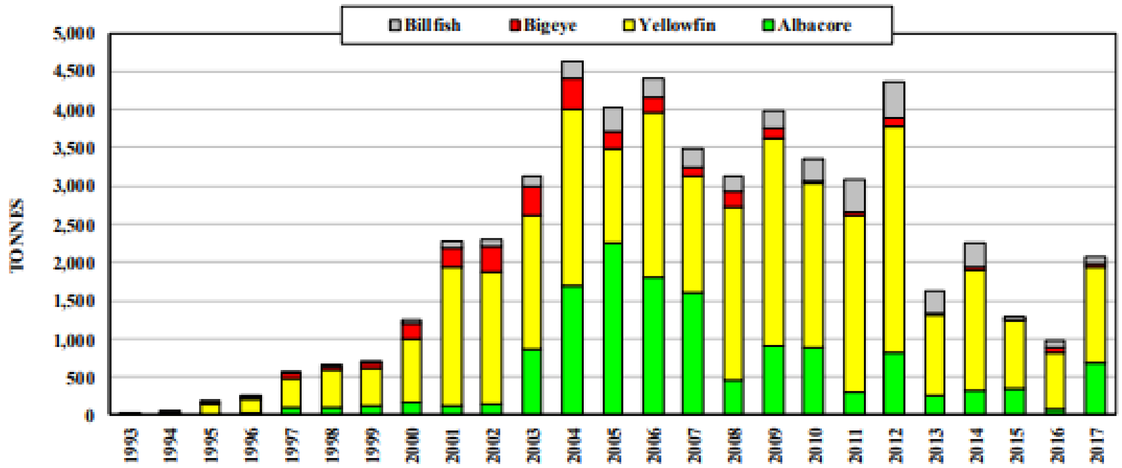


Figure 3.87: Catches by PNG Longliners between 1993-2017 (WCPFC, 2018)

Table 3.8. Number of vessels active and catches (tonnes) for Papua New Guinea purse seiners (WCPFC, 2018)

YEAR	VESSELS ACTIVE	SKIPJACK		YELLOWFIN		BIGEYE		OTHER	TOTAL	UNADJUSTED		
		CATCH	%	CATCH	%	CATCH	%	CATCH	CATCH	SKJ	YFT	BET
1994	2	924	68	393	29	33	2	0	1,350	987	344	20
1995	3	8,766	70	3,410	27	351	3	9	12,536	9,404	2,997	125
1996	4	6,960	67	2,700	26	677	7	4	10,341	9,341	905	93
1997	10	7,770	41	8,266	44	2,817	15	34	18,887	11,396	5,552	1,906
1998	13	23,054	46	21,906	44	5,139	10	38	50,137	36,356	11,381	2,363
1999	17	18,160	47	16,844	44	3,298	9	28	38,330	29,197	7,783	1,321
2000	20	35,917	53	28,643	42	3,067	5	47	67,674	53,123	12,938	1,566
2001	22	51,349	57	33,711	37	5,570	6	70	90,700	64,900	22,422	3,307
2002	26	73,079	60	39,616	32	9,812	8	76	122,583	91,671	25,459	5,377
2003	28	99,762	64	51,177	33	5,686	4	101	156,726	118,676	34,142	3,808
2004	44	148,241	67	60,117	27	12,684	6	122	221,164	192,099	24,852	4,091
2005	51	149,052	64	73,720	32	8,952	4	81	231,805	176,813	48,591	6,320
2006	42	163,416	71	57,259	25	8,329	4	120	229,124	184,087	39,224	5,693
2007	47	166,084	73	56,277	25	4,405	2	128	226,894	181,475	41,042	4,250
2008	49	132,434	65	65,246	32	5,078	3	71	202,829	146,954	51,039	4,765
2009	41	146,850	70	56,380	27	6,040	3	74	209,344	160,782	41,976	6,512
2010	45	147,241	72	51,661	25	6,282	3	89	205,273	152,299	48,412	4,473
2011	49	121,037	75	36,514	23	4,332	3	57	161,940	125,936	35,686	261
2012	51	165,433	70	63,722	27	7,008	3	107	236,270	169,435	65,235	1,493
2013	51	136,203	71	50,802	26	5,962	3	103	193,070	142,366	49,442	1,159
2014	55	174,126	74	53,160	23	7,594	3	102	234,982	187,011	46,344	1,325
2015	53	159,528	74	48,315	23	6,669	3	124	214,636	155,788	56,660	2,064
2016	67	198,387	69	80,694	28	8,995	3	121	288,197	206,539	72,254	9,283
2017	67	189,286	63	106,377	35	6,818	2	118	302,599	192,058	107,981	2,442

Figure 3.89 and Table 3.8 shows the catches figures by purse seiners between 1994 and 2017. Skipjack caught was higher than other species, which increased in 1994 and peaked in 2007, drops again but peaked in 2016. In 1994 the Skipjack recorded 924t and peaked in 1998 had 23,054 t being recorded but this figure then drops slightly in 1999 and peaked again significantly in 2000 with 35,917t. It catch reached a peak in 2007 with 166,084t and then fluctuated up and down until it reached a peak again in 2014 with 189,386t. Likewise the same

occurred for Yellowfin and Big Eye with fluctuating catches. Yellowfin started off with 29t in 1994 and peaked with 21,906t in 1998, dropped the following year but gained momentum and reached a peak of 73,720t in 2005. The catch then fluctuated and reached a low of 36,514t in 2011 before bouncing back to peak at 106,377t in 2017. Bigeye started off with 33t in 1994 and rose to 5,139t in 1998. The catch then fluctuated over the years and reached a peak in 2012 with 12,684t. The catch steadied in the following years between 4,000t and 8,000t.

Figure 3.90 indicates Skipjack was the most sought after species followed by Yellowfin tuna, bigeye and albacore using different fishing methods. Figure 3.91 shows the catch of three major fish species in Albacore (green), Yellowfin tuna (yellow) and Bigeye (red) over 6 decades from 1960-1960, 1970-1979, 1980-1989, 1990 to 1999, 2000 to 2017 by gear types. Figure 3.92 indicates Yellowfin and Bigeye occur prominently in the PNG waters and EEZ and their catch increased significantly over time. The common method used is purse seine followed by pole-and-line, longline and other methods.

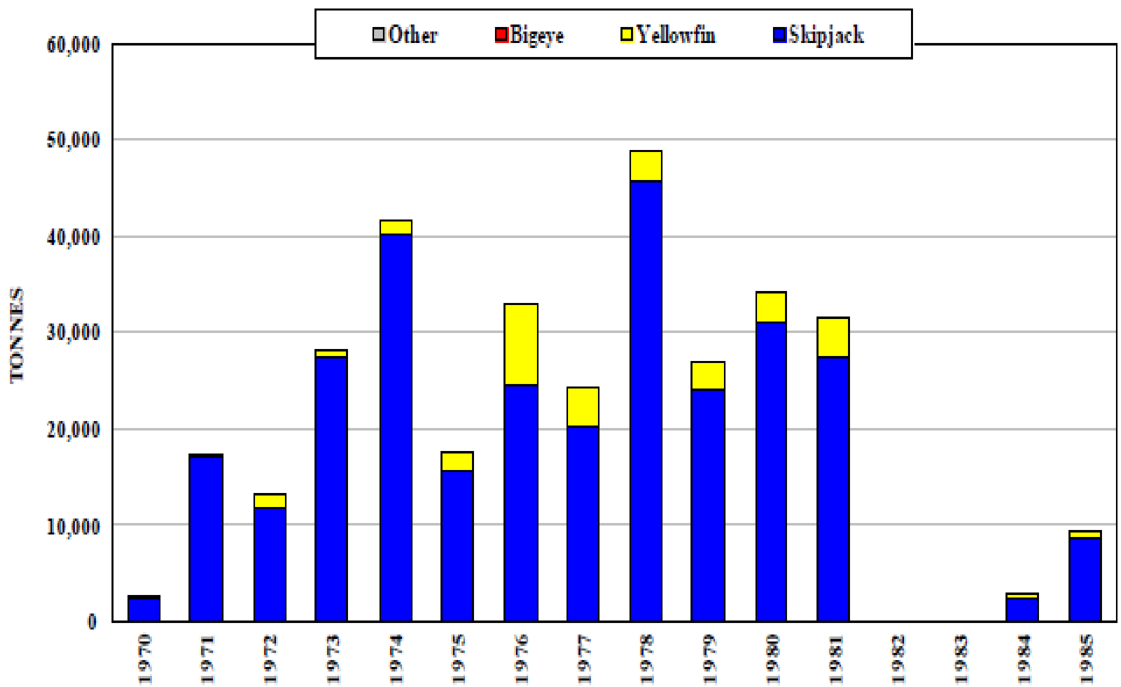


Figure 3.88: Catches by Papua New Guinea pole-and-line vessels between 1970 and 1985 (WCPFC, 2018)

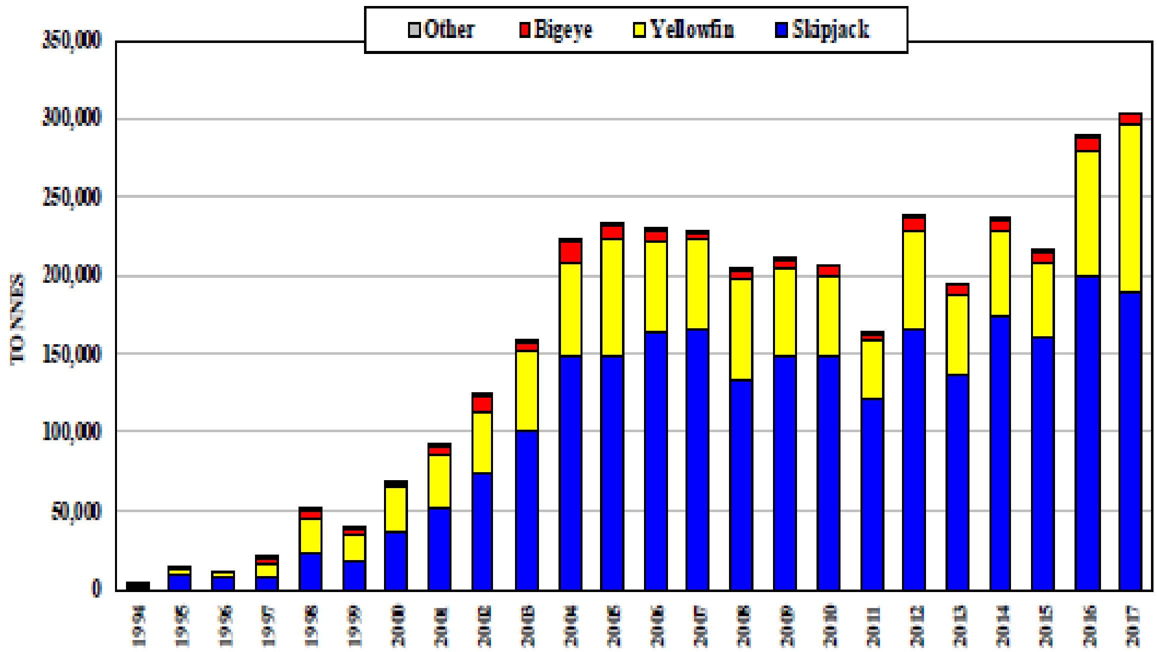


Figure 3.89: Catches by purse seiners between 1994 and 2017 (WCPFC, 2018)

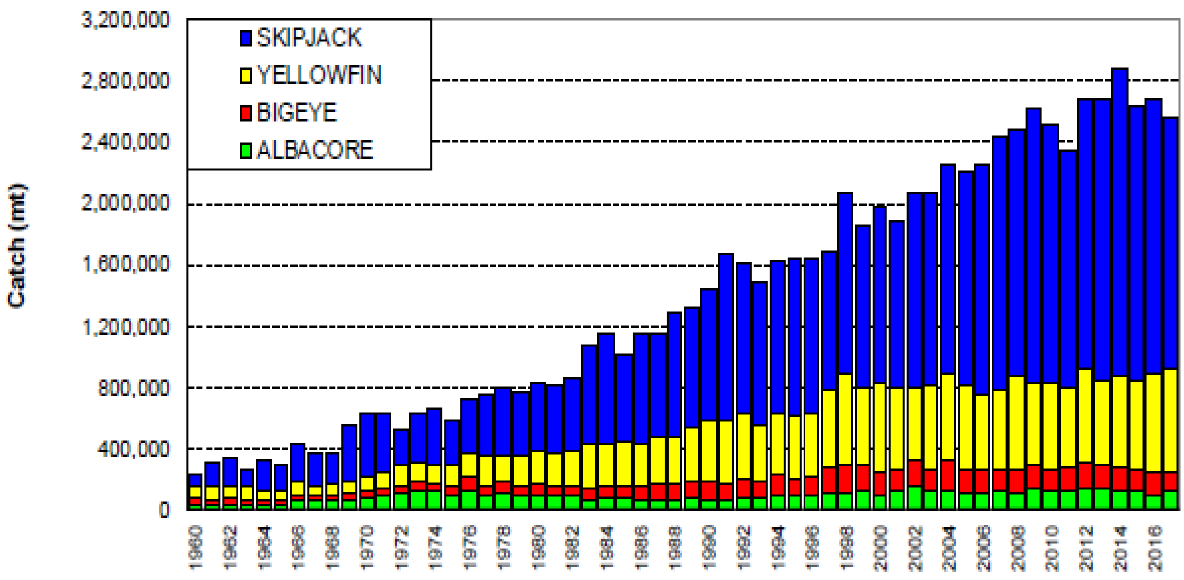


Figure 3.90: Catches in the WCPFC Statistical Area, by species (WCPFC, 2018)

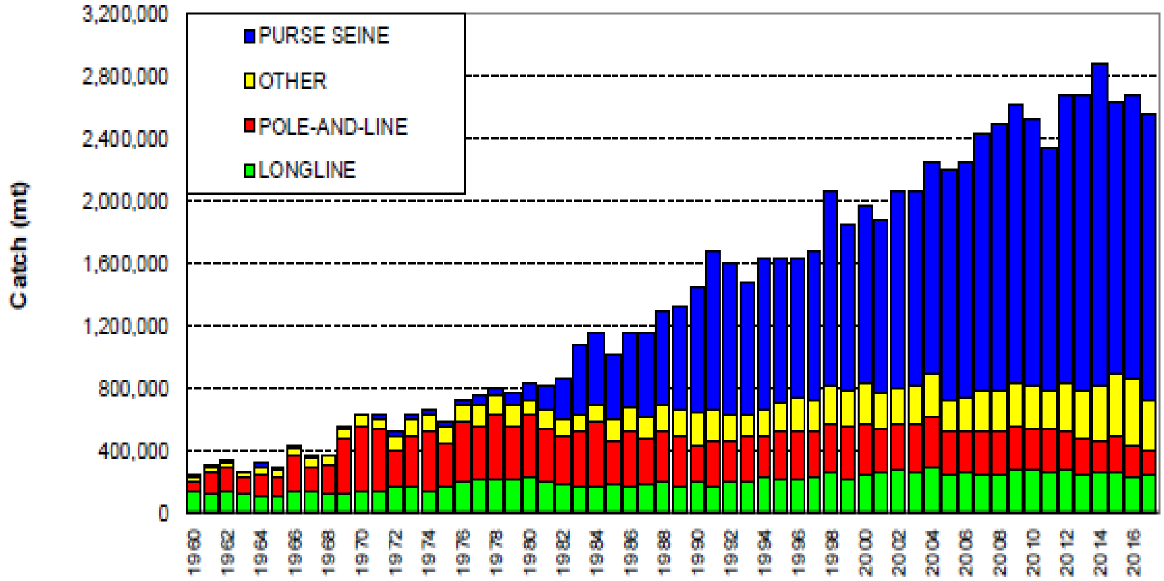
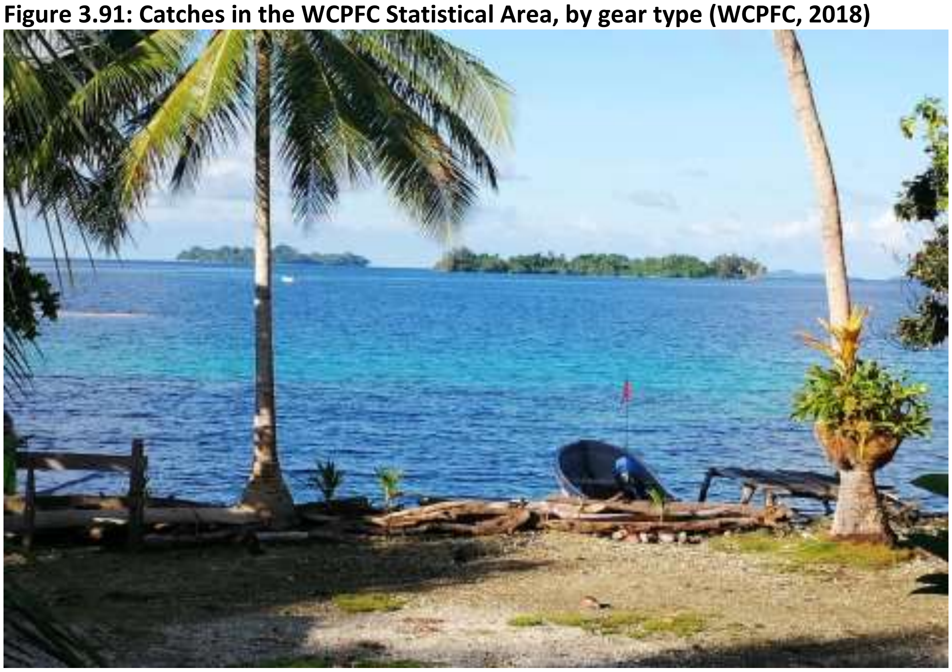


Figure 3.91: Catches in the WCPFC Statistical Area, by gear type (WCPFC, 2018)



Coastal Island community in Manus Province

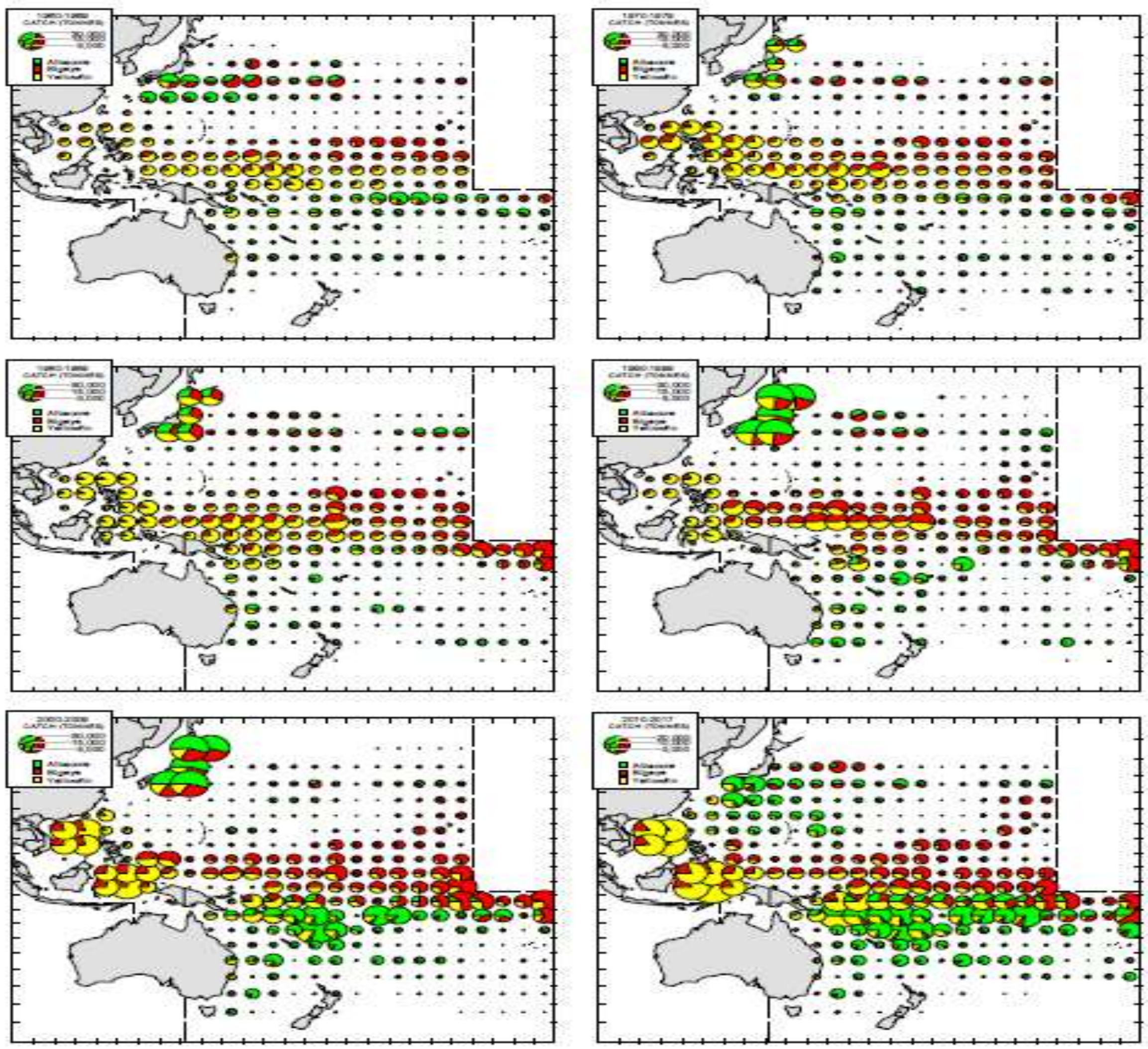


Figure 3.92: Distribution of target tuna catch by species for the WCPFC LONGLINE fishery, by decade since 1960 for Albacore (Green, Bigeye Red and Yellowfin (yellow) (WCPFC, 2018)

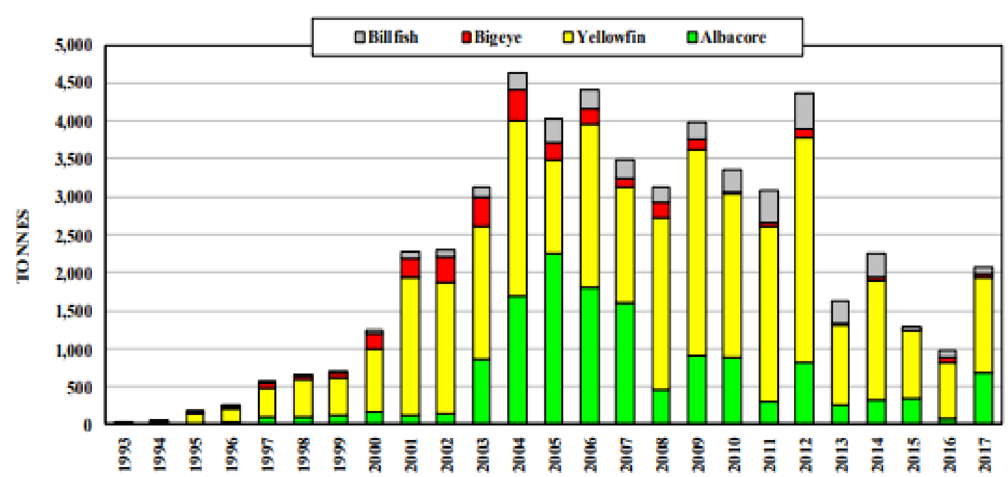


Figure 3.93: Catches by PNG Longliners between 1993-2017 (WCPFC, 2018)

By-Catch

During fishing activities, other species are also caught by fishing boats. Figure 3.93 shows the total and average by-catch by longline fishing over 25 years between 1993 and 2017. A total and average of 3861 metric tonne (mt) and 154.44 mt of catch was made respectively during that period. Blue Marlin has the highest number caught by longliners (1851 mt) followed by Swordfish (1229 mt), Black Marlin (571 mt), Stripe Marlin (192 mt) and Others (18 mt).

Annually, an average of 74.04 mt of Blue Marlin, 49.16 mt of Swordfish, 22.84 mt of Black Marlin, 7.68mt of Striped Marlin and 0.72 mt of other species were caught. Another 118 mt of other species was caught as by-catch in 2017 but between 1994 and 2017 an average of 76 mt over 4 years between 1994 and 2017 (Table 3.8). The highest was in 2008 with 128 mt.

Sharks

Shark fins harvested in PNG measured (Photo by NFA)

Some species of sharks and rays are culturally iconic in certain parts of PNG. For example in the New Ireland, sharks are embedded in legend which has led to the traditional practice of "shark calling". In the Sepik River, "some villagers have long believed that sawfish spirits will punish people who break fishing taboos by leasing destructive rainstorms". Shark fins are more frequently and sold to the Asian markets.

Figures 3.94 shows the shark fin exports and domestic purchases in PNG. Shark fin export had a steady increase and fluctuated over the years between 2004 and 2013 but peaked in 2008 and 2011. The highest number of shark fins recorded was in 2011 with 548,000kg and 2013 has the lowest record with 64,000kg. These figures may not be accurate because actual numbers were not recorded by NFA due to illegal fishing and poaching by locals.

The reason for high figures for export is probably because of increasing by-catch by fisheries companies. Trade of shark fins has been reported to be on the rise in Western and Gulf provinces with buyers coming from as far as the Papua Province of Indonesia. The domestic market is low for shark fins. Real values for commercial shark fin export is roughly between K1.5 and K3.5 million with an average price of K0.5 million and K1.5 million earned annually.

Figure 3.95 shows the export value of shark fins between 2004 and 2013 was worth over K3.4 mil in 2003 and reached a peak of K3.58 mill in 2006, then drops to K1.5mil in 2013. Figure 3.102 shows the main shark species caught are the Silky, Blue, Hammerhead, Grey Reef, Black Tipped, Oceanic White Tip and other species. The species which dominate the catch are the Blue and Silky sharks with the former making up the highest number of catch. Figure 3.96 indicates shark fin buying in provinces where there is market, namely National Capital District (NCD), Milne Bay, Manus, New Island, Morobe and others. NCD and Milne Bay are the largest traders of shark fins probably because of availability of buyers.

Shark fin production is usually higher when the sea cucumber fishery is open but not significant probably because many locals are having access to reefs. The same could be true for rays as local fishers fish for personal consumption. Local observation indicates that minimal anecdotal evidence of shark stock declines but there is evidence that shark fin production has been decreasing.

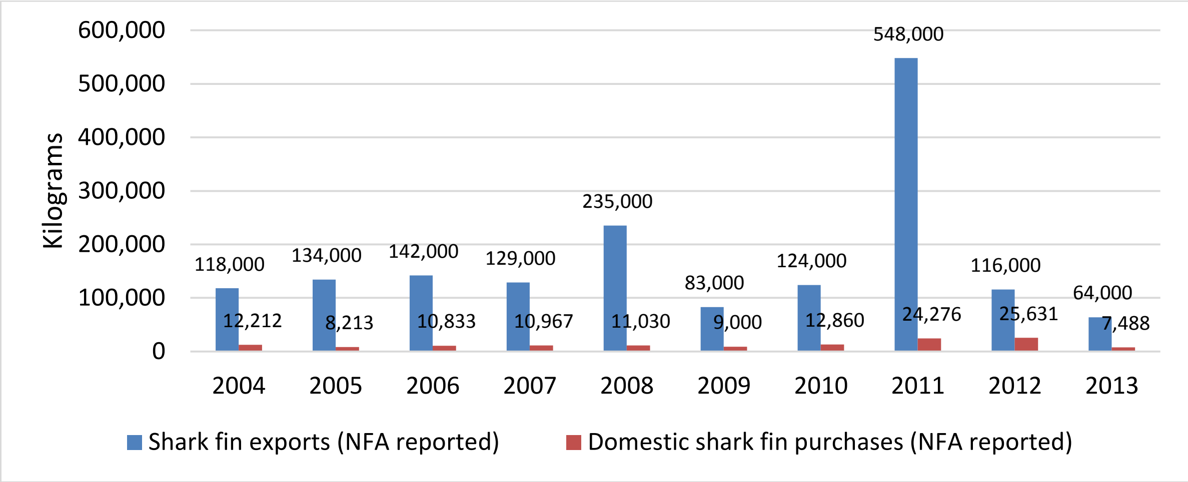


Figure 3.94: Shark fin export and purchase by companies between 2004-2013 (Source: NFA)

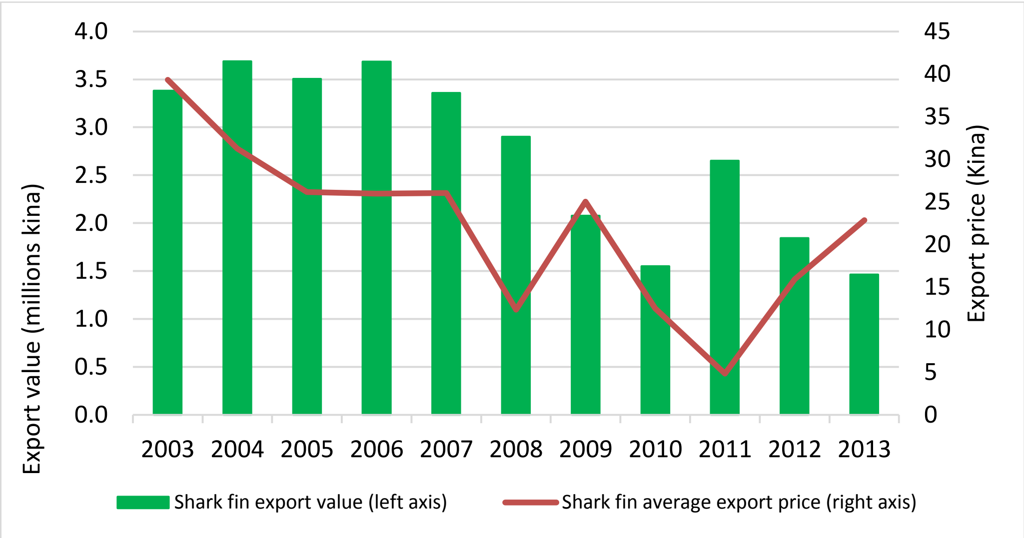


Figure 3.95: Shark fin export value and average export price between 2004-2013 (Source: NFA)

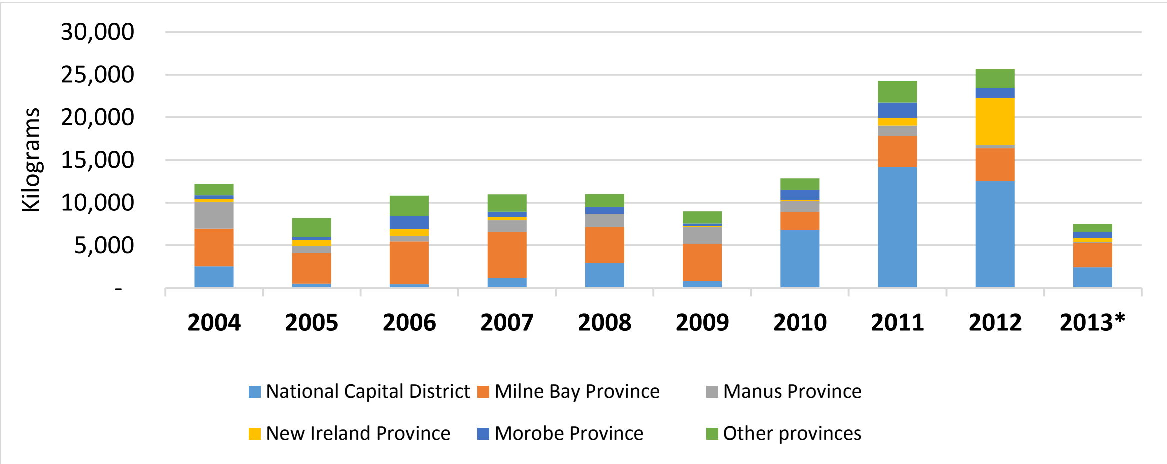


Figure 3.96: Shark fin buying in provincial capitals between 2004-2013 (Source: NFA)

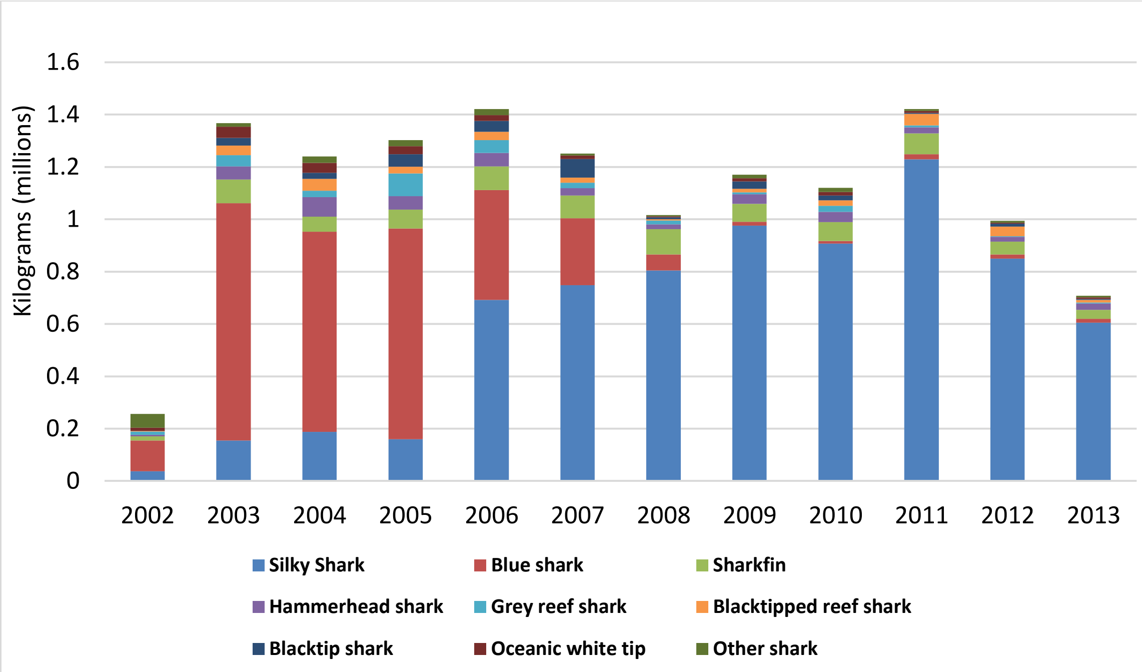


Figure 3.96: Shark longline catch and the species caught (Source: NFA)

Table 3.8: Annual catch estimates in metric tonne (mt) of shark species and effort estimate (hundred hooks) for PNG domestic shark longline fleet in waters under national jurisdiction (NFA, 2015).

	Annual estimate catch and effort by year in metric (mt) tonne					
Shark Species	**2010**	**2011**	**2012**	**2013**	**2014**	**Average**
Effort (HHooks)	*22,790*	*27,934*	*20,817*	*16,367*	*6,129*	*18,808*
Blacktip Shark	18.93	2.81	1.31	5.59	7.45	9.22
Blacktipped Reef Shark	19.75	43.98	36.53	11.17	12.79	24.85
Blue Shark	10.21	18.93	16.08	16.59	9.38	14.24
Galapagos Shark	0.99	0.29	0.06	2.89	2.69	1.38
Grey Reef Shark	23.87	8.42	2.59	4.68	2.1	8.33
Hammerhead Shark	39.15	22.34	18.64	31.06	15.09	25.26
Oceanic White Tip	12.9	7.15	3.74	7.42	7.66	7.77
Silky Shark	907.26	1,292.90	902.46	796.12	399.27	859.6
Silvertip Shark	6.37	0.45	0.39	0.38	0.30	1.58
Tiger Shark	8.76	2.15	1.21	2.16	0.16	2.89
Shark Unidentified	71.72	80.25	52.65	54.61	22.6	56.37
SHARK TOTAL	**1,119.90**	**1,479.66**	**1,045.64**	**932.65**	**479.48**	**1,011.47**

Sharks are a top apex predator in the ocean and brackish waters. A third of shark populations worldwide are considered endangered under the IUCN Red list. Prior to the shark ban, up to 1011 mt of shark per year were either caught as by-catch or targeted between 2010 and 2014. In PNG waters, a total of 79 species of sharks has been documented (Section 8.6.7). As effort catch (Hundred Hook, HH) for longliners increases, so too the number of sharks being caught.

Moreover, Figure 3.97 indicates the average by-catch of sharks caught between 2010 and 2014 was 1,011 mt with the highest number of catch was 1,480 mt in 2011 and the lowest was 479 mt in 2013. Table 3.8 also shows as the number of effort (Hundred Hook or HH) increases, so too the number of species caught.

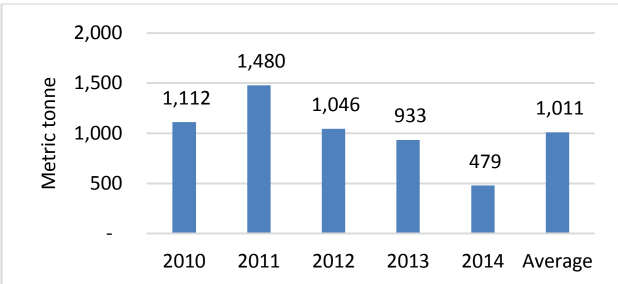


Figure 3.97: Annual catch estimates (mt) of shark species and effort estimate (hundred hooks) (NFA, 2015)

The highest number of catch by species was in ascending order with the highest being Silky head Sharks (849.6 mt), followed by unidentified sharks (56.37mt), Hammerhead sharks (25.26 mt), Blacktipped reef shark (24.85) while the rest are below 10mt. The lowest caught species are the Galapagos shark (1.38mt), Silvertip shark (1.58mt) and Tiger shark (2.89mt). Apart from other pelagic species, turtles and other species are also caught but there are no data to discuss about their status.

A shark species cruising underwater (Photo by Defenders of Wildlife)

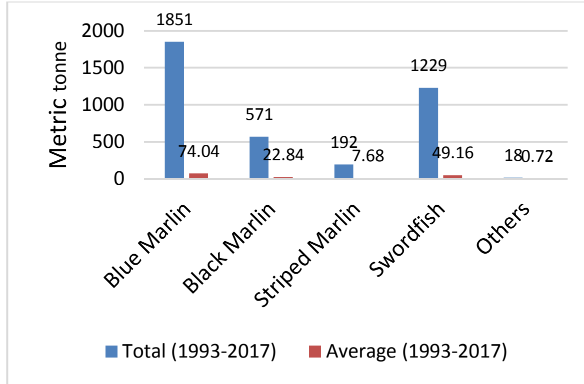


Figure 3.98: Total and average by-catch of species in metric tonne (mt) caught by longliners between 1993 and 2017 (WCPFC, 2018)

Impact

Apart from offshore fishing, economic activities such as tourism, offshore mining, oil spill and waste, marine pollution and shipping activities can have negative impact on the marine environment. With global warming and rising sea temperatures, this may also affect the ecosystem and habitats of different marine species, plus their breeding cycling.

Over harvesting is an issue of major concern. International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), released its finding on overfishing shows overfishing has now driven the Bluefin tuna population stock down by 97.4 percent or 2.6 percent of its original size (Nickson, 2016). It can be argued the leading cause of overfishing is economic exploitation and unsustainable fishing. This can affect the Maximum Sustainable Yield (MSY) of the fish population stock which can cause a collapse in stocks and the balance in the marine ecosystem. Rebuilding of the population stock can take decades with appropriate measures and approaches taken.

The removal of key species and megafauna like sharks, that maintain the trophic balance, can also impact the inshore and offshore ecosystems. Shark harvesting in the Pacific is mainly of silky, hammerhead, white-tip and blue sharks, all of which are classified by IUCN as near-

threatened. Shark populations are extremely vulnerable to overfishing because sharks grow very slowly, and have a much lower capacity to reproduce than other bony fish species. Similar to sharks, the bigeye tuna is harvested well beyond its critical limits, hence it is listed as a vulnerable species in the IUCN Red list.
High seas transhipment occurs more often in the tropical eastern Pacific, particularly within and around the WCPFC/IATTC overlap area and also in high seas pockets. This can lead to overfishing or unsustainable harvest. PNG is a major tuna breeding ground because of the underwater trenches and currents that has ideal temperature and current flows that provide ideal habitats and food sources for many deep water palegic species. In PNG, transhipment happens north of Manus Island, between the waters of the Federal States of Micronesia, east of Bouganville around Solomon Islands and in Milne Bay province near Vanuatu. When this happens, overfishing can occur thus depleting the tuna and other palegic stock below their MSY level.

Illegal fishing may be rife in the EEZ in the pacific. A research conducted made linkages between private vessel registries and tax avoidance in the global fishing industry around 17 jurisdiction (Galaz et al., 2018). Some pacific countries namely small island developing states such Marshall Islands, Tonga and Vanuatu, and a number of UK overseas territories wre part of the study. The study also focused on those jurisdictions that are both known as 'tax havens' (i.e. with low to zero tax combined with financial secrecy) *and* that have flags of convenience (FOC).

The study reveals when fishing companies register in jurisdictions that are both FOCs and tax havens, they are able to hide profits and the beneficial ownership of vessels. There was a close correlation with IUU fishing where only 4% of all registered fishing vessels are flagged in tax havens, while 70% of boats found to have engaged in or supported IUU fishing are registered in a combined FOC and tax haven jurisdiction, with Belize and Panama as the main jurisdictions.

The world is not working toward achieving sustainable fishing and accrediation where products come from reliable sources. The Fishing Industry Association of Papua New Guinea (FIA), representing 24 domestically-based tuna fleets and processors, agreed to pursue MSC certification at the national level where a memorandum of understanding (MOU) was signed between FIA and NFA. Currently, PNG vessels' sole option is to participate in PNA's MSC-certified Western and Central Pacific skipjack and yellowfin free-school tuna purse seine fishery. This product is exclusively marketed under the Pacifical tuna marketing company, which is 50% owned by Henk Brus under the entity Sustunable and 50% by the eight Parties to the Nauru Agreement (Campling et al., 2018).

Such certification and branding would allow tuna exports to be sold in other countries without any traceability status or tags shown on product. Some countries are very strict to ensure products come from reliable and sustainable produce sources. For instance, bulk of the PNG's tuna products are exported to the European Union market. Illegal, unreported and unregulated (IUU) fishing constitutes one of the most serious threats to the sustainable exploitation of living aquatic resources. Hence the European (EC) Regulation No 1005/2008 of 29 September 2008 establishes a community system to prevent, deter and eliminate IUU fishing. The IUU regulation provides the European Union with a tool to target behaviour that falls under the definition of IUU fishing and which causes the most serious damage to the marine environment, the sustainability of fish stocks, and the socioeconomic situation of fishermen abiding by the rules on conservation and management of fisheries resources.

PNG was given a 'yellow card' in 2015 which the European Union was seeking action as a result of "non-cooperating third countries" under the regulation – and to date, PNG had fixed those flaws (NFA, 2015). NFA was able to do major reforms such as amending the Fisheries Management Act 1998 and the Fisheries Management Regulation 2000, to adhere to international laws, including implementing a new Tuna Management Plan. This include introducing Vessel Tracking Devices (VTD), Inshore Fish Aggregating Devices (iFADs), observers are stationed on board fishing vessels and banning of gill nets use, improving compliance, monitoring and enforcement, improving traceability of fisheries products, and strengthened licensing systems and the administrative capacity.

The government of PNG also is committed to combating IUU fishing, both in its fisheries waters and through supporting its Pacific neighbours, through regional cooperation involving the eight Parties to the Nauru Agreement (PNA), the seventeen members of the Pacific Islands Forum Fisheries Agency (FFA) and the twenty six members of the Western and Central Pacific Fisheries Commission (WCPFC). Non-compliance and conformity would result in depleting fisheries stock and PNG jeopardising its trade and income generation potential.

Reponse and Recommendations

PNG is a member of the Parties to the Nauru Agreement (PNA) and the Forum Fisheries Agency (FFA) and is signatory to some international maritime conventions and treaties. The PNG tuna fishery is managed under PNA's Vessel Day Scheme (VDS), where member countries agreed to limit the number of fishing days. The number of fishing days are then allocated to each country and sold to the highest bidder. PNG's marine resources and economy has benefited from the PNA membership.

PNG is also part of the Niue treaty which was ratified in1995. Under the treaty, the members of the FFA agreed to enhance the ability of surveillance and enforcement of their fisheries laws by working together to address illegal fishing and other unlawful activities. This can be achieve through the implementation of its Tuna Management Plan that requires banning of any activities associated with harvesting sharks for commercial purposes and unsustainable fishing practices.

In addition, PNG does not yet have a specific policy and legislation relating to the ecosystem approach to fisheries management (EAFM). However, the government, NGOs, and other stakeholders are currently implementing elements of the EAFM to ensure sustainable exploitation is achieved. To date, no specific legal framework or set of laws addresses the implementation of EAFM principles and this must be done sooner.

There is also lack of knowledge and experience in applying EAFM principles. Existing fisheries management plans do not allow management of both fisheries and ecosystems. However, there are existing national and local legislations (e.g. Fisheries Act 1998) that are adequate for this purpose. Hence, planning, trainings, awareness, research, collaboration and enforcement are needed.

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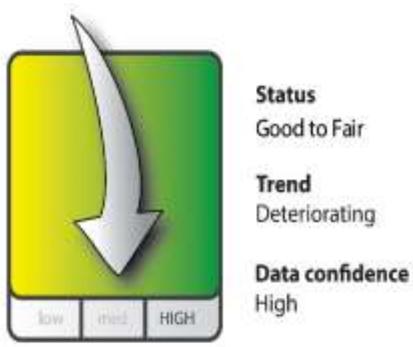
8.6.4 TOPIC/SUBTOPIC: INSHORE MARINE ENVIRONMENT AND FISH BIOMASS

Indicator Definition: Status of marine environment and fish biomass for inshore fish populations

Status and Trend



Sunset in Wide-Bay, Kove LLG, West New Britain Province

SDG/CBD Target

SDG: 14.2.1, 14.4.1, 14.5.1, 14.6.1, 14.7.1, 14.a.1, 14.b.1, 14.c.1

Aichi target: 1, 23, 4, 5, 6, 7, 8, 10, 11, 12,15

Trend and Status Discussion

PNG has an economic exclusion zone (EEZ) covering an estimated 3,120,000 km^2 of marine waters. A country with over 8 million people and over 80% of the population are living in rural areas, it is estimated that about 850,000 live in rural coastal and island areas (Tel et al. 2014). PNG also has a long coastline (~17,110 km in length) extending along 14 maritime provinces (Figure 3.99). Each of these maritime provinces has a wide and diverse range of social, cultural, economic and ecological environments which have varying degrees of harvesting and catch on multiple and targeted coastal resources from estuarine, coral reef, mangrove and sea-grass habitats.

The sustainable exploitation of these coastal resources provides many opportunities for development aspirations, economic opportunities and food security for PNG's coastal and island communities, as well as those people residing in ever-expanding urban centres (NFA, 2017). NFA categorises marine fisheries as being 'coastal commercial' or 'offshore'.

Coastal commercial fisheries are artisanal in nature, whereby local fishers target finfish and invertebrates for the export market or for local sale, and occur from shore or close to the coast. Invertebrates are collected by gleaning on reef flats or free-diving in deeper water, while reef fish are caught using handlines, gill nets, hand spears, or traps (Teh et al., 2014). Teh et al. iterates that sea cucumbers have been overexploited as evident by the moratorium on harvesting and export since 2009, and trochus are considered to be at or near their maximum sustainable yield (MSY), whereas other inshore resources are still considered to be underexploited.

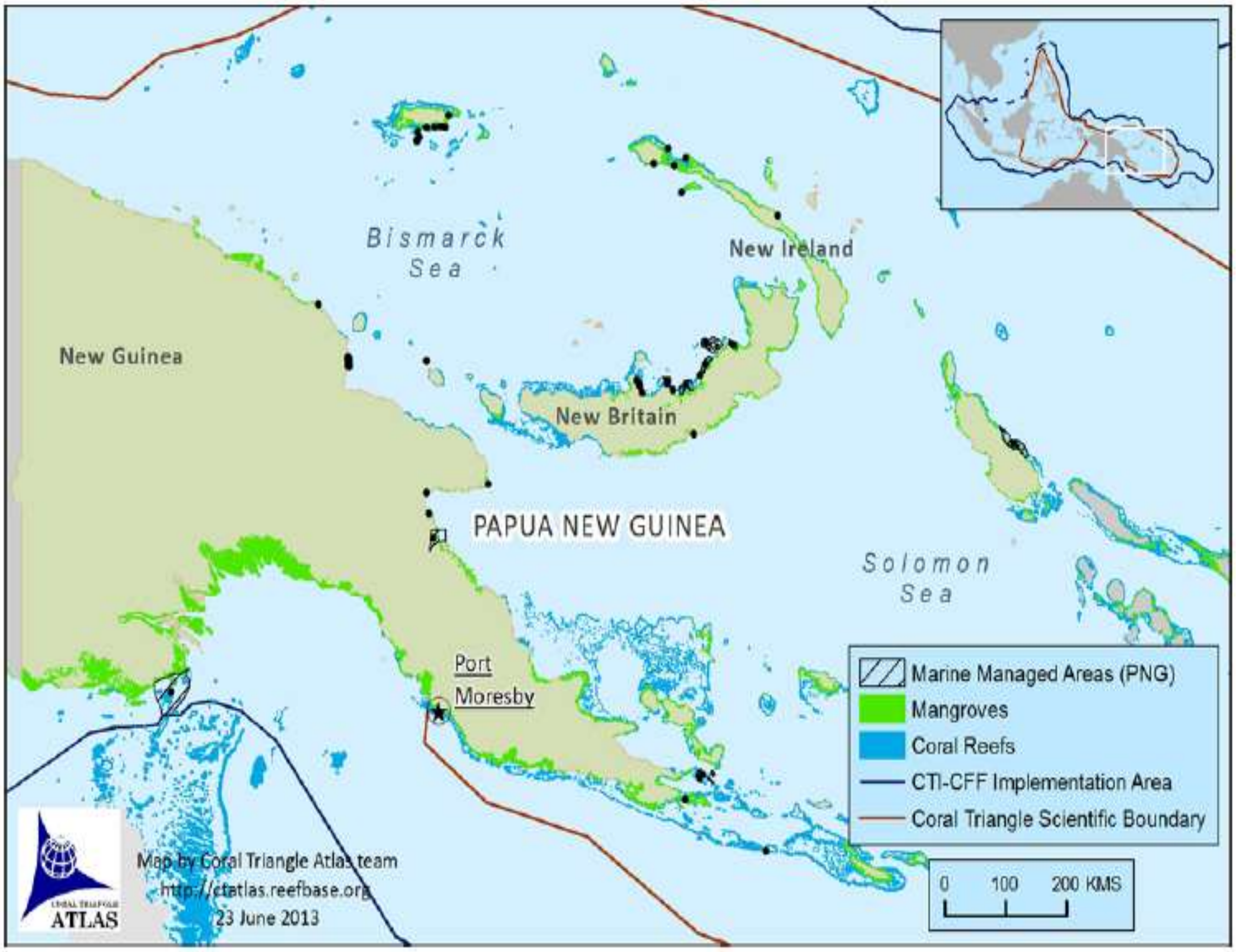


Figure 3.99: MPAs, corals and mangroves in PNG (CTI-CFF, 2013)

Generally, PNG's inshore reef systems and coastal environment are pristine and fisheries are healthy and stable. This is indicated by its rich marine biodiversity, including more than 500 stony coral species, nearly 200 marine and freshwater decapod crustacean species, and more than 3,000 fish species. Unfortunately, limited information are available about the total production of PNG's coastal commercial fisheries. Accurate estimates of subsistence fisheries landings are lacking, with estimated annual coastal subsistence fisheries catches in PNG ranges from 20,600 to 30,000 tonnes (NFA, 2017).

Moreover, much of the subsistence coastal fisheries catch is consumed in the fisher's home, with surplus sold, traded, bartered or used in customary exchanges. It is estimated that catch from subsistence fisheries totals about 50,000 tons, of which 30,000 tons are harvested from marine coastal areas, with freshwater sources accounting for the remainder (Teh et al., 2014).

A study by Teh et al. (2014) aimed at reconstructing PNG's small-scale fisheries to account for unreported catches shows total non-tuna catch in PNG was 2.4 million tonnes from 1950-2010, suggesting actual catches were four times the 590,000 t of non-tuna catches reported by FAO on behalf of PNG for the same time period. The study concludes there is high socio-economic reliance on PNG's small-scale inshore fisheries and that steps should be taken to ensure the future sustainability of this crucial food security resource and associated income opportunities are maintained or improved.

In the coastal and islands communities of PNG, estimates of fish consumption range from 4.8 kg/capita to as high as 24.9 kg/capita. It is estimated that up to 90% of marine resources sought or caught by fishers from coral reefs and deep water or other coastal marine habitats, such as mangroves and sea-grass beds are eaten, traded or sold.

Fish is an integral part of society, for food, as trade items in traditional barter systems, and as a commodity for earning cash. The majority of inshore fishing is conducted on a small-scale basis with diverse gears, ranging from gleaning (collecting) of invertebrates to hand-lining, spear fishing using canoes, netting, use of traditional and modern poisons, and trolling using outboard motors and fiber glass dinghy (FAO, 2010; Teh et al., 2014). Up until the 1980s, most inshore fishing was done using non-powered boats (canoes) on a part-time subsistence basis. In recent times, new technology and boats make accessibility to fishing grounds more efficient thus increasing fishing activities.

Subsistence fishing allows coastal and island communities to meet their immediate food needs. That is, subsistence fishers tend not to fish more than they need to consume, thus catches are limited (Teh et al., 2014). Only a handful of coastal and island community villagers still use traditional fishing methods, but there is very little information about the nature of fishing that takes place. There are known instances where dynamite fishing using old World War 2 bombs are used in reef fishing.

However, rising fuel costs have sometimes hampered fishing activities especially for those using powered boat dignhies. There is lack of management in the coastal fisheries but isolation has restricted continuous fishing. With the rapid growth of coastal populations and consequent demand for cash income, increased coastal subsistence and artisanal fishing activities are having a negative impact on the sustainability of coastal fish stocks, where no proactive sustainable management is in place.

Local fishermen have exclusive rights to fish within the 3-12 nautical mile zone set aside for traditional fishing grounds by the government through the Fisheries Act. There are instances where sometimes fishing boats enter and fish in traditional waters. These fishing grounds offer local fishers great opportunities to earn a sustainable income. If only these fishing grounds are well managed, fishers are well organised, have the requisite business skills and market access to venture into the fisheries business, the industry would become lucrative and sustainable.

The DSP 2010-2030 provides a platform for the government to assist local fishers to gain from their traditional fishing grounds through organised groups such as cooperatives, as a conduit to assist local communities establish administration, marketing of local catches, providing cold storage and processing facilities, organising credit facilities and arranging the acquisition of pump boats and other equipment for its members (GoPNG, 2010). The Government can facilitate such developments by encouraging joint ventures by providing key ports and jetty infrastructure.

Important contribution of the inshore fisheries

Marine fisheries are an important but underdeveloped sector in PNG and from 2000 to 2006, official statistics indicate that the fisheries sector contributed an average of 2.3% to national Gross Domestic Product (GDP). However, this figure may actually under-estimate the sector's true value (Teh et al., 2014). Figure 3.100 shows the percentage contribution from fisheries sector, with the marine component of PNG's fishery sector is the largest in terms of added value, making up over 90% of GDP contribution while the freshwater and aquaculture categories make up 9% and less than 1% respectively (Gillett, 2009).

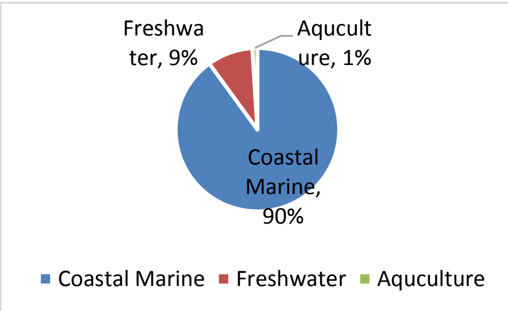


Figure 3.100: Contribution of GDP by non- tuna fisheries sector (Gillet, 2009)

Figure 3.101 shows the percentage contribution from inshore fishing activities. NFA stated that a typical inshore fish catches comprise of about 130 species of fish and an estimated 30% are reef fishes, 10% pelagic, and the remaining 60% are a mixture of crustaceans, molluscs, invertebrates, and seaweed (Teh et al. 2014). Until the moratorium in 2009 was enforced for 8 years banning beche-de-mer trade, the sea cucumber fishery was the most valuable inshore commercial fishery. This is followed by prawns, sashimi grade tuna, lobster, and trochus. Currently, beche-de-mer has been managed under its own management plan. For 8 years between 2010 and 2017, commercial trading of beche-de-mer ceased to allow recuperation of the population and sizes. The opening of sea-cucumber harvesting began in 2018 but was closed again in 2019.

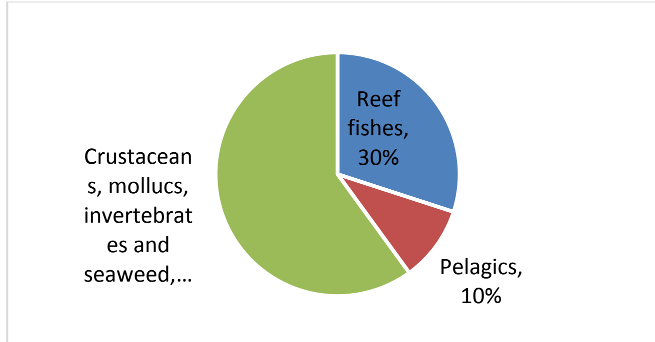


Figure 3.101: Percentage of major inland fisheries catches (Teh et al. 2014)

Figure 3.102a shows the major fish catch in PNG waters reconstructed from various data from 1950-2010. Figure 3.98a indicates PNG's reconstructed domestic catch, excluding tuna, totalled 2.4 million t from 1950-2010 (Teh et al. 2014). This estimate was 4 times the total non-tuna marine landings of 590,000 t that were reported to the FAO for PNG for the same period. Reconstructed catches averaged 22,000 t year^{-1}, peaked at 95,000 t·year^{-1} in 1992, and were about 44,000 t·year^{-1} in the late 2000s. Reconstructed tuna catches in PNG's EEZ are not addressed in the study by Teh et al. (2014).

Figure 3.102b shows subsistence catches made up 66% of total reconstructed catches, followed by the artisanal sector at 29% and the industrial fishery at 2%, while the marine recreational sector and fish discards together made up 3% of total reconstructed catches. Unreported catches totalled around 1.8 million t, of which the majority (1.2 million t) came from the subsistence sector.

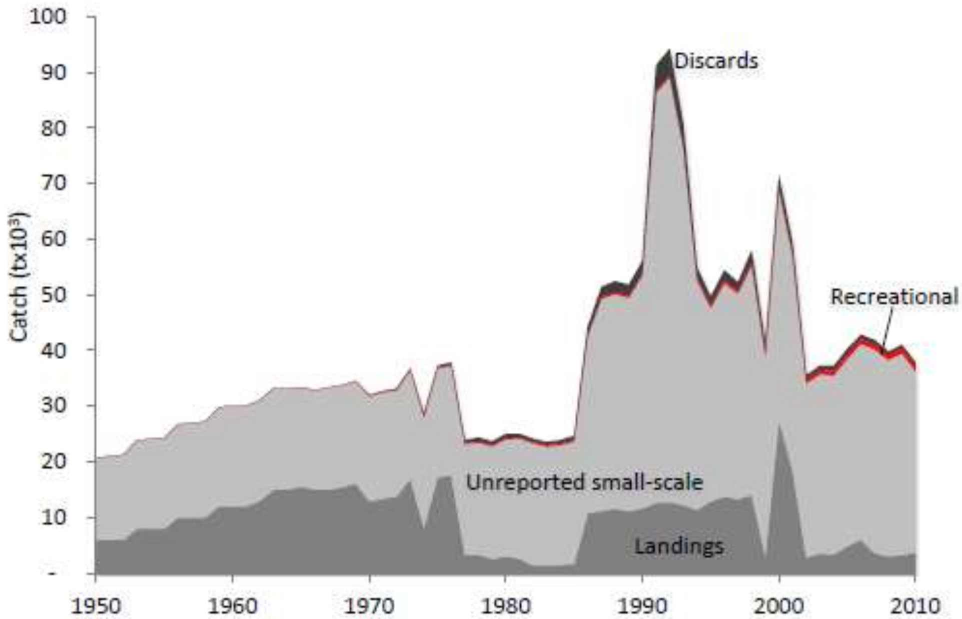


Figure 3.102a: Papua New Guinea's total catches from 1950-2010, showing unreported catches from small-scale fishing and discards added to the reported landings (Teh et al., 2014).

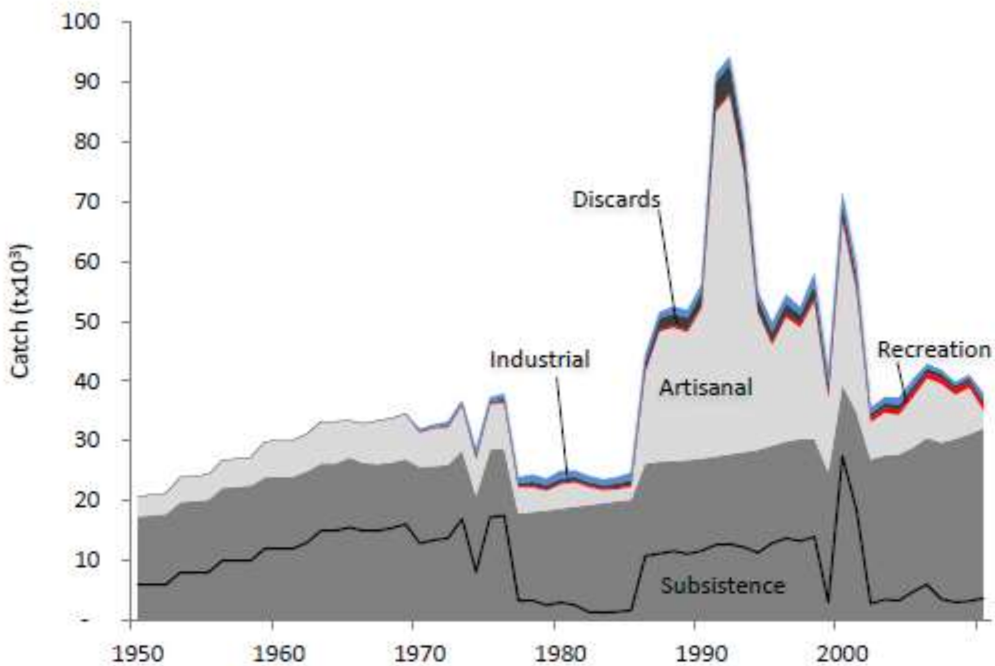


Figure 3.102b: Reconstructed catches showing contribution of different sectors, 1950-2010. The solid line represents FAO reported landings (Teh et al., 2014)

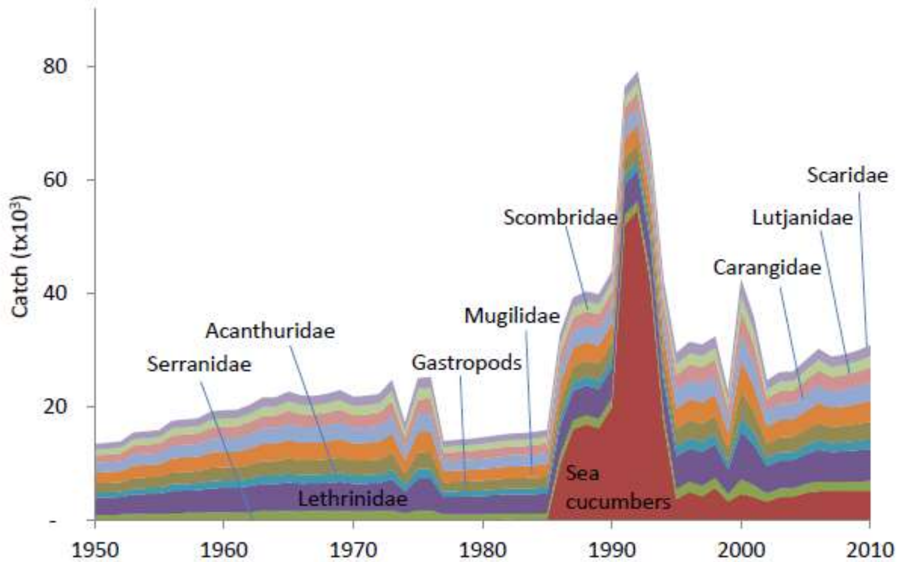


Figure 3.103: Top 10 taxa in reconstructed catches, 1950-2010 (Teh et al., 2014)

Figure 3.103 depicts ten major taxa group accounted for 72% of reconstructed marine catches from 1950-2010. Sea cucumbers was the most abundant (325,000 t), followed by Lethrinidae (284,000 t), Mugilidae (182,000 t), and Carangidae (161,000 t). Shark species made up almost 2.5% of total reconstructed catches with Sea cucumber catches increased significantly from the early 1990s, peaking in 2006 and then declined until a moratorium was implemented in 2009. Low value fish such as Leiognathidae and Engraulididae were present in discards, but made up less than 0.5% of total reconstructed catches.

Prawn Fishery

Prawn fisheries have been a significant contributor the economy of maritime countries. In Australia between 2010 and 2011, the industry recorded a gross value of production (GVP) of $30.3 million (K60.5 million), with a total catch of 1979 t of prawns (Knight and Tsolos 2012; cited in GoSA 2014). In PNG the industry is minor but contributes significantly to the national coffers.

Nineteen prawn vessels are operate in PNG and fifteen of them are domestic prawn trawlers operating in the Gulf of Papua Prawn Fishery, while one is operating in the Orangerie Bay Prawn Fishery and three in the Torres Strait Fishery (http://www.fisheries.gov.pg). The fishery is managed under the Gulf of Papua Prawn Fishery Management Plan.

The Gulf of Papua Prawn Fishery (GOPPF) has been in existence in fifty years since 1969 and prawn fishery is seen as one of the important renewable resources sector to PNG after Tuna export. It started in 1969 and became PNG's largest export fisheries apart from Tuna. Prawn alone contributes significantly to the economy annually, earning between K3 million to K28 million or US$ 1.5 to US$14 million (NFA, 1995). The main prawn species harvested are the Banana (*Fenneropenaeus merguiensis*) and Indian banana (*F. indicus*), both comprising about 50 to 60 percent of the catch (Liviko, 2012; Evans et al., 1995). Other prawn species caught are Black-Tiger prawns (*Penaeus monodon* and *P. semisulcatus*), which contributes approximately 15 to 20 percent of the total catch while the lesser valued Endeavour prawns (*Metapenaeus ensis, M. endeavouri*, and *M. demani*) make up the remaining 10 to 15 percent of the total catch.

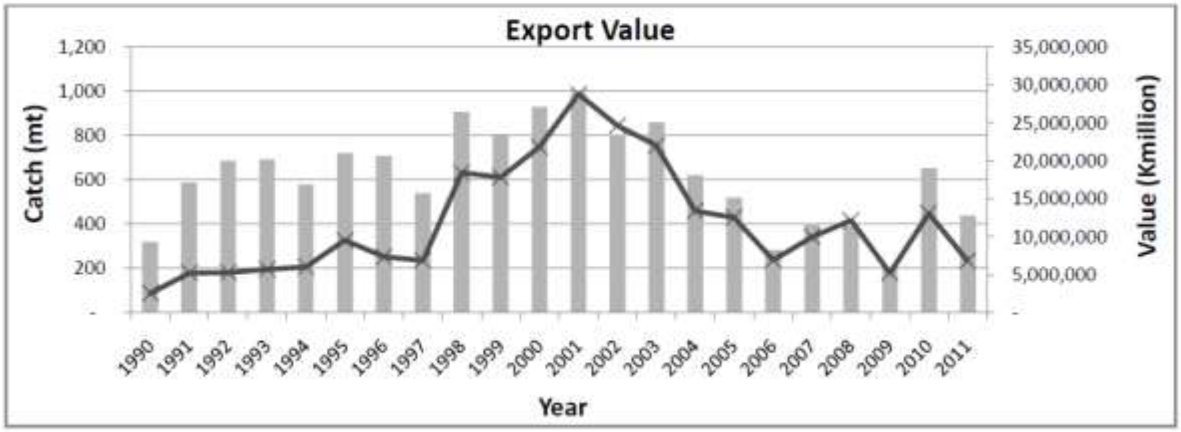


Figure 3.104: Prawn export value between 1990 and 2011 (Liviko, 2012)

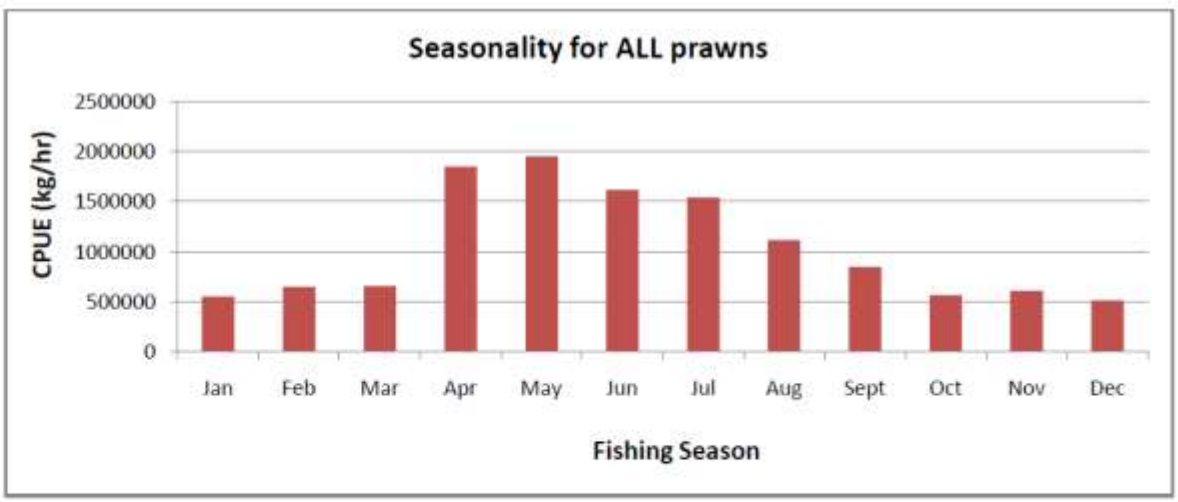


Figure 3.105: Peak season for all prawn species (Liviko, 2012)

Figure 3.104 and Table 3.9 shows the prawn export values for PNG between 1990 and 2011. Over the years the export increased significantly by 50% from 993,000 kg in 1979 to 1,960,000 kg in 1987, earning between K3.8 to K8.8 million (Matsuoka, 1995). Between 1990 and 2003, the revenue was between K2.5 million and K28 million (Liviko, 2012). The peak revenue period was experienced between 1998 and 2003 where between K18 million and K28 million was generated. Most years produced variable results ranging from K2 million to K13 million, with the lowest export earning achieved in 1990, with K2 million being generated. Australia, Japan and Korea were the main buyers of prawns. According to NFA, the Gulf of Papua fishery has a total annual catch for all species of prawns averaged about 1, 000 metric tonnes (tail weight) per annum, with an estimated value of K10 million (AUS$ 5 million). The fishery remains closed to foreign involvement. Figure 3.105 depicts the seasons most prawns were harvested in PNG. The peaked season was from April to July and this coincides with the migratory routes of the different prawn species from the Great Barrier Reef in Australian to breed and spawn in the Gulf of Papua. Prawns caught are processed and packed on board trawlers and are exported mainly to Japan, Singapore and Australia or are sold domestically within PNG.

Discards generated mainly by the prawn trawl fishery, as well as tuna longline and purse seine fisheries sometimes contribute to increase in value of inshore fisheries. Trawl nets are operated only in the prawn fishery while trawling of migrating lobsters was banned in 1984. Most prawn trawl by-catch in the Gulf of Papua (GoP) was initially regarded as minor component, especially sharks and rays, which caught are all finned. This could also potentially have significant impact on sharks and rays population. Possible future introduction of by-catch reduction devices (BRDs) would reduce the number of sharks and rays landed on trawlers. According to NFA, a total of 1800 sharks and rays were recorded and the key species are Australian Sharpnose (29% of sharks and rays), Whitecheek Shark (~10%), Australian Butterfly Ray (~8%), Milk Shark (~8%) and Scalloped Hammerhead (~6%).

The prawn fishery is thought to be nearing its catch potential, and with the increase efficiency in fishing effort, this has raised concerns for more research to verify thestatus of the prawns population. The lack of knowledge and uncertainty about the status of the prawn stock and a measure of effective fishing effort has led an ACIAR-NFA funded research project on the economics, biology and management strategy evaluation for the fishery. A management plan for prawn fishery has been developed and is currently being implemented by NFA.

Table 3.9: Prawn Export Volume (mt) and Value (USD & PGK) by years 1990 – 2011 (Liviko, 2012)

Year	Quantity (kg)	Quantity (mt)	Value (USD)	Value (Kina)	Country of Export
1990	320,084	320	2,662,835	2,552,236	Japan
1991	586,239	586	5,470,767	5,209,530	Japan, Australia, Guam
1992	684,834	685	5,473,712	5,285,768	Australia, Hong Kong, Guam, Japan, New Zealand, Vanuatu
1993	689,740	690	5,847,688	5,717,237	Australia, Hong Kong, Japan, Korea, Vanuatu,
1994	577,608	578	6,008,264	6,003,077	Australia, Japan, Solomon Is, Vanuatu, Vietnam
1995	720,483	720	7,284,995	9,532,392	Australia, Japan, Malaysia, New Zealand, Solomon Is, Vanuatu
1996	708,410	708	5,639,436	7,359,716	Australia, Japan, Korea, Malaysia, Taiwan, Vanuatu
1997	537,405	537	4,807,953	6,876,792	Australia, Japan, Korea, Singapore, Taiwan, Vanuatu
1998	905,592	906	8,703,967	18,424,518	Australia, Japan, Philippines, Singapore, Vanuatu
1999	806,338	806	6,928,693	17,828,815	Australia, Fiji, Japan, Vanuatu
2000	929,183	929	8,134,705	21,806,919	Australia, China, Fiji, Hong Kong, Solomon Is, Vanuatu
2001	992,778	993	8,509,232	28,770,367	Australia, Japan, Vanuatu
2002	803,795	804	6,344,185	24,629,541	Australia, Japan, Korea, Vanuatu
2003	859,611	860	6,143,671	22,014,540	Australia, Japan, Vanuatu
2004	619,384	619	4,163,854	13,393,992	Australia, Japan, Korea, Vanuatu
2005	520,581	521	4,038,831	12,538,943	Australia, Japan, Korea, Solomon Is, Vanuatu
2006	284,579	285	2,281,002	6,948,431	Australia, Japan, Korea
2007	401,711	402	3,371,809	9,996,683	Australia, Japan, Korea
2008	389,614	390	4,522,757	12,135,071	Japan

2009	198,471	198	1,931,772	5,239,870	Japan
2010	651,263	651	4,800,007	13,077,781	China, Japan, Korea, Taiwan

Giant Calm shells

Giant clam shells are used as sea walls or to raise garden mounts against rising sea level and salinity on Cateret Island, AROB (Photo by U. Rakova)

From the eight species that occur globally, seven Species of clam shells are found in PNG, namely *Tridacna gigas, T. derasa, T. squamosa, T. maxima, T. crocea, Hippopus hippopus* and *H. porcellinus* except *T. tevoroa.* Most of these species are under threat, mainly from overfishing, poaching by foreign boats and climate change. Only *T. gigas* and *T. derasa* are listed as Endangered (EN) under IUCN.

These clams occur in the Indian and Pacific Oceans and in the tropics and subtropical waters of the world. Clam shells are known for having the largest bivalve and are most commonly found on the reefs, especially from shallow waters to 40 meters deep. This makes them vulnerable to poaching and harvesting. On Cateret Island, in the Autonomous Region of Bougainville (AROB), giant clam shells are poached or harvested unsustainably for over 30 years. The remnants of the giant calm shells are used as sea walls and garden barriers against rising sea level. Caterets is the first island in PNG sinking as a result of rising sea level instigated by global warming and climate change effect.

On Caterets Island, many of those clam shell species are fished daily for household consumption, hence its rate of depletion in shallow waters and closer to villages and residents are facing marginal decline in population. Given lack of control by governing authorities and local conservation practices, the population is now under the MSY. This prompt the shells to move into deeper waters to recuperate or the population drops, hence they become rare locally.

Generally, most shells are fished on *ad hoc* basis for local consumption and trade between island communities than commercially traded. Instances of poaching by Asian of Taiwanese origin has led to rising harvesting activities by locals because they are after the bivalve or aductor muscles only with most other remains are often discarded. The locals also fish for the sea cucumber because of the demand for cash income. In 2017 two poaching boats were impounded for harvesting beche-de-mer.

In Milne Bay province, the largest maritime province in PNG, giant clam shells are harvested by rural coastal communities for their sussistence use or commercial because of their aductor muscles. More recently, coastal communties are venturing into other marine species such as beche-de-mer, reef fish, trochus, and shark fins fishery. The target species of Giant Clam shells harvested are *T. deresa, T. gigas* and *T. squomosa.* Figure 3.106 shows the weight of Aductor muscles of giant clam shells harvested between 1983 and 1988 on Samarai Island. Total weight in 1983 was 5,721kg and reached a high of 27,795kg in 1987 and then drops to 10,043kg in 1998. The status is unknown throughout the country but this figure gives an idea of how much has been harvested in a small island or coastal community in PNG.

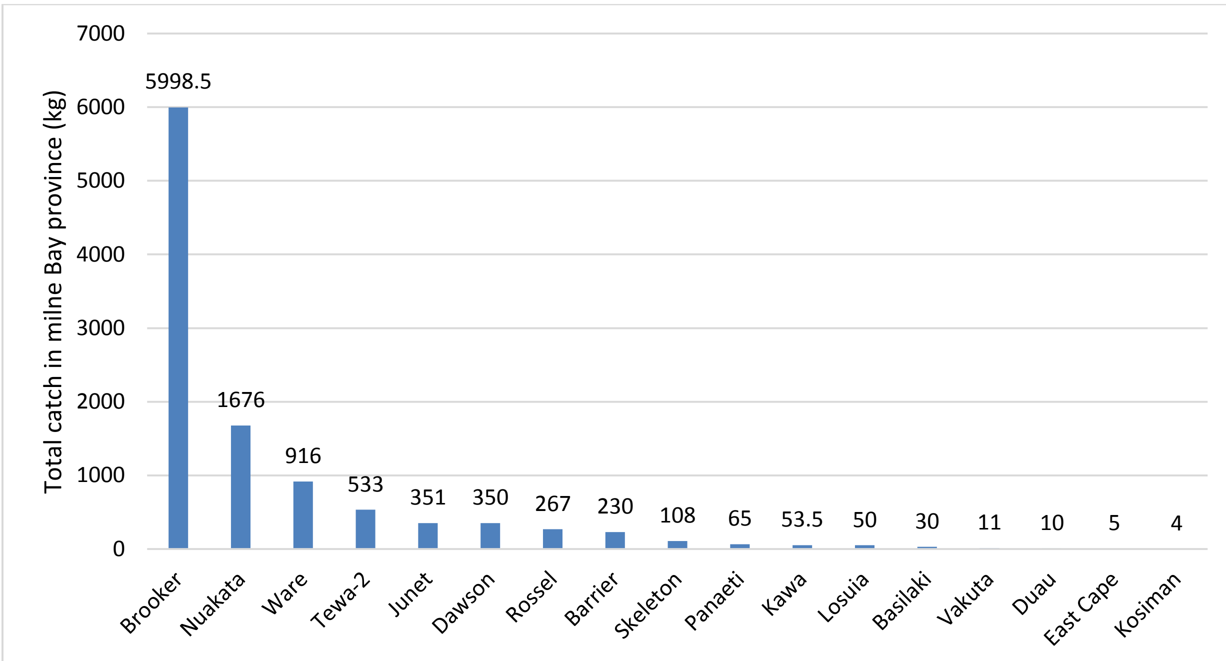


Figure 3.106: Quantity of Giant Clam shell caught in Samarai Island, Milne Bay province from 1983-1988 (Source: NFA)

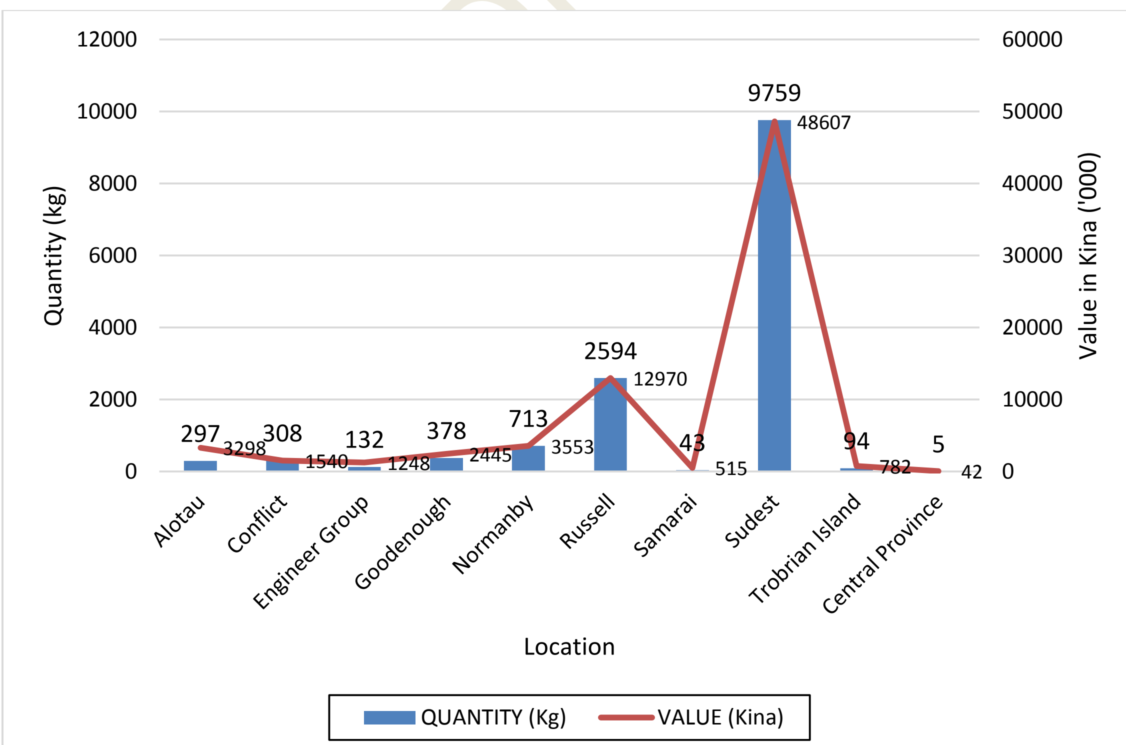


Figure 3.107: Quantity of Giant Clam shells harvested in Milne Bay and Central Provinces and monetary values (Source: NFA)

Figure 3.107 indicates the quantity and value of calm shells over different sites in Milne Bay and Central Provinces. In 1997, 10.65 tonnes of aductor muscles were harvested. Sudest Island has the highest catch with 9,759 kg and earned roughly K48,647 in revenue. Russell island harvested 2,594kg and earned about K12,970. Nomanby has the third highest harvest with 713kg and earned K3,553 in revenue. All other places have lower harvests rate probably because of less number of buyer and demand or because of isolation from nearby markets.

Generally, most shells are fished on ad hoc basis for local consumption and trade between island communities than commercially traded. Hence, its rate of depletion in shallow waters and closer to villages and residences are facing marginal decline in population. This prompt the shells to move into deeper waters or simply they are declined in numbers. There is lack of governance and control. Currently, locals are now establishing traditional conservation areas to bring back not only the population of clam shells but other species as well.

Beche-demer or Sea Cucumber

Beche-de-mer species are not recognised as PNG protected species, because they are not listed under CITES Appendix 2. In 2019, NFA has asked CEPA to assist it declare some sea cucumber species as PNG protected species under CITES Appendix 2 so that the species can be managed and harvested sustainably. So far a total of 31 species of sea cucumbers have been recorded to date in PNG waters and all play an important role in the ecological functions of marine ecosystems. Only 22 species have been targeted for commercialisation.

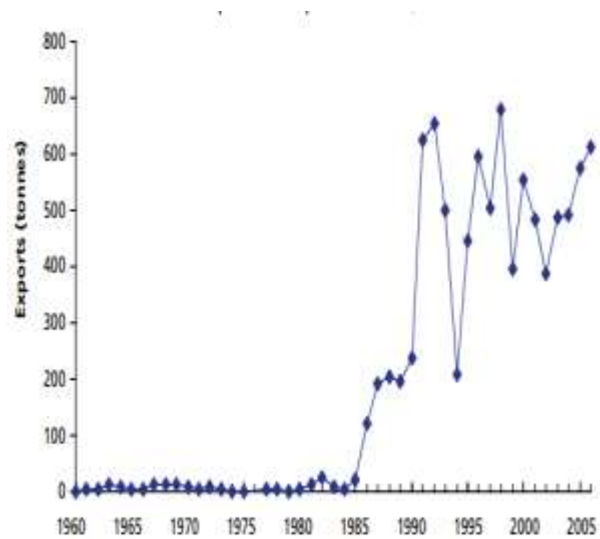


Figure 3.108: Bêche-de-mer exports from Papua New Guinea, 1960–2006 (Kinch, 2006)

All exports from PNG are as dried bêche-de-mer from capture fisheries. There are unreported sea cucumber catch estimated on the basis of bêche-de-mer export data. Usually, dry export weights are converted to fresh wet weight using a conversion ratio of 1/12. This means on average, only 12% of initial fresh weight remained once sea cucumbers have been processed for export (Teh et al., 2014).

Figure 3.108 shows sea cucumber production or catch data is not currently available, and subsequently export data has been used as a determinant of production to determine the catch over time. In PNG sea cucumbers do not appear to be a major item on either traditional or modern menus of most PNG communities, however, there are some exceptions where they are eaten or used as baits (Kinch et al., 2008).

PNG has been involved in beche-de-mer trade since the colonial era. During the late-1800s, the beche-de-mer trade was considered the 'gold of the sea' and average production for British New Guinea was 37.1 tonnes between 1878 and 1900, with a peak export of 96.8 tonnes recorded in

1883 (NFA, 2016). From 1900 to 1937, an average of 60 tonnes was exported annually in British Papua, while the mandated Territory of New Guinea exported an average of 98 tonnes annually. White teatfish and black teatfish were the two main species targeted throughout those periods. From 1960 to 1985, annual production in PNG was relatively low with an average of 20 tonne however this increased substantially in 1986 to around 100 tonnes (NFA, 2016). Harvesting peaked in the 1990s and reached a maximum of 580 tonnes in 1996 and steadied over time at an average of 500 tonnes (Figure 3.108).

NFA also reports between 2000 and 2009, annual production averaged 556 tonnes per annum with an average value of K 30 million per year. Annual production peaked in 2007, when 795 tonnes of beche-de-mer valued at K52 million was exported. Kinch et al. (2008) reported the export of beche-de-mer ranges from 200 tonne to 650 tonnes per year between 1992 and 2006.

Some negative impacts of Beche-de-mer on mangrove and other fringing coastal and island forests in PNG were reported because tonnes of firewood are needed to dry processed sea cucumbers into beche-de-mer (NFA, 2016). It is estimated that 10 tonnes of wood is needed to smoke 1 tonne of beche-de-mer. NFA iterates Beche-de-mer processing also results in the production of 'stick-water', which contains a toxin (holothurine) that originates from the skin of the sea cucumber. The toxin is released during the boiling process, and there is anecdotal evidence that the release of stick-water directly into the sea can result in fish kills.

Recent data were not available to extrapolate further however, according to the NFA, the growth in the beche-de-mer or sea cucumber industry has gradually increased proportionally with an increase number of participants. The hype of trade activities and multiple financing arrangements between locals and non-citizens is also increasing (http://www.fisheries.gov.pg). Subsequently this has constraint the allocated resources for monitoring for this fishery by both the NFA and the provincial administration. The Total Allowable Catch (TAC) for the whole country is set at 668 tonnes as stipulated in the national Beche-de-mer fishery management plan (NFA, 2016).

Despite lack of monitoring and enforcement, there is significant improvement in the quality of the export product, as a result of improving processing method by many operators. NFA iterates this is attributed to better dissemination of information to fishermen on handling of different species and processing techniques (http://www.fisheries.gov.pg). While the establishment of the national management plan had a positive impact on the sustainability of the fishery in some provinces, a greater commitment in the overall management of the resources is required (http://www.fisheries.gov.pg). The management plan also allows NFA to enforce blanket ban for a number of years for the population to recuperate and maintain its sustainable yield. The last ban was for 8 years from to 2009 to 2016.

Sea cucumber species are divided into two groups, high and low value and a Total allowable catch (TAC) is set for both groups for each provinces ranging from as low as 1 tonne to over 80 tonnes. It is often the case where the higher value species are heavily fished than the lower value ones. Once the TAC of a value group is reached, fishing for those species is supposed to stop, however NFA has never enforced a closure by value group (Kinch et al., 2008). Kinch iterates if the allocated TAC for a province is reached and exceeded over 5 tonnes, then the total excess amount should be deducted for the next season's TAC. This has never been enforced by the NFA.

Other species (Baramundi and Lobster)

The capture fishery for barramundi is based along the southern coast of the PNG mainland and mainly in the Western province. The fishery is now operating under a management plan that was developed under an ACIAR funded project that ended in 2002. According to NFA, barramundi exports in 2000 was 23.5 tonnes and earned around K402, 000 (http://www.fisheries.gov.pg). In 2001, export was 21.5 tonnes valued at around K353, 000. In 2002, the export worth K600, 000 with 31.5 tonnes exported while in 2003 10.6 tonnes was reported earning K230, 000. There is lack of data to show for recent export out of PNG.

Like the prawns species, most activities for export markets are occurring within the Gulf of Papua, in Gulf and Western Province. These provinces are the ideal marine areas because of seasonal migration from the Great Barrier Reef in Australia to spawn and breed in GOP before returning back to Australia waters. In other provinces, lobsters are caught and sold for local markets and hotels. Most lobsters are caught by divers using spear guns or by trawlers.

Figure 13.109 represents the lobster catch for PNG in comparison to Australia between 1950 and 2005. In PNG, the fishery operates more continuously with free divers taking lobsters in all months. A hookah ban begins starting December to March (Ye and Dennis, 2009). The only legal way to catch lobsters is by hand, usually by divers spearing the lobsters, yet some are caught alive. The other method which has produced large catches in the past is trawling but this is now banned since 1984.

In the 1970s and early 1980s, PNG caught more lobsters than Australia, with the highest catch of 256 t (tail weight) recorded in 1980. Between 1980 and 2005, the PNG's diver catch was maintained at about 801t but with large fluctuations was recorded as well. Before the 1984 trawler ban, PNG had has higher catches than Australia but since then, PNG's catch share has varied between 21% and 30%, with the exception of 56% in 2001 and 2002, during which low annual catches were recorded (Ye and Dennis, 2009).

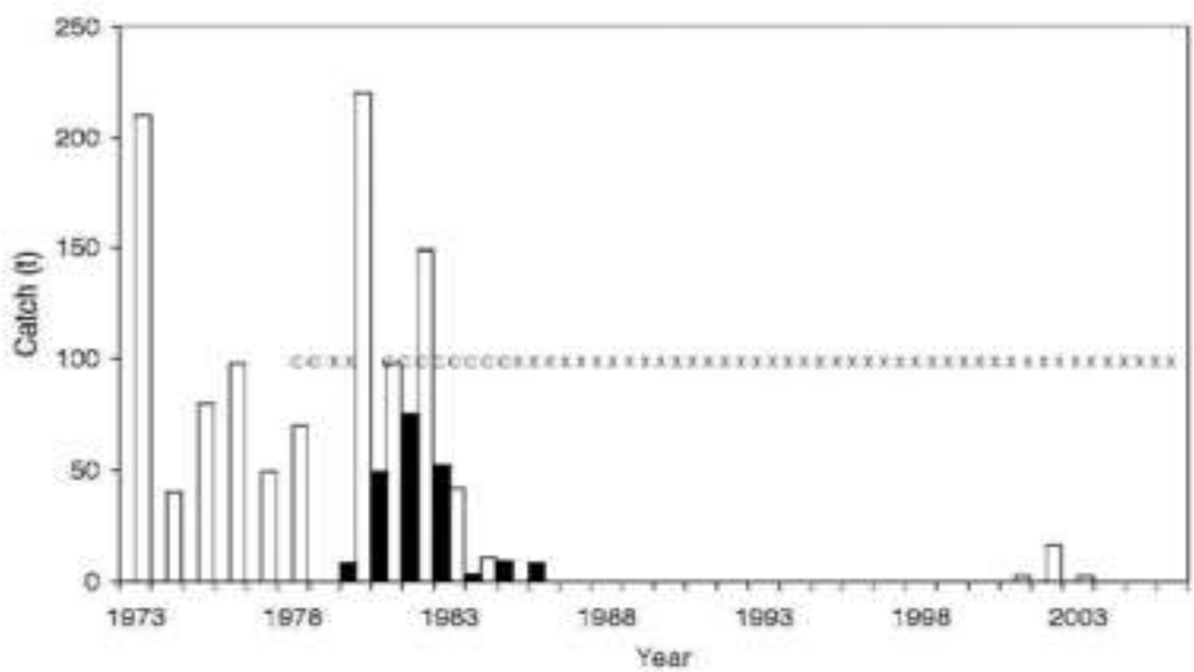


Figure 3.109: Annual commercial lobster (*Panulirus ornatus*) catch taken by trawling in Australia (solid bars) and Papua New Guinea (open bars) between 1972 and 2005. C, quota control over trawling; X, trawl ban implemented (Ye and Dennis, 2010)

Impact

PNG has pristine and diverse coastal reefs, offshore patch reefs, and lagoons that are filled with high biodiversity that are of both commercial and subsistence value for local communities and the country as a whole. However, information on their status is limited or not updated. In general, whilst data exist for exports of some species, basic catch data, and catch and effort data are generally poor except for few species (Teh et al., 2014).

With little research, isolation of many coastal sites, lack of monitoring and management capacity of NFA and partners to capture valuable information, and lack of capacity, resources and personnel to manage or enforce regulations to mange resources, the status of the inshore environment cannot be fully understood. However, the availability of some data may enable PNG to make inform decisions on how it manage its natural resources given rising pressures from over fishing. F

Generally, fisheries management in PNG has been predominately focussed on tuna, whereby nationalisation of the sector and sustaining the resource base have been NFA's major objectives in recent years (Teh et al., 2014). Small-scale fisheries management only extends to the inshore commercial sector, such as sea cucumber (holothurians), lobster (*Panulirus* spp.), prawn (*Panaeus, Fenneropenaeus, Litopeaneus and Marsupenaeus* spp) and barramundi (*Lates calcarifer*) fisheries.

This gap in basic knowledge about domestic food security and fisheries hampers effective management. At the same time, local nutritional needs, continuing involvement of people in the cash economy and associated desires, and the global demand for PNG's marine products will likely to continue thus exerting enormous pressures on small-scale fisheries. As more and more resources are extracted from the sea, it poses a life threatening issues for all marine species. However, isolation and inaccessibility of some inshore marine areas and reefs has reduced the impact of human activities on reefs.

Other pressures exerted on fringes reefs near urban areas or highly exploited areas due to activities such as mining, agriculture and logging have potential to lead to more sedimentation and pollution as a result of poor terrestrial land management. Over-fishing, particularly of invertebrates such as sea cucumbers, loss of top level predators in some areas such as sharks, destructive fishing, and rising population of Crown of Thorn starfish (COTS) outbreaks as a result of human impact caused by onshore industries and coral bleaching can exacerbate and threaten the inshore fishery (Chin et al. 2018). Other major threats to marine species are:

- Increase in population;
- Types of gear used;
- Increase mobility and improve transportation;
- Marine pollution;
- Plastics;
- Habitat loss;
- By-catch;

- Climate Change; and
- Overharvesting.

PNG inshore fishery is most likely to be affected greatly by global climate change and rising population (Section 6 and 7.2.3). The projected impacts of climate change on coastal ecosystems and associated fisheries resources are related to the level of exposure and capacity to cope, or become resilience to the impacts. Many coastal and island communities are already experiencing erosion of beachfronts due to rising sea levels and increasing frequency of storm surges and king tides. Climate models predict that El Niño Southern Oscillation events will become more frequent and the warming of oceanic waters will seriously affect marine life, especially corals, as sea temperature rise, causing more coral bleaching, ocean acidification, disruption to food chains (NFA, 2017).

Human population growth will also place more pressure on coastal fisheries as a vital source of protein for coastal communities. With the population of PNG expected to increase from 8 mil to over 10 mil by 2030, the current demand for fish may be expected to double. The estimated coastal fisheries production for PNG in 2007 was 35,000 tonnes where 80% comes from subsistence harvesting (NFA, 2017). NFA iterates there is an estimate of maximum coastal fisheries productivity at 98,760 tonnes, based on existing healthy habitat. This suggests that a projected increase in demand of 169,100 tonnes by 2035 will not be met by production given rising human population, which may lead to over-exploitation, especially if habitats are degraded.

In order to address threats, one way is to establish marine parks to protect biodiversity, for instance establishment of Marine Protected area (MPA). In addition, reduce destructive fishing methods such as trawling, enforce penalties to reduce the amount of by-catch, work on conservation initiatives, emphasize more on the use of traditional ecological knowledge (TEK) and community based management, where students are engaged in community based awareness.

Response and Recommendations

The increasing threats from uncontrolled commercial fishing pressures, habitat degradation, population growth and climate change, coupled with anticipated investment in community development, require more effective national and provincial resource management systems, that build on and support management and sustainable use by communities. Hence the onus is to promote sustainable harvesting practices and adequate conservation strategies for endangered or useful marine species.

Similarly, mangrove forests protection and rehabilitation as a nursery ground for fisheries to address declining fish population must continue. Sustainable fisheries management and conservation of critical habitats, disappearance of habitats and species as a result of unsustainable rates of extraction and natural or human impacts must involve collaboration, research and capacity building to enhance proper data are collected and analysed. Consequently, this would enable decision makers to make inform decisions. More awareness raising are needed country-wide.

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8.6.5. TOPIC/SUBTOPIC: MARINE MANAGED AREAS

Indicator Definition: Percentage (%) of EEZ formally protected for conservation and trend in conservation of marine habitats and species

Status and Trend

Photo: Low tide in Popomai, Manus Province

SDG/CBD Targets

SDG: 1.4.11.5.3, 10.1.1, 10.2.1, 13.1.3, 13.3.2, 14.1.1, 14.2.1, 14.4.1, 15.5.1, 14.6.1, 14.7.1,

Aichi Target: 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 14, 15

Status and Trend

PNG has a total water body area of 11,475.47 km^2. Its exclusive economic zone (EEZ) is about 3.12 million km^2 and is the world's second largest (ADB, 2014). The country's sparsely distributed population of only 8 million makes PNG's population density of approximately 9 people per km^2 the lowest in the South Pacific. A total of 59 Protected Areas is recognised in the country covering 2.5 million hectares (4%). The Terrestrial Protected areas (PA) are the largest with 84% (1,639,863.81ha), followed by terrestrial-marine with 14% (273,839.25ha) and marine with the lowest portion with 2% (45,417ha).

Table 3.10 shows 54 marine MPA and 45 Terrestrial-Marine MPAs. Some PAs covers both Marine and Terrestrial areas, with some most likely covering large terrestrial area. For Marine PAs, there are 4 areas of interest, 12 are designnated PAs, 1with dispute and draft sites with 1 each. There are 22 unknown and 14 volunatrily protected sites. A total of 45 marine and terestrial PAs exisit where 7 sites are of interest while 20 sites are designated PAs, 2 sites disputed , 5 sites drafted and 1 no longer active, 3 unknown and 7 sites are conserved voluntarily. Though yet to be formally gazetted under national legislation, a total of 2,101 Locally Managed Marine Area (LMMA) has been proposed (Leverington et al., 2017).

Table 3.10: Number of Protected Area recorded by CEPA (CEPA internal Data)

Status	Marine	Marine-Terrestrial	Terrestrial	(blank)	Grand Total
Area of interest	4	7	25		36
Designated	12	20	46		78
Dispute	1	2			3
Draft	1	5	7		13
No longer active		1	1		2
Proposed			7		7
unknown	22	3	5		30
Voluntary	14	7		1	22
Grand Total	**54**	**45**	**91**	**1**	**191**

Figure 3.110: Map of MPAs, corals and mangoves in PNG (Coral Triangle Atlas, 2012)

Generally most areas are conserved by local communities because of their cultural and biological value and from threats. That is, a customary system of tenure *(tambu)* applicable to fringing reefs and inshore fishing resources is widely practiced in many coastal communities. However, the practice of temporarily closing reefs under the *tambu* management regime is a practice now on the decline (ADB, 2014).

The formulation of the PNG Policy on Protected Area 2016 has now recognises the establishment of Marine Protected Areas (MPAs). NGOs and donors are working with communities to establish locally managed marine areas (LMMAs) to improve marine biodiversity and resource management. Figure 3.110 shows the mangrove, MPAs and reefs areas in PNG where local coastal communities depend much on for their livelihood.

One of the atolls in Manus Provinces (Photo by P. Polin)

Furthermore, Table 3.10 shows the total size of the Marine Protected Area recorded at CEPA is 17,730,689ha, with 2,524,589 ha designated as PAs. About 14,470,657 ha are of interests while others are disputed (17,226 ha) or in draft stage (53,366ha), and proposed (575,040ha). Another 19,730ha is no longer active due to various reasons because they are managed by the landowners. A total of 39,794ha are voluntarily conserved while another 28,186ha has no record or is unknown. All in all, 2,101ha of LMMA are proposed to be conserved formally.

Table 3.11: Sizes of each Marine Protected Area recorded by CEPA (CEPA internal Data)

Status	Hectare (ha)
Area of interest	14,470,657
Designated	2,524,589
Dispute	17,226
Draft	53,366
No longer active	19,730
Proposed	575,040
unknown	28,186
Voluntary	39,794
Locally Marine Managed Area	2,101
Grand Total	**17,730,689**

Table 3.12 indicates from other sources that the total MPA is 63 (39 documented), with an area of 4,550 km^2 or 0.2% of the EZZ. In additional about 300 km^2 of reef and about 35 km^2 of mangroves (out of the total 4,159 km^2 of mangrove area in PNG) are found within these MPAs.

Table 3.11: Summary of MPA, ree and Mangrove (Source: CT ATLAS and UNEP)

Number of Known MPA	63 (39)
Total MPA areas (Km^2)	4550
MPAs in EEZ (%)	0.2
Coral Reef area (Km^2)	7,126
Reef area in MPA (Km^2)	35
Mangrove area (Km^2)	4,159
Mangrove area in MPA (Km^2)	35
Mangrove in MPA (%)	1

The marine environment of PNG is vast and diverse and is well renowned for its rich coral reefs and iconic marine species with very high species diversity and endemism. PNG is located within the "Coral Triangle'' which encompasses 147, 629, 32.23 mil km^2 (Figure 3.111). The region covers some of the world's richest coral diversity that house unique and species rich ecosystems. The corals reefs of Australia and PNG combined together constitute about 19% of the world's total reef area and contain high levels of biological diversity approaching the 'hot spots' of the Philippines and Indonesia (Chin et al., 2008).

PNG is known for its rich coral reef and species diversity (Photo by J Yonova)

The Coral Triangle Initiative (CTI) on Coral Reefs, Fisheries, and Food Security known as Coral Triangle Initiative [CTI) was launched in 2007 as a multilateral partnership of the governments of Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands, and Timor-Leste ADB, 2014). The CTI recognizes the need to safeguard the coastal and marine resources of the seas that surround these countries, which together constitute a uniquely diverse and economically important region often referred to as the 'Coral Triangle'. In 2009, these six countries adopted a 10-year, five-point CTI regional plan of action for improving management of the region's coastal and marine resources.

ADB has supported countries like PNG in implementing the CTI programs and establishing marine pilot projects. Work on large-scale marine areas (seascape) are the geographical focus of major investment and development activities in PNG. There are 12 recognised Marine Protected Areas, with another 20 covering both marine and terrestrial ecosystems. A total of 5927,044 ha (2.28% of EEZ area) of interest but overall, 504,713ha (0.21%) of the total seascape is designated protected area in response to climate change impacts (CTI Report, 2018; CEPA internal database).

Though most of the PAs are located near the coastal communities, the government is embarking on conservation of seascapes at a landscape level. By 2020, the PNG government plans to increase conservation of coastal and marine environment up to 10% under the Conservation on Biodiversity (CBD). Though this is too remote, there is potential to start now. Figure 3.112 shows a Maxan Analysis of the priority areas for PNG waters, including the EEZ. The pink colour represents areas of high species biodiversity and endemism, followed by dark blue and light blue in their order of priority. The areas marked are improtant for future conservation and can be protected under seascape and ecosystem conservation.

Figure 3.113 shows areas where some threatened bird species occur namely the Beck's Petrel, Red-necked Phalarope, Brown noddy, Black noddy, streked shearwater, Heinroth's Shearwater, Great Sand Plover, and the Far EasternCurlew. Hence the need to protect these species and their habitats is very important. Figure 3.114 indicates critical areas for the protection of both whales and marine turtles, especially near villages and coastline, where human harvesting and movement can have a negative impact on those species and their population. Without more conservation efforts put by the government in bilateral partnership with major development partners, most species and their environment will be threathened from extinction and degradation.

Figure 3.111: Coral triangle coverage area (CTI-CFF, 2013)

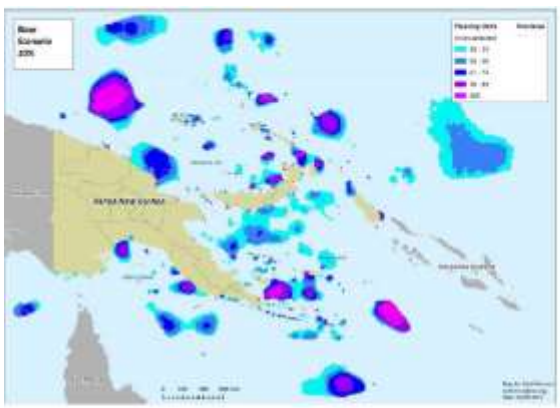

Figure 3.112: Marine priority areas using base 10% scenario (GoPNG, 2015)

Figure 3.113: Priority conservation area for seabirds and shore birds (GoPNG, 2015)

Figure 3.114: Critical area for turtles and whales (GoPNG, 2015)

Impact

About 80% of the coastal population in PNG depend much on the marine environment for their livelihood, and fish (including other fisheries products) is a major source of protein and income in PNG. According to ADB, the annual per capita fish consumption is 13 kilograms (kg), but reaches 53.3 kg in 2009, with subsistence fishing accounts for approximately 64% of total fish consumption in rural areas (ADB, 2014). Despite the availability of modern transport systems, access to fish is poor for residents living more than 5 kilometres (km) inland, where their annual per capita consumption is estimated at less than 5 kg. Significant loss of coastal fisheries is evident along PNG's coastline.

In recent times, marine resources in maritime provinces which coastal communities rely heavily on to sustain their ,livelihoods have come under increasing stress.Over fishing sometimes exceeds the sustainable levels and dstructive fishing methods, coupled with the use of outboard engine-powered crafts to access distant or protected fishing grounds are also impacting fisheries population. In addition, agroforestry projects are active in many of the 14 maritime provinces, hence over the years, have contributed to marine resource degradation (ADB, 2014). Siltation discharged into the ocean caused by seasonal heavy rainfall has likewise contributed to degrading marine resources, particularly when it follows extended droughts.

Ela Beach in Port Moresby was rehabilitated for the good of the residents by the national Capital District Commission

Moreover, discharge of chemicals and waste have increase significantly thus causing eutrophication and deaths in coral reefs. Even coastal provinces with major gold and copper mines have suffered from food insecurity. For instance, in the Western Province, which borders Indonesia, flooding in May–June 2012 caused by heavy rain along the Fly River inundated 15 coastal villages, destroying food gardens, smothering seagrass meadows, and causing tributaries of the Fly River to flood (ADB, 2014). Following this, health concerns were widespread, and most marine-based food was deemed unsafe to eat for several months.

Threats from deep sea tailing is also of concern as mine waste have been dumped into the seabed floor (e.g. Lihir Gold Mine, Krumbukari mine and the proposed Seabed mine in the Bismarck Sea). This may have a serious repercussions on the fisheries population and the food chain, particularly the top apex predators such as tuna, sharks, dugongs, dolphins, turtles and whales. Thus, conservation of the coastal environment from degradation is important. In Port Moresby Ela Beach, local businesses and partners are involved in coastal clean-up and for the protection of its values for the welfare of the people.

There are major threat to marine species, ecological function and the marine livelihood of coastal communities and the country as a whole. Major factors causing the decline of many species include (i) unfavorable weather patterns, (ii) runoff from heavy rainfall, (iii) habitat degradation and loss of foraging and breeding areas because of illegal fishing practices, (iv) illegal unreported and unregulated fishing, and (v) lack of research regarding these threatened species and insufficient monitoring of their capture rates (ADB, 2014).

These threats are caused by natural causes such as global warming, economic development, pollution, over exploitation of resources, invasive species, increasing trade and method of exploitation. Figure 3.115 shows the major threats to coastal resources in the coral triangle communities versus the global communities in ascending order are: Integrated Threats plus Thermal threats (climate change) is the major threat followed by Integrated Local threats, Overfishing/Destructive fishing, Land-based pollution, Marine-based pollution and coastal Development. The first three threats are more likely to happen that will threatened the diversity and livelihood of the local communities in PNG while the other three are most likely to cause serious problems.

PNG's relatively porous international boundaries with Australia and Indonesia have also facilitated unsustainable rates of capture of many marine species. Mangrove forests are likewise in retreat due to unsustainable rates of exploitation and urbanisation. While most threatened species and mangroves are a significant for the livelihood for coastal communities, these natural resources must be managed and used sustainable without compromising the future of the future generation.

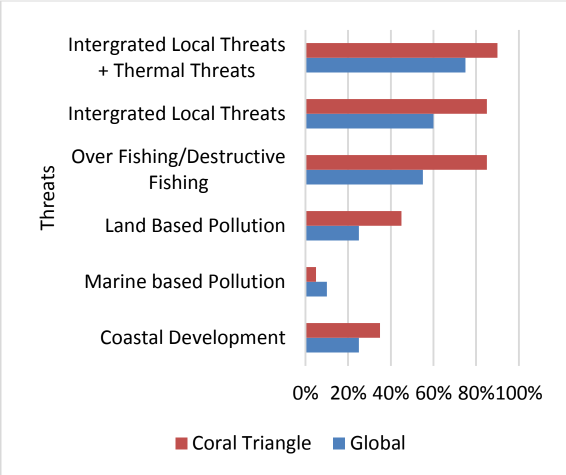

Figure 3.115: Threats to communities in Coral Triangle regions compared to the world (CTI-CFF, 2013)

In the meantime, the government is considering instituting a payment for ecosystem services scheme that would provide revenue and incentives for local residents to maintain mangroves and their reef system. A new Protected Area Bill is now before the National Executive Council to endorse before it is presented in parliament for enactment. The bill captures biodiversity offset and the establishment of the biodiversity Trust Fund. At least the government is trying to address the threats and issues of conservation but if nothing is done, PNG may loss many of its species and ecosystems.

Response and Recommendations

More awareness and funding, including sustainable projects are needed for community driven LMMAs to meet the 20% of the country under PA target by 2020. Priority seascapes investment plans have been completed, along with arrangements for sequencing investments in a manner consistent with PNG's Vision 2050, but thus needs implementation. Development of management plans, a separate marine policy on seascapes and Implementation are needed.

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The Sepik River meeting the sea. This habitat is unique for some species

8.6.6. TOPIC/SUBTOPIC: ENDANGERED MARINE MAMMALS, RAYS, SHARKS AND TURTLES

Indicator Definition: Population abundance of identified endangered marine species

Status and Trend

Karkum Conservation Area in Bogia, Madang Province is protecting the nesting site for endangered Leatherback Turtle, *Dermochelys coriacea* (Photo by W. Magun)

SDG/CBD Targets

SDG:14.1.1, 14.2.1, 14.3.1, 14.4.1, 14.5.1`14.7.114.a.1, 14.b1,14.c.1

Aichi target: 1, 2, 3, 4, 5, 6, 8,, 10, 11, 12, 14, 19, 20

Status and Trend Discussion

Papua New Guinea is a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Some of the species of fauna and flora are listed under Appendix 1, Appendix 2 or Appendix 3. The International Trade (Fauna and Flora) Act 1976 and the Crocodile Trade (Protection) Act 1976 for crocodile management are the two Acts of parliament that enables CEPA to govern all CITES species trade and export. CITES was drafted as a result of a resolution adopted in 1963 at a meeting of members of IUCN (The World Conservation Union).

In PNG Species listed under Appendix 1 species are not for export as alive such as the Queen Alexander Birdwing butterfly (*Ornithopera alexandrae*) for terrestrial species and species of sawfish for marine species. There is exception only for research purposes where tissues are extracted for scientific or research purposes. Those species under Appendix 2 are traded, but not alive, and are done so with the issue of an export Permit by CEPA. Species in this category must be harvested sustainably using a management plan, ranching facility, by required sizes etc as for species such as salt water crocodile (*Crocodylus porous*), Bigeye Tuna (*Thunnus obsesus*), and Wedge Fish (*Rhynchobatus* spp.), Black and Acropora coral species, all shark and ray species, and Giant Clam (*Tridacna giga*) in this Appendix list are country specific threatened species. The Dugong (*Dugong Dugon*) is a PNG protected Species are is listed in Appendix 2. These species are corresponding to the IUCN redlist species. PNG is

yet to update its CITES species slits. For instance, there are not sea cucumber species listed in Appendix 2 but in 2019, work has been done to protect these species under CITES Appendix 2.
Appendix 3 species are those species that are voluntarily identified by a country which then ask other countries to help protect it For instance, Samoa and Niue sees Mako Sharks and Wedgefish (*Rhynchobatus* spp.) are under threat and had listed them under Appendix 3. Both countries have asked other pacific countries like PNG to help protect these species. Species under this category can be exported with all criteria under Appendix 2 applicable. PNG does not have a species listed for Appendix 3.

Widespread information nowadays about the endangered status of many prominent species, such as the Giant clam, Napoleon Wrasse (*Cheilinus undulates*), Barramundi Cod (*Cromeleptis altivelis*), Beck's petrel *(Psuedobulweria becki*), Streaked shearwater (*Calonectris leucomelas*), Squaretail coral grouper (*Plectropomus areolatus*), and Black-saddled coral grouper (*P. laevis*) to name a few might make the need for such a convention seem obvious. Of the total 7 marine turtle species found in the world, 6 of them are occurring in PNG but only 3 are listed as Critically Endangered, 1 near threatened and 1 species is vulnerable. There are also growing concerns on the status of the turtle species whose migration patterns brings them to PNG for foraging and nesting.

A Leatherback hatchling leaving the beach for the ocean (Photo by W. Magun)

Table 3.13: List of marine species under threat (IUCN, 2019)

Taxa	Critically Endangered	Endangered	Extinct	Vulnerable	Total
Fishes	0	4	0	4	**8**
Corals & anemones	0	6	0	151	**157**
Sea Birds	1	3	0	2	**6**
Shellfish	0	0	0	2	**2**
Sharks and Rays	2	8	0	22	**32**
Sea Cucumbers	0	5	0	5	**10**
Crustaceans	0	0	0	1	**1**
Cetaceans	1	3	0	2	**6**
Sea Turtles	3	1	0	2	**6**
Sirenian	0	0	0	1	**1**
Mollusc	0	2	0	2	**4**
Mangrove	1	1	0	2	**4**
Total	**8**	**33**	**0**	**196**	**237**

Some example of Critically endangered species are:

- the Irrawaddy Dolphin (*Orcaella brevirostris*) found in the Gulf Province;
- Blue Whale (*Balaenoptera musculus*), found in the Bismarck Archipelago,
- Hawksbill Turtle (*Eretmochelys imbvricata),*found in Manus, WNB, Madang, Milne Bay, Central, Western and AROB province;
- Green Turtle (*Chelonia mydas),* found in WNB, Manus, NIP, AROB, Milne Bay, Central and Western province; and
- Leatherback Turtle (*Dermochelys coriacea),* found in AROB, NIP, WNB, ESP, Sandaun, Western, Central and Morobe province.

In many marine communities, many people are still unaware of the status of many threatened species but being frequently fishing or collecting marine products from the ocean, many have noticed a big drop in the population some species, including those threatened or endangered species. Hence, awareness raising is important. There is also limited data to indicate the true state of marine species in PNG.

For instance, the trend in leatherback turtle harvest by local fisherman is not known across PNG. The local people of the Karkum Conservation Area in Bogia, Madang province are no fully aware of the importance of Leatherback Turtle nesting on their beaches. In the past, they thought everything is for food and harvest unsustainable. With more awareness being done, the villagers are now conserving that Critically endangered species and their nesting beaches and have seen increase in number of females returning to the beach for nesting.

In Milne Bay province where overfishing has led to reduction in fish population. With the introduction of traditional conservation practices called Gwala the over exploited reefs and many marine life has returned. Traditional closure of fishing grounds has enable population exploitation of marine life, including increasing in sizes of fishes.

In New Ireland province, the impact of oil palm plantation and logging has affected the reef's health. WCS has worked with locals to protect fringing coral reefs, lagoons and mangroves using Tambu has seen increase in macro-algal cover. The study found out that agriculture waste or impacts from palm oil plantation and Crown of Thorn starfish (COTS) outbreak can affect average coral cover. Although some reefs are affected by problems, most reefs in PNG remain relatively pristine and are in good condition (Chin et al. 2008).

The declining population of species has been prominently featured throughout this State of the Environment (SOE) Report. This mean if PNG is not careful in managing its natural resources, many species will become extinct. Table 3.13 shows the threatened species list by different marine taxa group. A total of 237 species are listed as threthened, with 8 species are listed by IUCN as Critically endangered and can go into extinction, 33 species are endanagered from entinction, and 196 species are vulnerable to threats from extinction. There are no extinc species.

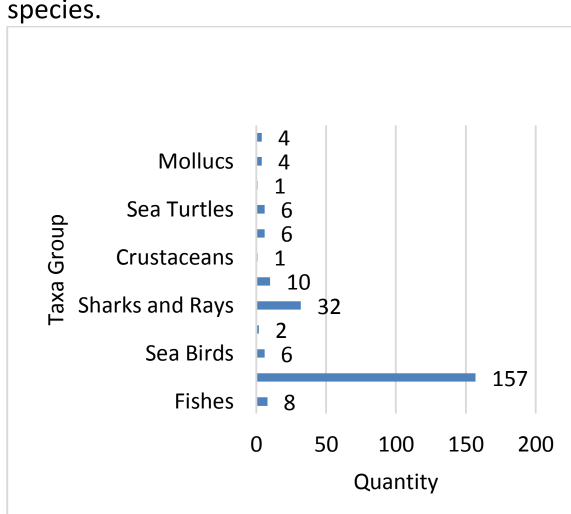

Figure 1: Number of threatned species for major marine taxa (IUCN, 2019)

Figure 3.116 shows the total number of taxa groups under threat. Corals make up about 66%

with 157 species, Sharks and Rays with 32 (13%), Sea cucumber with 10 (4%), and Fishes, Sea turtles, Cetaceans and Sea birds with 6 each (3%). Mangroves and Moluscs have 2 species (2%) each while the Crustacean and Sirenians have 1 species each (<1%). CEPA has already mapped out locations of most of the threatened species and where they occur (Figure 3.117).
A concerted effort needs to be made to ensure the public are educated, to ensure the vulnerable, endangered and critically endangered species are protected from the brink of extinction. CEPA also need to esnure the goal of the CBD is met by protect at least 10% of coastal and marine areas that can also provide refuge for those threatened species.

Giant Napoleon Wrasse catch by fishment in Milne Bay Waters is a critically endangered species around the globe (Photo by Rock Expeditions)

CEPA must work with local communities, NGOs, fishing companies and other government agencies to protect those threatened know the status of the marine species and protect them.

Between 2010 and 2014, collaborative deep water surveys in the Bismarck and Solomon Seas was led by the Museum National d'Histoire Naturelle (MNHN), Pro Natura International (PNI), Institut de Recherche pour le Development (IRD) and the University of Papua New Guinea (UPNG).

The inventory was done for benthic biodiversity in deep water, between 100 – 1500 m depth. A total of six (6) new species of sharks and rays were identified, including the newly identified Papuan Guitarfish (*Rhinobatos manai*). Another study was also conducted concurrently, from 2014 to 2017, under a major project funded by ACIAR and partly by PNG NFA. The aim was to collect and provide sufficient information and develop a framework to enable PNG to manage its shark and ray resources on a sustainable basis. The project was implemented by CSIRO in collaboration with the PNG NFA and James Cook University (JCU). Consequently, a total of 79 shark species, 51 ray species and 2 chimaeras were recorded.

A validation study under the leadership of Dr. William T. White (Australian Fish Scientist) to examined PNG shark specimens stored at the various biological collection around the world confirmed that in total 5 new species of sharks and 8 species of rays were discovered during the recent ACIAR-NFA Shark and Ray Project. All in all, an estimated total of 23 species of sharks, 4 species of sawfishes, 3 species of guitarfish, 13 species of string rays and a species of chimaera have been identified to be species listed under the IUCN Red list (threatened species).

Some of the sharks and rays species identified in PNG are protected from commercial harvesting as a result of the species being listed under the CITES Appendix II

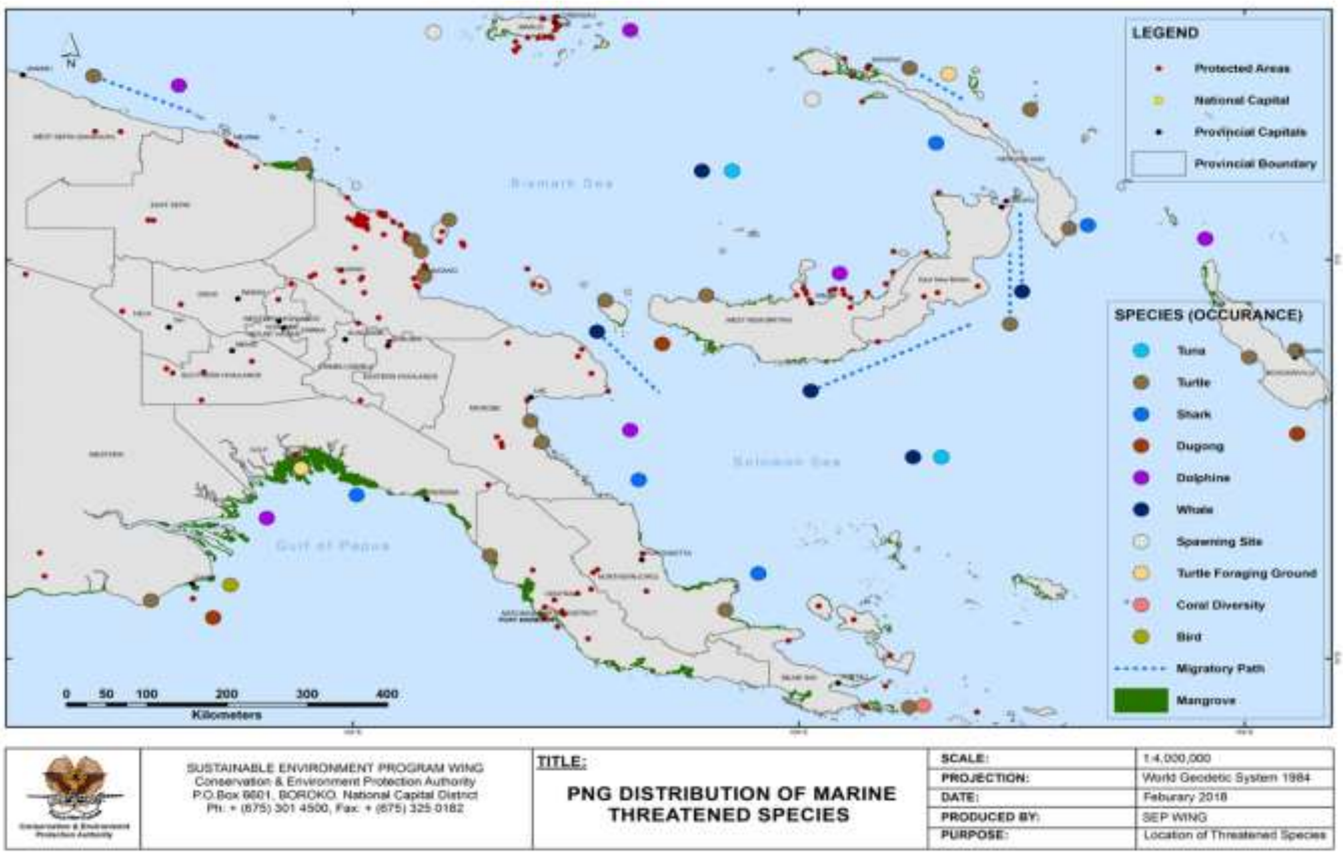

Figure 3.117: Distribution of marine threatned species occurance in PNG (CEPA, 2018)

Endangered species of sharks and rays that are associated with the tuna fishery are protected under the WCPFC CMMs. PNG is a member of CITES and the WCPFC. Currently, more attention is placed on endangered shark and ray species (list as per WCPFC CMMs) that are associated with the commercial tuna purse seine and tuna longline fishery. NFA has around 300 professional fisheries observers that monitors and reports on the fishing activities of the vessels including reporting on the compliance of fishing vessels with regard to the CMMs.

PNG used to have a small Shark Longline Fishery before 2014, managed under the Shark Longline Management Plan 2002. The fishery was limited to 9 vessels, setting 1,200 hooks per day with a total allowable catch (TAC) of 2,000 mt dressed weight per year. All the vessels in this fishery fished only in the PNG waters. The average estimated catch of sharks from the Shark Longline Fishery between 2010 – 2015 was 1,011.47 mt (WMCFC, 2016).

Collaborative research work with partners and monitoring work by NFA are important, not only for sharks and ray but for the country in monitoring endangered marine species and to know the status of endangered species. The same could be done on terrestrial endangered species too. Many species are yet to be discovered and protected from extinction.

Impact

Most threatened species or species that are vulnerable or under threat are included in different categories under the Convention on International Trade on endangered Species (CITES) when traded around the world. The CITES database of Appendix 1 and Appendix 2 introduces to the world the threatened species. Institutions such as the IUCN, CITES, CMS, WWF, WCS, JCU, and CBD have evolved to counter illegal trade or address species conservation.

At the country level, PNG has passed legislation such as the Fisheries Management Act 2004, Environment Act 2000, CEPA Act 2014, International Trade (Fauna and Flora) Act 1976, and the Crocodile Trade (Protection) Act 1976 to promote conservation of those threatened species.

PNG also had signed international conventions and protocols such as the Convention on Biodiversity (CBD) to protect the environment and species from threats as well.

Thus, Inventory of threatened species namely cetaceans, sirenians, marine turtles, corals and other threatened species are vital in the marine program of CEPA and PNG.

Many megafauna such as sharks, tuna, and whales have slow growth, hence overfishing can affect the MSY and food chain, thus causing a cascading effect on the food web. The major threats to marine threatened species include:

- Rising population;
- Types of gear used;
- Transportation;
- Marine pollution;
- Plastics;
- Habitat loss;
- By-catch;
- Overharvesting
- Sedimentation; and
- Climate Change effects.

With increasing threats and unsustainable fishing practices, PNG and the pacific island countries may lose their rich marine biodiversity and resources. Thus the PNG government must work collaboratively with like-minded countries and organisations, including the fishing industries and local communities to raise awareness and ensure appropriate laws and regulations are followed to save those endangered marine species from extinction.

Response and Recommendations

CEPA needs to work with research organisations, universities, fishing companies and National Fisheries Authority to assess the status of marine biodiversity and their environment.

Coastal provincial data collection point studies are needed to be collected and studies must complement this. Appropriate plans for turtles and marine mammals, and endangered species need to be developed and database centralised at CEPA under the Environment Portal.

In addition, more education and awareness on endangered species must be done. Training of monitors with appropriate skills are vital.

Reference

Chin A, Sweatman H, Forbes S, Perks H, Walker R, Jones G, Williamson D, Evans R, Hartley F, Armstrong S, Malcolm H, Edgar G, Ban Croft K , Valentine J and Halstead B (2008). *Status of coral reefs in Australia and Papua New Guinea. In Status of the coral reefs of the world*. ResearchGate publication.

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8.6.7 TOPIC/SUBTOPIC: LIVE CORAL COVER

Indicator Defintion: Percentage (%) of live coral cover in coastal and marine environments.

Status and Trend

Ships anchoring outside the barrier reef, near Ela Beach, Port Moresby

SDG/CBD Targets

SDG: 14.1.1, 14.2.1, 14.3.1, 14.4.1, 14.5.1, ,14.7.1, 14.a.1, 14.c.1

Aichi Target: 1, 2, 3,, 45, 7, 8, 10. 11, 12, 15 , 18, 19

Status and Trend Discussion

PNG also is the largest island nation in the Pacific in terms of landmass and Exclusive Economic Zone, the second largest in the world, with total land area of 462,000 square kilometers (km^2) and 3.12 million km^2 respectively (ADB, 2014), which is the largest and more productive in the Western and Central Pacific Ocean. The GoPNG (2018) states PNG EEZ is 2.4 million km^2 and a total coastline length of 17,110km (GoPNG, 2011). The country's sparsely distributed population of only 8 million makes PNG's population density of approximately 9 people per km^2 the lowest in the South Pacific (ADB, 2014).

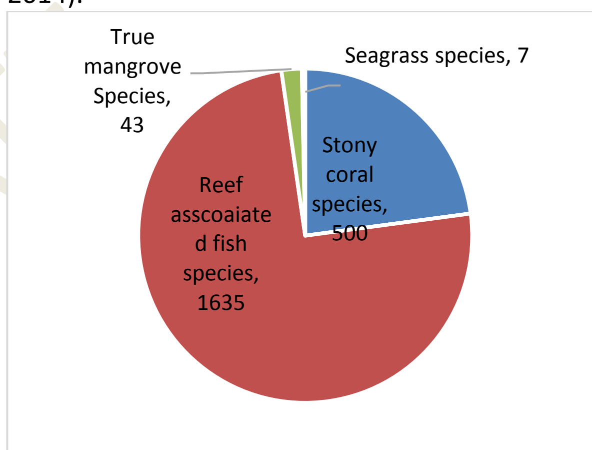


Figure 3.118: Number of species of coral, fish, sea grass and mangroves (ADB, 2014)

The United Nations Environment Program (UNEP) records PNG's marine and coastal ecosystems have approximately 13,840 km^2 of coral reefs (0.44% of the EEZ), 4,200 km^{2}of mangrove swamp forests, and extensive seagrass beds (Figure 3.118).

Other reports state that PNG has a total sea area of 11, 475. 47km^2. It was reported also that PNG has 40,000 km^2 of coral reefs, with Milne Bay province having the largest maritime province with the most abundant coral reefs (GoPNG, 2018). PNG has one of the biggest coral reef system in the Pacific and is the center of the Coral Triangle which is rich in spices of corals and fishes, plus numerous other marine life (Figure 3.119).

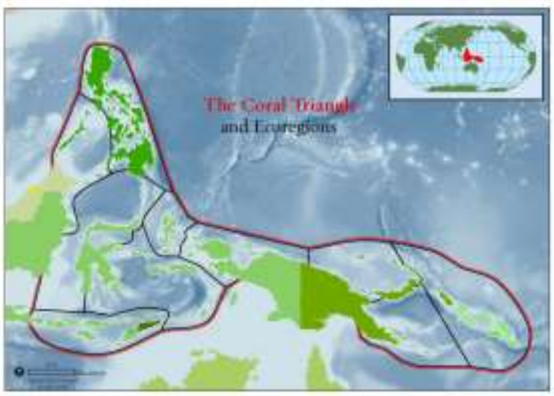


Figure 3.119: Coral Triangle region (ADB)

PNG is also a member one of the Coral Triangle member countries, which have unique and fascinating oceanic environment comprising of complex ecosystems. The Coral Triangle is the global centre of biodiversity housing more species than any marine environment on the planet including highest coral diversity with over 600 species or over 75% of the world's known total. The region also boasts the highest assortment of over 2,200 reef fish species, comprising over 50% of all coral reef fishes in the entire Indo-Pacific region and over one third of all known worldwide.

PNG has an estimated reef fish species count of well over 2,100. The reasons for this extraordinary congregation of undersea life are as vast and as varied as the range of habitats within PNG. The bountiful diversity of life in Papua New Guinea's reefs is as remarkable as it is breath-taking. ADB reported that the country is home to at least 500 species of stony corals, 1,635 reef-associated fish species, 43 mangrove species, and 7 seagrass species (ADB, 2014). A study by The Nature Conservancy (TNC) in Kimbe Bay has recorded at least 860 fish and 400 hard coral species (Chin et al., 2008).

Mald and Yip (2001) iterates ecological assessments of Milne Bay, the largest maritime province in PNG, recorded on or near its great barrier reef, diverse coastal habitats of mangroves, seagrass meadows, sandy beaches and coral reefs. For instance 1,039 species of fish, 637 species of molluscs, and 362 species of hard corals (with 14 new species discovered). There is a potential of 420 plus coral species in its waters of Milne Bay depending on depth, location and other variables.

Another study by Conservation International in Milne Bay Province in 1998 identified 429 coral species, including 10 new species, exceeding the Great Barrier Reef's diversity and an equal to the number found in both Indonesia and the Philippines (ADB 2014). ADB also reported that study by Jenkins (2002) in a Madang Lagoon shows high diversity of coral reef fishes that is related to the high degree of biodiversity at the coral reefs. These findings suggest PNG's coral reefs were in a near-pristine state at the time the study was performed. Further research could share light on this status.

Healthy reef ecosystem in the tropics are very diverse (Photo by IBORISOFF/ISTOCK)

Average reef cover was estimated between 3-51% depending on the location (Mald and Yip (2001). On reefs closer to the equator where cyclones are rare, the cover is approximately 80% and this declines around river mouths. Similar studies conducted elsewhere around the country indicate high level of coral cover that is over 50% while some individual sites show coral cover exceeding 75% (Holthus and Mangos 1994; cited in ADB, 2014). A study by Exxon Mobil in Caution Bay of Port Moresby on Vari Vari Island and Idihi Island shows hard coral cover comprised of 37% and 32% respectively, because these offshore islands have a greater diversity and abundance of hard corals and fewer abiotic features than all other sites sampled (Coffee Natural System, 2008). A study by WCS on Andra and Ahus Islands in Manus province found hard coral cover was 24.5 ± 9.7% and 23.9 ± 7.8% respectively whereas the algae cover was 43.8 ± 6.7% and 44.6 ± 12.6% respectively (WCS, unpubl.).

While PNG's extensive coastal reefs and offshore patch reefs show a high degree of biodiversity, information on the country's reef environment is limited, largely because of limited research, monitoring, and management capacity (ADB, 2014). Nevertheless, some monitoring data are available from non-government sources and research organisations such as James Cook University and CSIRO of Australia and others.

Many of PNG's coastal areas are remote and isolated, making them difficult to access, and much less manage. However, this isolation has resulted in one beneficial impact, which is, human activity and accessibility are restricted, thus making negative impact of human activities minimal. In areas that are more accessible, environmental pressure on the country's reef resources includes (i) terrestrial sedimentation from poor land management practices; (ii) overfishing, particularly of invertebrates such as sea cucumbers; (iii) loss of predators at higher levels of the food chain; (iv) destructive fishing practices; (v) crown-of-thorns starfish outbreaks; and (vi) coral bleaching (ADB, 2014).

Coral bleaching will be discuss more further below because global climate change will likely affect PNG's reefs, including environmental stresses from human activity must be addressed if these reef areas are to remain resilient to climate change impacts.

A recent environment Impact study by the Freda Mine Limited in 2017, inside the Vanimo Port, reveals low diversity of reef fish and the sizes of fish are small. It was concluded that overfishing and impact of human activities are the major causes of declining fish population and sizes.

Figure 3.120 shows PNG's coral reefs are mainly located on the country's north and east coasts, lying within an area widely referred to as the Coral Triangle.The coral triangle is a global centre of marine biodiversity and has very high conservation value. Few marine protected areas exist in PNG and as a result, awareness of and support for marine resource conservation and management are mainly limited to areas in which nongovernment organizations are active, such as Kavieng and Kimbe Bay, and Madang and Manus provinces.

Most PNG's coral reefs are of the fringing or patch type, mainly located on the country's north and east coasts. Fringing and patch reefs are predominant along the northern coast (e.g., Madang) and the New Guinea islands. There are extensive barrier reefs occurring only along the country's southern coast (e.g., the Motuan coastline), the Louisiade Archipelago, and around the East Cape on the eastern coast (ADB, 2014).

Moreover, many reefs in PNG occur closer to shore and are sensitive to human impacts coming from terrestrial sources. Research and monitoring of reefs in PNG is very low because of lack of capacity, with most programs run by NGOs such as the Nature Conservancy (TNC) and research organisations such as CSIRO and James Cook University from Australia and others, hence there are few long term datasets for PNG reefs.

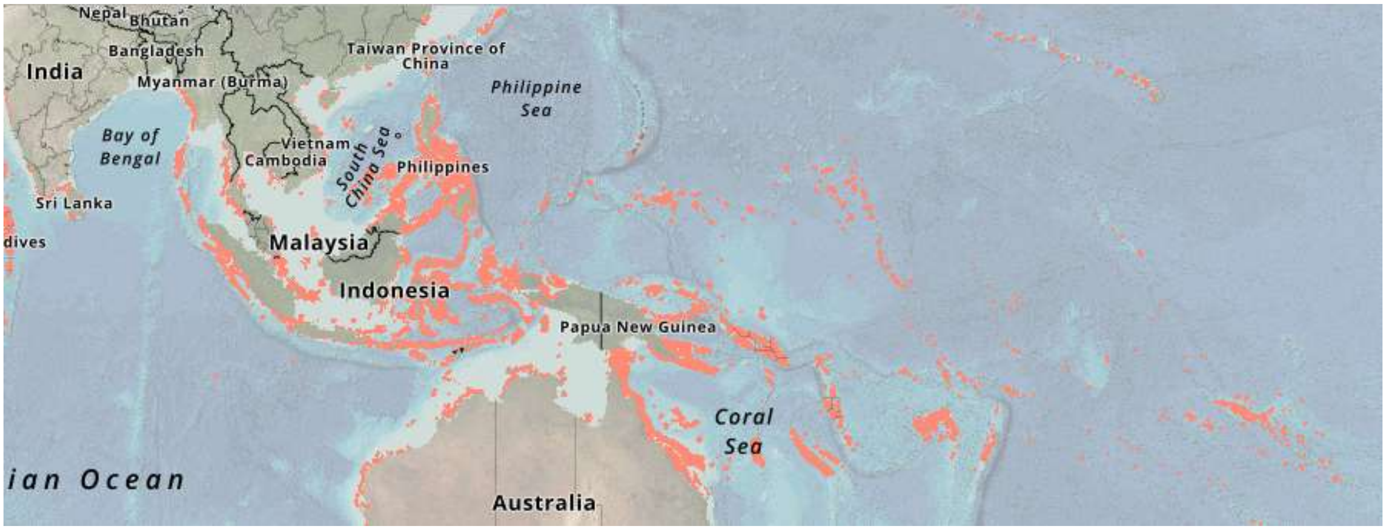


Figure 3.120: Coral cover in Southeast Asia Pacific region: Source: http://data.unep-wcmc.org/datasets/1

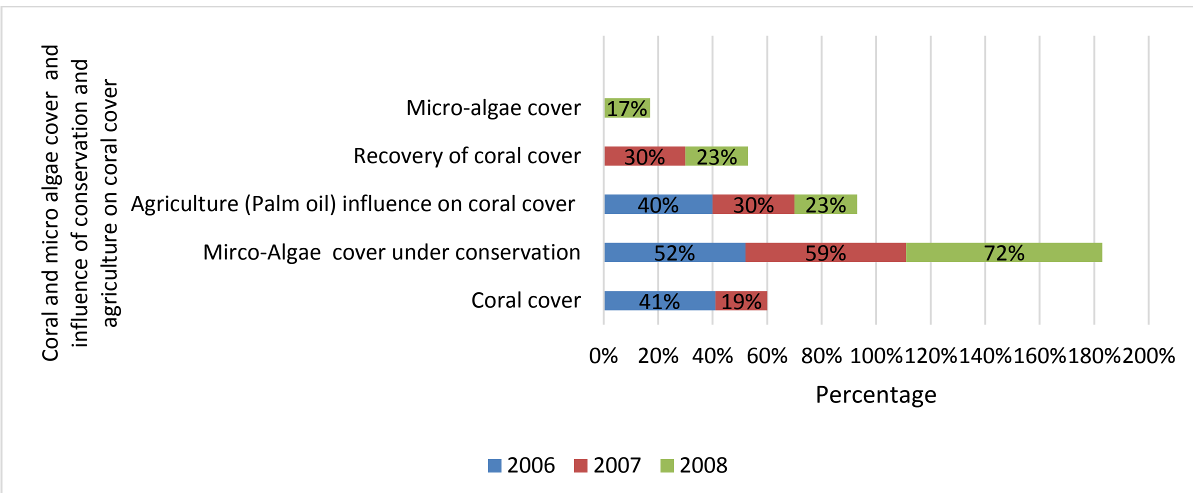


Figure 3.121: Percentage of coral cover, and microalgae at Tsoi Island, New Island Province (Source WCS; in Chin et al. 2008)

Figure 3.121 shows the percentage of coral and micro-algae as a result of oil palm activities and traditional conservation of reefs by Wildlife Conservation Society (WCS) in Tsoi Island, New Island Province in 2008. The study detected that the mean coral cover in the Tsoi islands was 19%, dropping significant from 41% in 2007 (Chin et al. 2008). WCS also recorded that coral cover at the main island sites in 2007 ranged between 24% and 30%, and in 2008 results for Malom was 23%. When traditional *Tambu (*traditional conservation*)* was placed on the reefs, macro-algal cover increased at all sites from 52% in 2006 to 59% in 2007, and further increased to 72% at 3 of the 6 sites in 2008.

The study found out that agriculture waste or impacts from palm oil plantation and COTS outbreak can affect average coral cover. For instance coral cover dropped from 40% in 2006 to 30% in 2007 for all sites studied, and declined again to 20%-23% at 3 of 6 sites in 2008, mainly at the central main island sites, Lasigi and Malom (Chin et al. 2008). The macro-algal cover increased by 17%; possibly due to impacts from extensive oil palm plantations and COTS outbreaks. There has been minimal coral disease and some coral bleaching, but some *tambu* areas have been affected by COTS.

In the Bismarck Sea, corals are in excellent condition in water temperatures that hover around 30ºC most of the year. Although some reefs are affected by problems, most reefs in PNG remain relatively pristine and are in good condition.

An annual reef monitoring by James Cook University (JCU) and TNC in Kimbe Bay began in 1996. The study detected coral cover on the coastal fringing reefs declined from ~70% to ~7% between 1996 and 2003 (Chin et al., 2008). Over time between 2003 and 2007, the coral reefs recovered considerably, with coral cover of all major coral families such as *Acroporids*, *Pocilloporids* and *Poritids* increased remarkably, with total branching coral cover peaking at 26% in 2007.

In comparison, there was a decline in coral reef fish biodiversity between 1997 and 2002 and almost full recovery of most affected reef fish species between 2002 and 2007. Severe localised coral bleaching was also recorded at surveyed reefs in early 2008, and macro-algal cover and the amount of unconsolidated sediments have increased gradually over 10 years. The decline in the coastal reef could probably cause by increased activities in terrestrial environment such as increasing sedimentation from logging and oil palm activities, and other pollutants entering the reef ecosystems from human sewage and chemical run-off from oil palm activities.

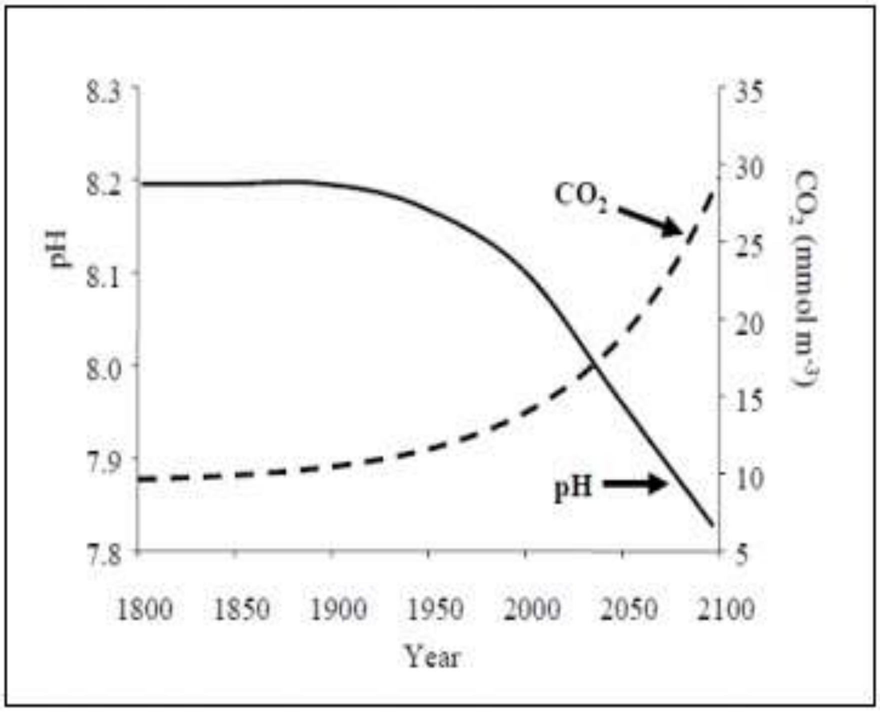
In Manus, at WCS monitoring sites at Andra and Ahus islands, 5 km off the north coast of Manus Island, total coral cover is about 25% at Andra Island and 24% at Ahus Island, slight decreasing from the 30% reported in the Status of the Coral Reefs of the World: 2004 (Chin et al. 2008). Algal cover is approximately 43–44% at Andra and Ahus islands respectively. Fish biomass is relatively high at both islands (Andra 332 kg/ha, Ahus 346 kg/ha) compared to other sites in PNG. In terms of Tridacna spp., clams and sea cucumber, the Acropora cover on Andra is low compared to Ahus (5.4% compared to 10.6%).

Another area of high coral diversity is Madang Province. Madang Lagoon is the largest and most ecologically diverse lagoon along this coast. In 2002, 652 species of reef fishes had been recorded on the fringing reefs to about 30 m depth; representing about 61% of PNG's known fauna and 24 % of the Indo-West/Central Pacific (Chin et al. 2004). Previous surveys (reported in Status: 2004 report) suggest that Madang Lagoon has relatively high coral cover (35–40%) but there seemed to be decline in top predators and an increase in macro-algae. This may be the result of increase fishing activities, movement of shipping vessels and pollution discharged from the inland such as sediments and pollutants caused by humans and industrial wastes.

The above studies were done almost 10 to 13 years ago may not show the true condition of the coral reefs but may depict what human activities and climate change effect can have on the reef system and other associated species. Unless there is continuous studies on corals reef, the real status of the reefs would not be fully understood.

Apart from the natural forests, oceans sequestrate almost one quarter of carbon dioxide (CO_2) emitted from human activities and natural phenomena. Oceans also absorb about 90% of global heat, 25% of global CO_2, and excess melting ice (Bell and Gupta, 2015) Over the decades, anthropogenic activities have caused a significant increase in greenhouse gas (GHG) emissions into the earth's atmosphere, with 24–33% of the excess CO_2 being absorbed by oceans globally, which alters the chemical composition of seawater Bell and Gupta, 2015). Once the CO_2 is within the ocean, it reacts and becomes more acidic, thus affects or inhibits coral growth, including other marine species.

Figure 3.122 shows CO_2 has increase significantly since the Industrial revolution in the 1800s and has increase exponentially that has potential to cause decline in ocean acidity or pH. When this happens, it affects the ecosystem functions such as the food chain and causes coral bleaching or ocean acidification which then leads to death of corals or loss of coral cover.



Source: Turley et al. 2006

Figure 3.122: The projected change in atmospheric CO_2 concentrations and seawater pH under a business-as-usual emissions scenario (cited in Harrould-Kolieba and Herr, 2015)

Figure 3.123 shows when there is more hydrogen ions, the pH reduces, and acidity increases. Increasing levels of hydrogen ions from the absorption of carbon dioxide lowers the ocean's pH and increases its acidity (Harrould-Kolieba and Herr, 2015). That is wcarbon dioxide (CO_2) is dissolved in the surface waters of the ocean, certain chemical reactions take place that dissolved inorganic carbon to form carbonic acid, bicarbonate compounds, and carbonate ions. It may also forms hydrogen ion, and if there are more hydrogen ion in the ocean, the pH will be high hence resulting in death of coral reefs. Figure 3.124 shows the ocean acidification process that can lead to weaker coral skeletons, increased bioerosion, reduce growth of corals and calcification and crumbling reef framework thus the ocean acidification process.

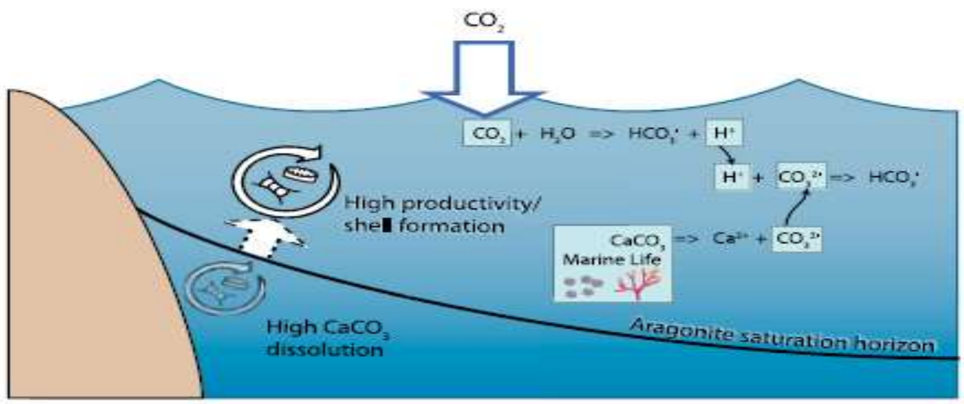


Figure 3.123. Summary of ocean acidification (Ganachaud et al., 2011; cited in Harrould-Kolieba and Herr, 2015)

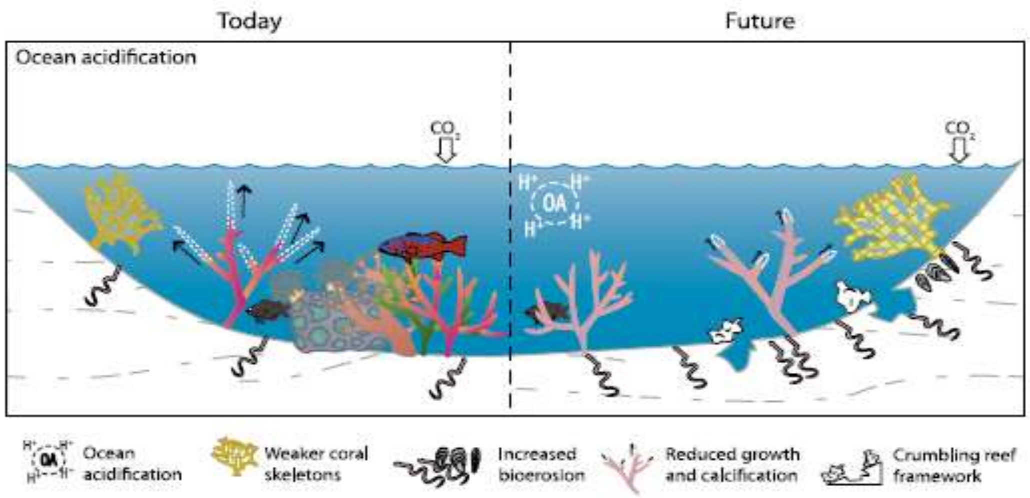


Figure 3.124. Effects of projected ocean acidification (ocean acidification) on coral reefs. Reduced calcification of reef-building corals and calcareous algae as ocean pH declines is expected to change the balance of reef processes from net construction to net erosion, leading to loss of corals and reef frameworks (Hoegh-Guldberg et al. 2011; cited in Bell & Gutpta, 2015).

When there is change in ocean temperature, particularly in the Intrtropical Convengence Zone (ICZ) in the Pacific Ocean, the weather patterns changes, including the ocean currents, the temperature and acidity (pH). The average ocean pH is now 8.1 and varies seasonally and spatially by 0.3 units but increasing global emissions of GHGs have decreased the pH of the tropical Pacific Ocean by 0.06 pH units since the beginning of the industrial era (Bell and Gupta, 2015). Bell and Gupta concluded that the current rate of decrease is ~0.02 units per decade, but ultimately, the pH of the tropical Pacific Ocean is projected to decrease by a further 0.15 units by 2050 based from the historical data of 1986–2005. A rich coral reef may become affected by human impacts and climate change as a result of increase ocean acidity.

The declining ocean pH will consequently cause dramatic changes in aragonite (calcium carbonate) saturation, with implications for calcifying organisms, such as corals, some plankton, and shellfish. The best available modelling suggests that by 2050, only about 15% of coral reefs around the world will be in areas where aragonite levels are 'adequate' for sustainable coral growth (Bell and Gutpta, 2015).

Coral bleaching can be harmful to the marine ecosystem and local livelihood in PNG (Photo by bummble1, 2017)

The Pacific island region and PNG will potentially experience drastic changes and, as a result, oceanic and coastal reef habitats are expected to be modified. Subsequent declines in fisheries productivity of some target species (e.g. reef fish and sea cucumbers) and impacts on calcareous aquaculture commodities (e.g. pearl oysters and marine ornamentals) are anticipated to occur.

Since lack or no proper data were collected, it is assumed the level of oceanic acidification is increasing in PNG. A study conducted in Milne Bay Province on underwater coral reefs near vents that release natural CO_2 shows some interesting finding. Corals closer to the vents has lower pH (i.e. high acidity) compared to those distant away from the vent. There are no corals reefs closer to the vent and as distance increase further way from the vent, the number of corals increase (Kleine, 2011, cited in GoPNG, 2015). This study indicates that when CO_2 rises in the ocean and the ocean becomes acidic, the number of corals will decline. Consequently, the effect will be imminent on the habitats and the food chains, thus affecting ecological functions .Food security and economy may become affected as well because almost 25.9% of the population depend on their ocean and coral reefs, and consume about 53kg/person/year of fisheries products (GoPNG, 2015).

Impact

Corals are integral part of the subsistence economy in most coastal regions where people rely on them for coastal protection, food, medicines and cultural properties. Subsistence and artisanal (or game) fishing is the predominant human activity on PNG reefs. Presence of World War 2 relics such a ships and planes are found on many reefs systems in PNG. Impact of human activities on land and climate change can have a major impact on coral reefs and marine species population and in general, reef fish harvests are thought to be below sustainable levels.

Sedimentation deposition along mangrove and coastal fringes, at Tuna Bay, Port Moresby. This is a result of urban development and sifting cultivation activities

The pressures on reef resources in PNG will almost certainly increase as the population continues to grow, especially in large coastal towns, along with a growing tourism industry. This is because the national economy is poorly developed although the islands are rich in resources and foreign aid plays a major role in this economy. There are a few mining and oil palm projects in the coastal areas, with most of the people are subsistence farmers and fishers that may contribute to decline in reef cover (Madl and Yip, 2000).

Repeated use of explosives in some areas has resulted in reefs that contain few living corals and are almost devoid of topographic structure (Halstead, 1998), although these effects appear to be localized (Werner and Allen, eds., 1998).

Some of the most serious threats to coral reefs in PNG appear to come from terrestrial activities, such as sediment mobilisation as a result of large-scale forestry and agriculture. Given that most of PNG reefs are nearshore and downstream of steep, forested watersheds, then significant additional inputs of sediments can be expected from large-scale deforestation.

Although there are almost no data to substantiate elevated sedimentation as a result of past or current logging operations, there is equally no quantitative monitoring of reefs that might be affected by these logging activities. Increasing stresses on reefs will also come from the growing coastal population and pattern of urbanisation, though increased fishing pressure and pollution, such as inadequately treated sewage. Sedimentation build up along mangrove fringes are prominent in coasatal towns due to urban development and shifting cultivation.

Attempts to assess anthropogenic impacts to coral reefs in PNG are limited by a lack of data on the spatial and temporal patterns on the abundances of reef organisms and a lack of data on the physical and chemical characteristics of the reef environment. The apparent good condition of PNG reefs must, therefore, be considered with this lack of information in mind. Reliable monitoring programs should be encouraged, particularly in areas of increasing population pressure and where anthropogenic impacts are likely to occur in the future.

Coral bleaching has been observed in PNG during three main periods over the past 20 years. The most severe and widespread bleaching event in PNG appears to have occurred during 1996-1997 the *EL Nino* drought period. Bleaching has again been observed in several locations during early 2000.

Milne Bay province was the most affected area with one study reporting 54% of corals exhibiting bleaching. Most other areas had lower level of bleaching and good recovery has been reported in most areas, indicating that this bleaching event was short enough to prevent large scale death in affected colonies.
On average, none of the bleaching events in PNG appear to have been as severe as those reported from some other countries.

With the apparent increase in the frequency of bleaching events in PNG over the past few years, it is important that coral bleaching and associated physical parameters (particularly sea temperature) should be monitored in a coordinated manner (Madl and Yip, 2000).

In the meantime, most reefs surveyed in the past have had relatively high coral cover and little evidence of damage from human activity, hence are in relatively good condition. The remote location of many reefs and relatively small populations, the overall prognosis for these reefs is good (Chin et al. 2008). Managing the threats and be resilient to climate change and extractive industries, provided that on ground management of coastal activities effectively and establishment of effective MPA systems are needed. Dilution of seawater with freshwater (i.e., salinities of less than 35 parts per thousand) tends to suppress coral growth, as does turbidity of the aquatic environment, causing corals to be noticeably absent in the mouths of major rivers, and together, both dilution of seawater and turbidity can influence the distribution of coral (ADB, 2014).

Further predicted consequences of climate change suggest that PNG will experience more frequent droughts, heavy precipitation events, extreme storm surges, and more intense tropical cyclones, which may significantly impact coral seas and marine resources.

An overall conclusion can be stated that reefs or habitats closer to urban areas or populated areas such as villages are under stressed or pressure compared to isolated areas. In some isolated sites, access to better technology and transport are enabling easy access and exploitation of marine resources can increase.

A study by TNC in Kimbe Bay indicates the establishment of marine reserves have resulted in increases in the abundance of a few reef fishes, most notably the surgeonfish in the family Acanthuridae (Chin et al. 2008). In Milne Bay province, the introduction of traditional conservation practices called *Gwala* has allowed rehabilitation of over-exploited reefs thus many marine life has returned to the condition they were before traditional form of conservation was introduced (*D. Mitchell, per com*m.).

Traditional closure of fishing grounds has enable population explosion of marine life, returning of some species such as marine turtles and increase in the sizes of different fish, shellfish and clam species. In New Ireland province, WCS has worked with locals to protect fringing coral reefs, lagoons and mangroves using *Tambu*.

Response and Recommendations

The National Fisheries Authority (NFA) together with CEPA and the Justice Department, Climate Change and Development Authority (CCDA) who is implementing the Law of the MEA and the Ocean policy must work in partnership with research organisations, NGOs, universities and bilateral partners to conduct monitoring of reefs state, cover and species over time. This require capacity building and training for coral research, breeding, restoration and conservation, improve budget and resources. State of the art research equipment such as satellite programs must be purchase to provide reliable and up to date information on all marine activities including habitats.

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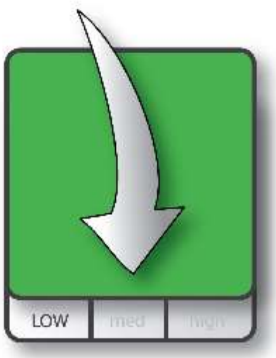
8.6.8. TOPIC/SUBTOPIC: LAGOON WATER QUALITY

Indicator Definition: Trend or state of water quality

Status and Trend



Status
Good

Trend
Deteriorating

Data confidence
Low

Pristine marine environment of Baluan Island, Manus province, is isolated from major environmental threats

SDG/CBD Targets

SDG: 13.1.2, 13.3.2, 13.b.1, 14.4.1, 14.2.1, 14.3.1, 14.5.1

Aichi target: 1, 2, 4, 5, 8, 11, 12, 15

Status and Trend Discussion

The marine environment is one of greatest the significance ecosystem and coincidently is one of the most sensitive to urban development pressures. A harbor city or coastal village may possess a significant range of coral life, invertebrates and fish species, which are important assets for everybody for many obvious reasons. Recent development and reclamation activities, including movement of sea vessels appear to be having negative near-shore impacts on both marine life, water quality and tidal flushing cycles.

Rising population also puts stress on the city's infrastructures such as sewage systems. Also increasing human activities upstream from logging, agriculture, industrial development and urban development activities are discharging tonnes of waste such as sediments, chemicals and pollutants into the ocean, wetlands and lagoons annually.

Generally, the state or pristine condition of a lagoon is determined by many associated factors that influence species diversity. Schubel (1994) mentions some effects that may occur to the marine environment namely:

- nutrient contamination;
- microbial contamination of seafood;
- disposal of debris (particularly plastic debris);
- trace contaminants such as lead, cadmium, and mercury when discharged in high concentrations;
- occurrence of synthetic organic compounds in sediments and in predators at the top of the marine food chain; and
- oil in marine systems and the effects of spills in local sheltered areas.

Madang Lagoon (Photo by J. Thomas)

In PNG, the marine environment seem to be pristine but not anymore, particularly the marine lagoon water quality in urban ports, which are declining in quality. There are limited data to substantiate this statement but since PNG has 17 commercial ports and numerous small wharves and other landings, with increasing development activities, the impact is expected to be significant.

The National Maritime Safety Authority (NMSA) also oversees all aspects of maritime safety but data are not collected because of lack of capacity and resources. If only data are collected, they are stored somewhere or is of private use. Hence, there are lack of study on maritime water quality in PNG (Benet-Monico et al., 2006), hence the Madang Lagoon will be used as a case study. Photo 1 shows the world's famous Madang Lagoon.

PNG has hundreds of lagoons but many are not well documented for their quality. The Madang Lagoon is the largest lagoon in the north of PNG with an area approximately 50 km^2. The Madang Lagoon has the greatest diversity of marine species in the world that has been formally described.

Madang's natural environment is a biodiversity treasure hotspot, with well over 1,300 different species of reef fish, and a diverse range of corals, along with sea grasses, mangrove forests, marine turtles including the threatened leatherback, dolphins, dugongs, and whales found in the province's marine environment (WWF, 2017).

A recent 2012 expedition called Papua Niugini Biodiversity Expedition of the Madang Lagoon reveals no shallow bays and lagoons, typically see in most coral reef environments (National Geography, 2012). When the expedition team returned to their labs and began to formally assess their collections, they found more species in the organisms studied, confined to this relatively small lagoon than can be found in the Great Barrier Reef of Australia. The team of researchers also concluded that the high biodiversity was likely linked to the complex geology of the area rather than the biology, caused by the layered accretions of old reef heaped up, as the Australian tectonic plate moves northward colliding with other major and minor plates (National Geography, 2012).

The entire reef system and surrounding deep waters, were studied resulting in hundreds of new species discovered, many awaiting to be confirmed as new to science. The study also reveals the Lagoon is degrading over time.

Madang Lagoon like many other lagoons in PNG is connected with rivers and estuaries. Some of these estuaries have water salinity well mixed than others. This is mainly influenced by seasonality and strong tide, water depth, water acidity, oxygen level and natural occurring metals. These factors tend to influence the health of the corals, abundance of species and population, water condition, temperature and other marine life.

Tidal current that mixed with estuaries and the distance where the tidal limit extends upstream are also important thus influencing the condition of the lagoon (Wolanski et al., 1997). Discharged of high suspended sediment loads into the estuaries can end up in the lagoon thus affecting distribution, abundance and diversity of corals and other marine life (Section 8.6.7). Local fishermen normally enjoy fishing in the Madang Lagoon because it is like their 'supermarket' where they gets their goods and services.

A fisherman using the Madang Lagoon (Photo by:A. Smith/WWF)

Currently, Madang Lagoon and its various ecosystems are under threat from coastal population growth, intensive agriculture, urban development and intense logging activities, aggravated by minimal planning for waste disposal and the lack of water purification systems (Benet-Monico et al., 2006). Hence, there is a need to develop an Integrated Coastal Zone Management Plan for the Lagoon counter address any future environmental problems.

Table 3.14: Low-risk trigger values calculated as the mean ± one standard deviation for temperature and pH, and the 80%ile–20%ile of the median for DO, conductivity and salinity for the three natural environment categories found at the Madang Lagoon (Benet-Monico et al., 2006) * s-surface, d-depth.

	T (°C)		pH		Dissolved oxygen (% sat)		Conductivity (mS cm^{-1})		Salinity (ppt)	
	Mean ± st.dev (Surface)	Mean ± st.dev (15m))	Mean ± st.dev (Surface)	Mean ± st.dev (15m)	Mean ± st.dev (Surface)	Mean ± st.dev (15m)	Mean ± st.dev (Surface)	Mean ± st.dev (15m)	20-80 percentile (surface)	20-80 percentile (15m)
River outlet (n=7)	30.86 ± 0.61	-	7.8 ± 0.21	-	80.85 (75.2-84.9)	-	39.83 (32.7-54.4)	-	23.58 (21.5-28.3)	-
Coast (n_s=15n_d12)	30.07 ± 0.83	29.18 ± 0.39	7.97 ± 0.17	7.85 ± 0.22	87.65 (81.4-91.9)	95 (85.2-107)	52.7 (49-55.8)	56.6 (56.2-57)	32.75 (31.4-33.6)	34.4 (34.2-34.5)
Inshore/offshore (n=19)	29.39 ± 0.52	29 ± 0.26	8.08 ± 0.07	8.02± 0.09	92.3 (88.3-93.9)	107.15 (98.8-114.8)	54.9 (54.5-55.5)	56.4 (56.2-56.8)	33.6 (33.3-33.8)	34.3 (34.3-34.6)

Table 3.15: Faecal coliform counts and BOD in the Madang feeder river sites Benet-Monico et al., 2006). a Highly polluted; b Semi-polluted; c Unacceptable levels

Sample	**River**	**Faecal coliform (counts/100ml)**			**BOD (mg/l)**		
R1.A	Biges, N	2000	82	30	not sampled	1.37[b]	3.85b
R1.B	Biges, S	2800	500[C]	30	not sampled	<1	3.04
R2.A	Nagada	8900[C]	150	1150[C]	1.76	<1	2.9
R3.A	Miss	6900[C]	3600[C]	6200[C]	1.72	<1	3.2
R4.A	Meiro	6700	140	not sampled	1.8	<1	not sampled
R5.A	Marain	1400	1370[C]	625[C]	1	1.06	3.08
R6.A	Siar Creek 1	9000[C]	0	107000[C]	1.62	10.4[b]	109.05[a]
R6.B	Siar Creek 2	560	70	0	1.7	<1	3.66

Table 3.16: Metals range found in the Madang Lagoon Benet-Monico et al., 2006). a ANZECC (1992) admissible trigger levels for metals.

Metal	NHMRC Limits[a]	This study
AS	20	1.5-34
Cd	3	0.1-2.2
Cu	60	0.7-77
Pb	300	0.2-138
Hg	1	0.04-0.24

A study to investigate the level and variation of contaminants in Madang Lagoon was done between May 2002 and April 2003, in 41 sampling sites within the Lagoon, and eight sites on rivers and creeks (Benet-Monico et al., 2006). Results are presented in Table 3.14-3.16. Table 3.14 summarises the low-risk trigger values of the measured indicators for the three categories at both surface and 15 m depth, and the values are similar to the interim trigger values listed in the Australian Guidelines for coastal and open waters. Table 3.15 summaries the faecal coliform counts and biochemical oxygen demand (BOD) in the Madang feeder river sites. Table 3.16 summaries the metals range found in the Madang Lagoon.

With the present degrading condition of the Lagoon, the Madang Lagoon was previously moderately pristine, as indicated from studies conducted on corals and fish ((Benet-Monico et al., 2006). Hence the Lagoon was used as the control of the study. Several sampling sites along the Madang coast and rivers were sampled.

Temperatures around Madang waters ranged from 29 to 31 °C, with water temperature reduces from the coast outward to the sea, in tandem with decreasing depths that promotes less water movement (Benet-Monico et al., 2006). The temperature is also influence by occurrence of rain as it cools off rising temperature. Nonetheless, temperature variation in tropical waters is very low, hence any changes can affect the ecosystem function, growth and reproduction of biota and coral bleaching. With climate change effects and global warming, sea temperatures are most likely to rise and may have serious repercussion on marine environment (Section 6.1.9 and 8.2). The NWQMS guideline states that a maximum permissible increase of 2 °C over the temperature for optimal growth, is allowed and any temperature rise of 2 °C is harmful to the ecosystem. Water width, movement (static) and hot water sources from nearby processing plants can affect the ecosystem. In the Bismarck Sea, corals are in excellent condition in water temperatures that hover around 30°C most of the year (Chin et al., 2008)

Climate change has potential to profoundly impact the life histories of tropical marine fish species, by altering dispersal patterns, or possibly shifting ranges away or into a country's territorial waters. All life-history traits are sensitive to climate change, particularly dispersal and vulnerability to extremely warm ocean temperature (Booth et al., 2017).

Many of the responses of fish and fishery populations are unpredictable. Their movement, growth, survival and reproduction is influenced by climate change impact such as sea level, sea surface temperature, salinity and other changes may influence productivity of tropical fisheries and persistence of species (Booth et al., 2017).

The acidity of lagoon water quality also shows some interesting results. pH trigger values increased slightly from river outlets to inshore–offshore waters, both at the surface and 15 m, with little variation in inshore-offshore sampling sites. There was no significant variation or departures in the sea. Hence, any changes in pH can have adverse effects on aquatic and may alter toxicity or speciation of some pollutants (Benet-Monico et al., 2006).

The study shows the lagoon is in good state when the pH is more neutral around the pH 7.0. The study also found the Lagoon's surface waters were strongly influenced by freshwater input, which causes stratification effects, hence keeps water pH more constant.

Moreover, river outlets and surrounding waters had low and very variable salinity values ranging from 1.7 ppt to 33 ppt while coastal and inshore–offshore sites had consistent and higher salinity values across the Lagoon. In terms of water conductivity, the Lagoon condition is variable and is low in river outlets and higher and more consistent in coast and offshore–inshore sites. As expected, the study also found lower values of both salinity and conductivity correlated with precipitation on the mountain ranges. Benet-Monico et al. (2006) states that most aquatic biota can tolerate a range of conductivity, but marine biota are especially sensitive to decreased salinity (the ionic composition). Near the coast these parameters are episodically subject to changes due to enhanced freshwater runoff.

Consequently reefs and corals near the coast, such as those in Madang, may have a higher resilience. Strong variability in conductivity readings was also observed in rivers. Although most of the values were below 400 lS cm^{-1}, well within the NWQMS guidelines, recommend threshold of 1500 lS cm^{-1} readings ranged from 140 to 41,000 lS cm^{-1} (Benet-Monico et al., 2006). The study concluded that high variability may be attributable to natural geology and hydrological variability, local contamination at the sampling sites, and possibly to the suspended solids that affected meter readings.

The study also argued that the large degree of dissolved oxygen (DO) variability in the Lagoon might reflect the influence of organic matter in the water and its decomposition rate, since DO readings were higher in coastal sites, close to vegetation such as river outlets and seagrass beaches (Benet-Monico et al., 2006). Low DO concentrations have adverse effects on many aquatic organisms, and can cause sediments to release nutrients and toxicants to the water column.

Thus the study concludes that even though there is high levels of organic matter or rapid biological activity occurring in the Lagoon, possibly because of the presence of mangroves and seagrass, DO can also be reduced as a result of discharge of organic contents from nearby food processing industry in to the lagoon. DO readings in the rivers are generally very low, plummeting to <10% saturation on two different sampling days, representing a significant water quality concern.

Visibility in the Lagoon was generally poor by tropical standards, ranging from ≤1 to 21m, as visibility above 15 m is rare (Benet-Monico et al., 2006). At river outlets, turbidity was highest, including sediment load. Hence, any changes in light penetration have a critical effect on marine biota. The particulate matter can bury hard corals as it sediments out the water column and alter the structure and nutrient dynamics of reef surfaces, thus influence species diversity and abundance.

Water clarity is highly dependent on rainfall frequency and intensity. Extensive plumes of silty water were observed in the Madang Lagoon on the days after heavy rains have occurred in the Adelbert Ranges. In New Ireland province, the impact of oil palm plantation and logging has affected the reef's health and saw an increase in the population of Crown of Thorns starfish (COTS) population which are harmful to the reef ecosystem (Chin et al., 2008).

Oil spills coming from the wharf at the northern end of the Lagoon have been repeatedly reported by local people, and the impact of these was also observed.

At the Lagoon, dissolved phosphorus concentrations ranges from <50 to 245 lg L^{-1}. River concentrations are generally higher than in the sea (around 100 lg L^{-1}) and higher than the accepted trigger values for freshwater with 37 lg L^{-1} (Benet-Monico et al., 2006). In one survey, sample R6A contains 4149 lg L^{-1}, which is a very high concentration for a natural aquatic system.

The study implies that pollution have been discharged upstream. Increasing accessibility by sea transport and oil spill are also major threat to the lagoons. The marine environment and outer islands and atolls are now easily accessible by many coastal communities for fishing, leisure and other activities.

Photo 3: Beautiful atolls are now easily accessible by people (Photo by B. Bito)

Table 3.15 shows the BOD readings for the surveyed sites. Almost all surface values for BOD_5 along the Madang Lagoon were 62 mg L^{-1}, indicative of unpolluted waters (Benet-Monico et al., 2006). River samples, on the other hand, showed a different picture. R1A (Biges River, North) had BOD_5 values falling in the category of semi-polluted to polluted waters. Similarly, BOD_5 values at R6A were indicative of highly polluted waters.

Table 3.15 also shows the faecal study results of the Madang Lagoon. The World Health Organisation's (WHO, 1983) faecal coliforms (FC) criterion for marine bathing waters is <350 F in 100 ml of water adopted by the study. In the Lagoon, the variation in FC counts was very high, not only between points, but also at the same point in different surveys, significantly higher than in the other surveys (Benet-Monico et al., 2006). Thus it was concluded that most of the assessed sites in the Lagoon had coliform counts lower than the WHO threshold except two points (1A and 12B) had values higher than 350 (ranging from 90 to 3250 counts per 100 ml) seen in more than one survey. In contrast, most of the sampled rivers tend to indicate FC counts is higher than the recommended trigger value in at least one of the surveys. The Marrain, Miss and Nagada rivers and Siar Creek were of greatest concern since high values (>1000 counts) were observed repeatedly. This could have come from nearby tuna factory or villages that dump their wastes into the river system. Looking at the PNG standard of ≤200 per 100ml, the FC is above the required standard for most sampling sites. This is expected because of discharged into the lagoon from homes and urban areas and wildlife and direct fecal into the sea or rivers.

In comparison, a study conducted by the Department of Health for the popular Ela Beach waters in Port Moresby and its adjacent waters was commission after it received complaints from people. Appalling pollution conditions featuring harmful bacteria strain which causes ailments ranging from skin irritations to dysentery and typhoid were reported (Kuble and Konia, 1998).

The study reveals a strong link to raw sewage from the city pouring out of seven outfalls located along the seafront was the main cause. Laboratory tests of water collected daily from various points along the beach and the Fergusson Harbour area between December 1997 and February 1998 indicate a strong presence of faecal coliform at 1,000 parts to every 100 millilitre of water at some points (Kuble and Konia, 1998). This is highly polluted and is about eighth to ten times more than the World Health Organization (WHO) recommended safety limit for recreational waters, which is 100-200 parts of this particular bacteria to every 100 millilitres of water. Even Eda Ranu, the company responsible for the National Capital District's (NCD) water and sewerage system, admitted that one part of Ela Beach, near Koki Point towards Koki Village, was heavily polluted.

More recently, in 2018, the Japanese government through the Japanese International Corporation Agency (JICA) built a sewerage treatment plant that processes all waste before discharging them into the sea.

Finally, high variability was encountered for Arsenic (As), Cadmium (Cd), Copper (Cu), Lead (Pb) and Mercury (Hg) concentrations. The low number of surveys only allow general conclusions being drawn. However these metals should be included in the routine monitoring programme and these surveys show that this is feasible with the protocol proposed In general metal concentrations were lower than the ANZECC (1992) admissible trigger levels for metals in sediments (Table 3.16).

As per the PNG standards most readings are from the study is higher, except mercury. Further studies are required to verify this finding because of deep sea tailing dump by the Ramu Nickle Mine at Astrolabe Bay in Rai Coast. The authors admitted there was high variability of concentration and low number of surveys done and future studies were recommended.

The study by Benet-Monico et al. (2006) concluded that the Lagoon is still in a relatively pristine state, with most indicators generally at natural concentrations for this type of system, in both inshore and offshore, indicating concentrations are within the trigger levels determined by the survey campaigns or lower than the NWQMS or WHO interim trigger levels. However, the study warned that signs of pollution were found in the neighbouring areas or river system of the food processing industry.

All water quality standards are provided in the Environment Act 2000 and the Environment (Water Quality Criteria) Regulations 2002 (No. 28). See Appendix 7 and 8 for more detail. Some proponents uses water quality standards from the Asian Development Bank, World Bank's International Financial Corporation, the Australian Standards and the World Health Organisation standards to name a few because PNG has yet to revised and improve its standards.

The above case study of the Madang Lagoon 15 years ago shows the Lagoon's water quality was decreasing in quality. It cannot be confidently stated that the water quality is good or what percentage of the lagoon is safe for human use because long term data are unavailable. Based on anecdotal evidence confirmed in the 2012 Expedition survey, it can be concluded the ecosystem in Madang Lagoon has degraded over the last 32 years. This scenario also gives a good picture that lessons learned from the Madang Lagoon can be postulate as the state of other lagoons across the country. Only reliable research and data collection through periodic monitoring can determine the true state of all lagoons in PNG.

Thus it is assumed discharge of human waste, increase deforestation and agricultural activities, urban development and contamination of rivers and seas from various pollutants will continue to degrade marine environment and threatened the rich biodiversity and livelihood of local communities. This now calls for urgent sustainable coastal development plans to be developed and local municipalities and companies to take responsibilities to ensure development is done sustainably without compromising the future of the environment.

Impact

The 2012 biodiversity expedition conducted in Madang by the 2012 expedition has shown the Madang Lagoon, once famous for its rich biodiversity, is now adversely affected. This revelation was made by the senior scientist of the Papua Niugini Biodiversity Expedition, Professor Philippe. The expedition had attracted scientists from more than 20 countries and covers expedition from the both Madang Lagoon and surrounding areas in Madang and the Terrestrial expedition f from Madang up to Mt Wilhelm, in Simbu province.

The Madang Lagoon was made famous through the years of research and documentation done by the Christensen Foundation working in Madang in the 1980s. With the expectation of making new findings, four weeks into the expedition and the scientists had found the diversity was no longer as rich as it was 25 years ago and has become degraded (Dalbaniel-Evara, 2012). However, near the lagoon on the edges of the inshore, hundreds of species were discovered that are new to science. Increasing urbanisation and natural resource extraction and shipping activities are threating the natural marine environment (Photo 4).

Photo 4: Development activities and increasing shipping activities some of the major threat to the pristine marine environment (Photo by: B. Bito)

Increasing urbanisation and resource extraction from mining, logging and agriculture activities are escalating the problem. Rivers are also discharging tonnes of sediments into the lagoon that now buried important habitats the corals. Pollutants and heavy metals discharged into the lagoons and sea are affecting the pristine state and health of lagoons. Increasing oil and fuel spill from speed boats and ships plus discharges from the nearby industries are also contributing to the degradation of lagoons in the country. For instance, the Madang Lagoon was once rich in cowrie shell but was now lacking them and becoming rare, declining from about 40 species being surveyed in the area to only 15 of being found (Dalbaniel-Evara, 2012). Figure 3.125 shows the trend of the decline in the cowrie shell population over 25 years, from 1987 to 2012. This is a decline of 62% of the population sampled. Shells are good environmental indicator species because that shows the health of an ecosystem.

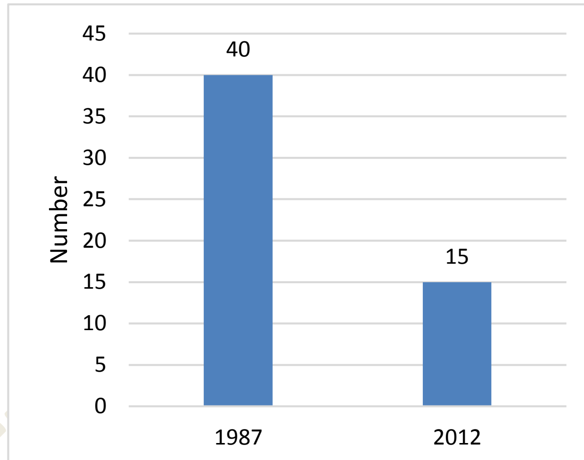


Figure 3.125: Population of cowrie shells from survey by the Papua Niugini Biodiversity Expedition between 1987 and 2012

WWF who has been working in the area for some years iterates that exacerbating the problems is the loss of mangrove habitats through extraction for timber and fuelwood; clearing of mangroves for subsistence gardens and for roads and jetties; and littering and dumping of rubbish (WWF, 2017). Waste from Madang township and settlements, the tuna cannery, and from shipping is also contributing to pollution of the marine environment. The deteriorating marine environment has impacted on fish catch, with families reporting sometimes returning from a day's fishing without a catch, hence making survival tougher than previously experienced.

When tangible measures and inform decisions are not undertaken by the government, developers and landowners, most lagoons health in PNG will lose their pristine status.

Response and Recommendations

There is a need to do more water quality tests and research conducted, supported by collaboration work with research organisations, universities, NFA and others. This can only be done through collaboration and partnership, and improving resources, capacity and facilities. Appropriate land uses, coastal zone management planning and better sustainable development practices upstream must be promoted. Protection and rehabilitation of degraded habitats is necessary to preserve threatened status.

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8.7. THEME 6: BIODIVERSITY

Overview

PNG occupies the eastern half of the island of New Guinea and constitute about 0.5% of the global landmass. The total country area is 46,514.771 km^2, of which 45,367.224 km^2 comprises of islands islands while 1,147.547km^2 is sea. The country is situated just south of the equator and as expected, it is biodiversity rich. PNG is the last frontier for biodiversity conservation as it host between 6-8% of the global species. The total number of species in PNG is not known but some estimation puts it around 200,000. Some stated that roughly half plants and half animals are yet to be named scientifically and every year new species are found. PNG is also among the world's top 17 mega-diversity countries (Mittermeier et al., 1997).

PNG is so biodiversity rich because of its various intrinsic and extrinsic features of the environment such as local climatic conditions, the diverse geological landforms, terrain, mountains and undulating hills, rainforests, swamps, rivers, savannah, grassland, and pristine coral reefs. Natural events such as volcanic activities, fires, floods, landslips, natural treefall gaps in the forest, and other ecological factors such as isolation, competition, and predation also contribute to this species richness and endemism. Altitudinal and gradients and geology also plays a significant role in the outstanding biodiversity of the country. Every year new species has been discovered, especially in areas where no scientific research has been conducted. PNG's mountain terrestrial and marine ecosystems are known for high endemism.

This chapter covers the theme biodiversity, reviewing the state of the threatened and endemic species, invasive species, key species of concern, and species diversity. This section describes what the PNG's government is doing, and needs to do, to protect its unique species and ecosystems from further degradation. In this Chapter, Species diversity and endemism, Endemic and native species, Threatned species and species of concern, and Invasive or exotic species are discussed.

8.7.2 BIODIVERSITY HIGHLIGHTS

Topic	Status, Trend and data confidence	Key Findings	Response and recommendations
SPECIES DIVERSITY & ENDEMISM		PNG is a megadiverse country in the world with high biodiversity and endemism. It constitute about 8% of the global biodiversity, with only 1% of the global land mass (46,514.771 km^2 or 46 mil ha) and 11,475.47Km^2 (11 mil ha) of sea surface. PNG contains about 600,000 to 1 million species.	Protected Area must be managed sustainably with more funding resources, awareness and capacity building done. Proper and stringent Environment Impact Assessments (EIA), monitoring and governance issues must be addressed amicably, with more researches done and data collected to make inform decisions.
ENDEMIC AND NATIVE SPECIES		From 600,000 to 1 million species (5%-8% of world's total species), of which a total of over 400 endemic species are PNG protected. Another 118 native species that are under threat are endemic, near endemic or shared with other countries in the world.	A detailed Management plan should be put in place for a number of species and resources and funding made available. Also a proper national land-use and seascape plan should be promoted and capacity building provided to agencies. Education and awareness must be conducted as well. The new PA Bill should capture species protection.
THREATENED SPECIES AND SPECIES OF CONCERN		PNG has been recognized as one of the mega diversity countries of the world. In recent times the number of species under threats is increasing. Under the IUCN Red List, a total of 540 species are threatened with 1 water insect species (*Rantus papuanus*) already extinct, 36 species are Critically Endangered, 83 species Endangered, and 420 species are Vulnerable to threats.	Papua New Guinea's (PNG) biodiversity is continuing to face threats from climate change, development activities, pest and diseases, exploitation, loss of habitats and invasive species. More studies and monitoring are need to be conducted, and more training and funding is required. Also education and awareness are needed and development activities must have proper plans.

INVASIVE OR EXOTIC SPECIES		Invasive species (pest and diseases) are the second major influential cause of economic loss after natural disaster. Its spread is a major threat to biodiversity loss and the integrity of the ecosystem and its health. So far almost 478 Invasive species have been documented.	There is a need for developing an invasive species management strategy for PNG. Collaboration, capacity building, baseline monitoring and research, awareness, legislation and policy and management action of invasive species are major set-backs that need to be improved.

8.7.3 TOPIC/SUBTOPIC: SPECIES DIVERSITY AND ENDEMISM

Indicator Definition: The number of species and how unique and abundant they are in an area

Trend and Status

Different vegetation, altitude, climate and landform influence biodiversity richness

SDG/CBD Targets

SDG: 12.2.1, 12.2.2,12.4.1, 12.5.1, 12.8.1, 13.2.1, 13.3.1, 13.b.1, 14.1.1, 14.2.1, 14.4.1, 14.5.1, 14.c.1, 15.1.1, 15.1.2, 15.2.1,15.3.1, 15.4.1,15.5.1, 15.7.1, 15.8.1, 15.9.1, 17.9.1

Aichi Target: 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, , 12, 14

Trend and Status Discussion

Species diversity and endemism is generally higher in the tropics but declined as one moves north or south of the equitable. Why is this occurring across the globe? Several biotic and abiotic factors were involve in influencing diversity and specie richness in the tropics. Competition, allelopathy, physical site factors, predator-prey relationship, pathogens and diseases, symbiosis or mutualism, pollinators, effective breeding, dispersal, species abundance, dormancy, and niche specialisation, just to name a few are important (Begon and Townsend, eds., 2012).

However, the most influencing factors would be latitudinal and climatic gradients for terrestrial and bathymetry gradients for marine biomes, communities and ecosystems, which favours the vast number of species in the tropics.

Any changes in the pattern of species diversity can be compared with changes in the environment and climatic gradients (Rosenzweig, 1992). For instance, small or remote islands and atolls with uniform topography have fewer species than large or complex islands or islands nearer the source of colonization (McCarthur, 1965). That is, the island biogeography of the smaller islands and atolls given their isolation are restricting speciation and diversity compared to bigger and larger islands. Species availability on an island depends on size and isolation, instigated by immigration and extinction (Begon and Townsend, eds., 2012).

Local variations in the species diversity of small uniform habitats can usually be predicted in terms of the structure and productivity of the habitat. Some species only occupy certain habitats because of competition, predation and other biological, ecological or edaphic factors, with productivity being the main influence while some species may succumb to extinction (Rosenzweig, 1992; Begon and Townsend, eds., 2012). The Raggiana Bird of Paradise (*Paradisae raggiana*), is an endemic and national bird of PNG found throughout the country.It is heavily harvested by locals but its population is not threatened because it is an evasive bird and hard to catch. Laws prohibite uses of modern technology for locals to harvest them.

The Raggiana Bird of Paradise (*Paradisae raggiana*) is an endemic and national bird of PNG at Varirata National Park (Photo: Angus Fraser)

Previously it was estimated by some scientists that the total global species (plants, animals and bacteria) to be between 2 million to 10 million, with approximately 1.5 million species being described (Larsen et al., 2017). The current total global species as of 2017 was estimated by scientist to be about 2 billion because of the high number of bacteria and insects.

If 12 million species of the world is used to compare PNG in terms of percentage, PNG would house almost 1 million species or 8% of the total global species. This elevates PNG status as one of the mega diversity countries of the world, in terms of species diversity. PNG has a land mass of 46, 514.771 km^2 (46 mil ha) and 11, 475.47Km^2 (11 mil ha) of sea surface. It contains about 600,000 to 1 million species.

PNG's tropical forests is found within the greater 'Papuasia Region', known as a major centre of plant diversity (Takeuchi, 2003b). PNG including Papua province of Indonesia (New Guinea), Congo Basin and the Amazon were recognized as having forest is also a global biodiversity hotspot and major tropical wilderness area (Olivieri et al. 1998). WWF also recognized PNG as having 7 of its global 200 Ecoregions that have species that are dynamic with various environment (WWF, 2002). PNG's corals, reefs and marine life are so diverse, within the biogeographical regions of Indonesian-Philippines and the Far southwestern Pacific Regions, known as the known as the coral triangle (Allen, 2007). Every year new lesser known areas to science not biologically studied finds new species.

On record, PNG has about 293 mammals (263 terrestrial mammals and 30 marine species), 324 fish species, 371 amphibians, 346 reptiles, and 813 bird species with 548 species are resident and 265 are migratory (Allison and Fraser, 2018). Between 80-89% of mammals and 50% of birds are endemic respectively (Allison and Fraser, 2018; GoPNG 2017).

Reptile richness is higher in low land, especially at warmer savannah lowland areas and hill forest than high altitude. Bird, mammal and amphibian endemism strongly correlates with elevation, as altitudinal gradient increase, so too is species richness.

There are between 3000-5000 invertebrates but this estimate could double as more are yet to be described. The number of vertebrate or insects is estimated to be between 300,000- 400,000 species and to date, a total of 3,952 have been documented (marine and terrestrial (Allison and Fraser, 2018). About 2112 terrestrial vertebrate species are currently described from PNG, which is approximately 8% of the world's total vertebrates, including marine vertebrates, and approximately 5% of world's total terrestrial vertebrates (*Allison, pers comm.*). PNG's corals, reef fish and mollusc is amongst the highest species richness in the world, in the Coral Triangle and is of global significance. There are 430+ species of corals, approximately 1000 species of mollusc and 1100+ reef fish species (GoPNG, 2016). Table 3.17 shows the species richness and endemism of some groups of species of PNG compared to the world.

Table 3.17: Species diversity nd Endemism of PNG compared to the world. This table was constructed from Allison and Fraser (2018), Chin et al. (2012) and A-Z Biodiversity and local PNG information.

No.	Class	Total PNG	PNG Endemism (%)	Total World
	Terrestrial and Freshwater			
1	Freshwater Fish	324	2.2	15,000
2	Amphibians	380	5.2	~7302
3	Reptiles	352	3.5	~10,038
4	Birds	813	40.6	>10,425
5	Plants	~14000	60	307,634
6	Terrestrial mammals	263	89.5	5513
7	Monotremes	2	40	5
8	Marsupials	76	17.5	434
9	Rodents	91	4.1	2200
10	Bats	92	7.1	1300
11	Insects	>3000	0.3	1,000,000
12	Spiders and scorpions			102,248
	Marine			
1	Corals	>430	19.7	2175
2	Molluscs	~1,000	1.2	85,000
3	Reef Fish	>3000	16.3	11428
4	Mammals	30	25.2	119
5	Introduced species	>600	1.2	50,000
6	Crustaceans			47,000

PNG covers only 1% of the global total landmass and with an area of more than 27 million km^2 of sea, dominated by the Pacific Ocean. It is a country in the tropics that experience both tropical and temperate climatic conditions to some extent because of low temperature experienced at high altitude such as Mt Wilhelm and Mt Giluwe, which sometimes have snow-capped mountain top throughout the year. In recent times, climate change effect is experienced and some of the snow-capped mountains are now gone. A study supported by the New Guinea Binatang Research centre shows temperature decreases as altitudinal gradient increase with an average of 5-6 °C per 1000 m (Figure 3.126). The altitudinal gradient, climate (high humidity, temperature, and solar energy) competition, parasites and pests and the large geographical areas has influence species diversity in PNG, together with various ecosystem and biogeographic influences.

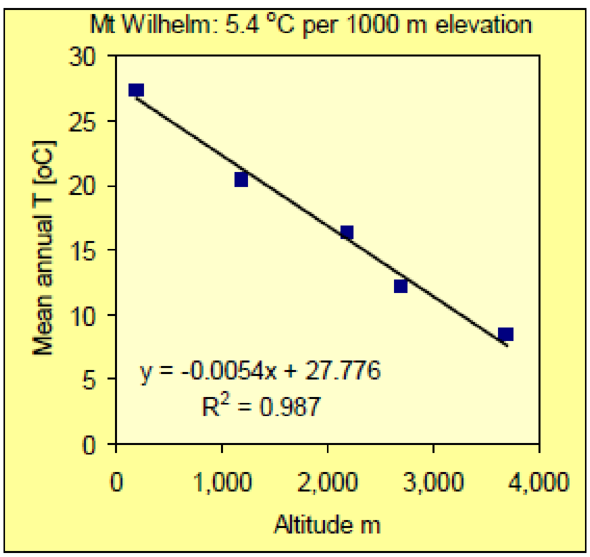

Figure 3.126: Mean annual temperature from sea level up to 4000m asl (Nuigini Binatange Research Center, Madang)

Figure 3.127 : 18 megadiverse countries in the world (Wikipedia, 2018)

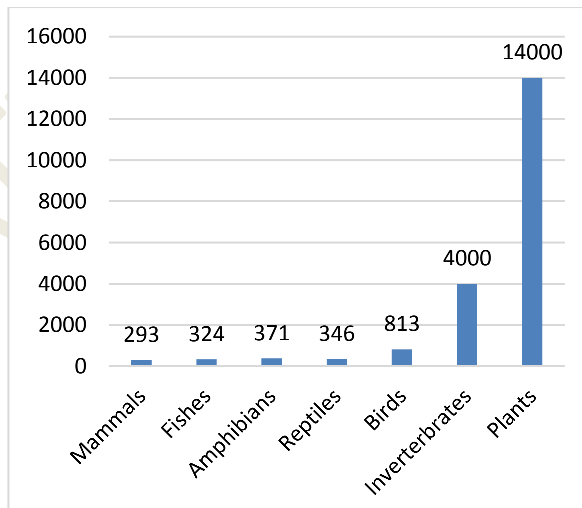

Figure 3.128: Species richness of PNG's biodiversity

Species richness is greatest in tropical ecosystems with the two most diverse and complex ecosystems on earth are being the tropical rainforests and coral reefs. Although tropical rainforest contains only 7% of the earth, it housed over 50% of all species. The world's largest coral reef, the Great Barrier Reef, which occupies only 0.1% of the ocean, 15000 fish species, 4000 species of molluscs, 6 species of turtles, contains 400 species of corals and provides sites for 252 species of birds (Primack, eds. 2010).

In 1998, Conservation International rated PNG together with other 17 countries as the megadiverse countries in the world in terms of species diversity. Figure 3.127 shows these countries are found in or partially in tropical or subtropical regions. The term megadiverse country refers to any one of a group of nations that harbour the majority of earth's species or biodiversity and high numbers of endemic species (Wikipedia, 2019). The main criteria for megadiverse countries is endemism at the level of species, genera and families and where at least 5,000 species of endemic plants occur and must border marine ecosystems. Figure 3.128 inidcates Mammals with have 293 species, fish with 324, amphibians with 371, reptiles with 346, birds with 813, invertebrates with 4000 and plants with 14,000.

Figure 3.129 – 3.137 shows the species diversity and adundance of different species assemblages in unlogged tropical rain forests along the altitudinal gradient, from 200m *a.s.l* in Mandang province up to the Mt Whilhelm in Simbu Province in PNG. These region comprises the entire altitudinal zonation of tropical forest from lowlands to the timber line. This is quite exceptional in the tropics as in many regions, where there are no mountains reaching timberline, or native reinforests have already been damaged. PNG is exceptional in having such ecological gradients such as Mt Wilhelm in the Madang and Simbu provinces.

Another such gradient is in the Finisterre Mountatins, that span over both the Madang and Morobe provinces. There are other similar ecosystem gradients and lanscapes around PNG as well that boast high diversity and endemism such as the Owen Stanley Ranges, Huon Gulg, the Ok Tedi Region, South Western TransFly, north-western Sepik lowlands, Bewani and Torecilli Mountains, Kikori River Basin, and Central Highlands just to name a few (GoPNG, 2015).

Green Tree Python, *M. viridis* (Photo. B. Bito)

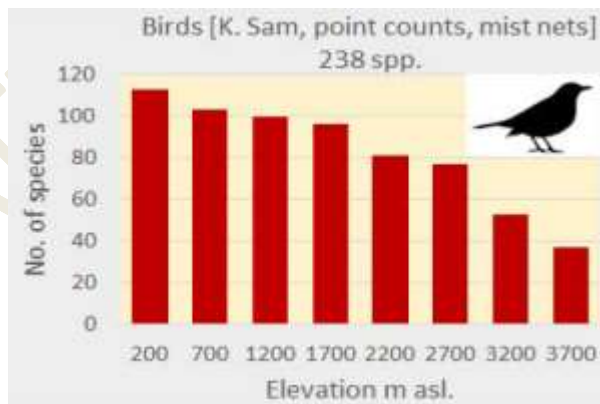

Figure 3.129: Species diversity& abundanceof birds (Sam et al. 2019)

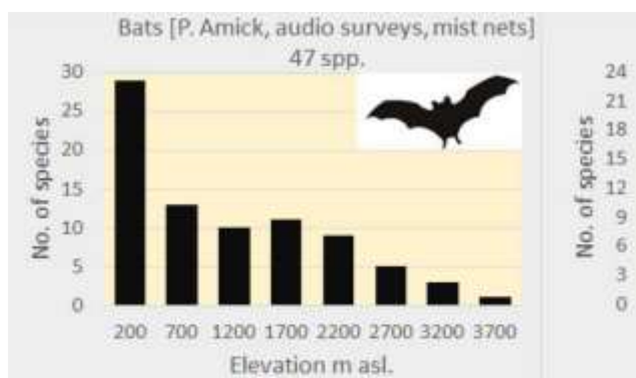

Figure 3.130: Species diversity & abundanceof birds (Amick, 2019

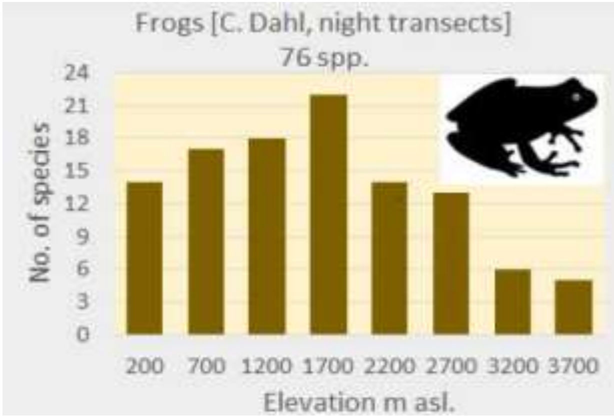

Figure 3.131: Species diversity & abundanceof frogs (Dahl, 2011)

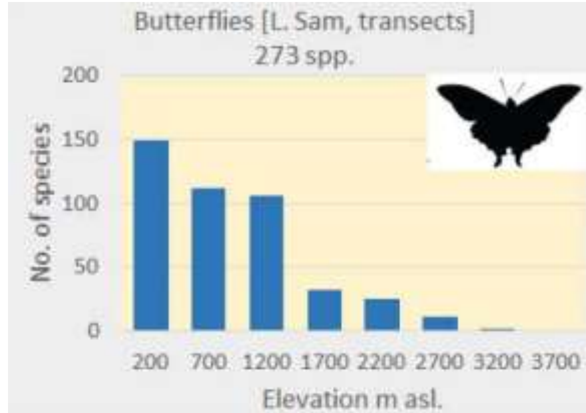

Figure 3.132: Species diversity & abundanceof butterflies (Colwell et al., 2016)

Figure 3.129 shows 238 bird species were recorded along the altitudinal gradient from 200m *a.s.l* up to 3,700m *a.s.l*. Diversity was high in the lowland and decreases as elevation increases (Sam et al., 2019). Some species are generalist and migrate in search of food and breeding can influence diversity as well. Figure 3.130 shows 47 bat species were recorded with diversity highest at lower altitude and decreases as elevation rises (Amick, 2019). A study by by Exxon Mobil in the Kikori River basin reveals Diversity of bats species decreases from 11 species at 1000m to 6 species at 1400m, 3 species at 2200m and 2 species at 2700m. Figure 3.131 shows 76 species of frog were recorded with diversity incresing from from 13 species at 200m up to 22 species at 1700m and then declines to to 4 species at 3700 (Dahl, 2011), indicating some species are only confined to certain elevations. This is confimed in another study in the Kikoririver Basin where visual and acostic frog diversity along altitudinal gradient increases from 11 families at 1000m to 9 families at 1400m then declines to 6 families at 2200m down to 2 families at 2700 (Richards eds., 2017).

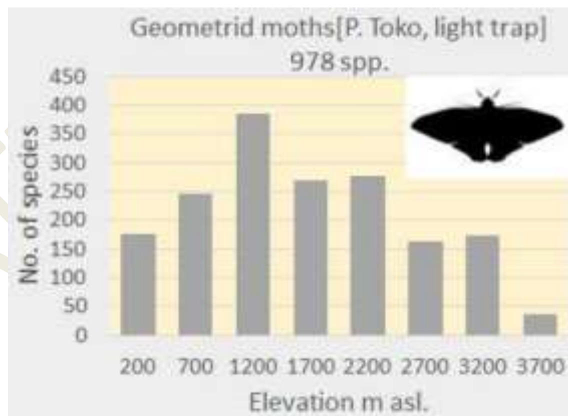

Figure 8: Species diversity & abundanceof moth (McCain et al., 2017)

Figure 3.132 shows diversity of butterflies decrease as elevation rises from 150 species at 200m down to 10 species at 3700m (Colwell et al.; 2016). Figure 3.133 shows the diversity of Geometrid moths is 980 species and increase at lower elevation from 170 species at 200m up to 380 species at 1200m then drops to 270 at 1700m and fluctuates slightly up then down to as low as 30 species at 3700m (Beck et al., 2017).

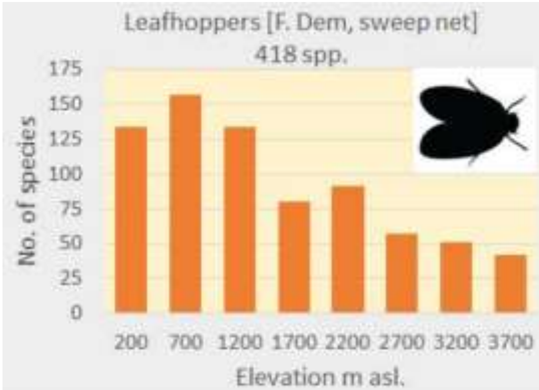

Figure 3.134: Species diversity & abundance of leafhoppers (Dem, 2011)

Moreover, Figure 3.134 shows similar trend with diversity for leafhoppers that increase from 130 species at 200m up to 165 species at 700m then slowly declining down to 40 species at 3700m (Dem, 2011). Figure 3.135 also shows similar trend as other genus by ants. The diversity increases from 100 species at 200m to 115 species at 700m then drops to 75 species at 1200m and drops sharply down to less than 10 species at 3700m (Colwell et al., 2016). Photo 2 shows the green tree python (*Morelia viridis*).

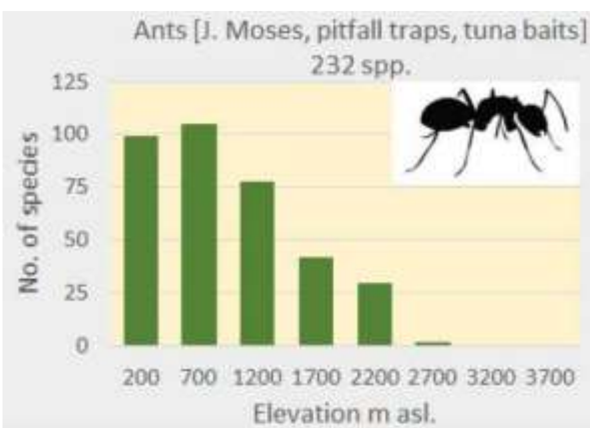

Figure 3.135: Species diversity & abundanceof ants (Colwell et al., 2016)

For *Ficus* tree species, Figure 3.136 indicates diversity increases from 200m to 700m and then declines drastically 1200 and 1700m then falls to a low at higher elevation of 3700m (Legi, unpubl). For palms, the diversity decreases as altitude increases while Figure 3.137 shows ferns diversity also increases with elevation to mid altitude then becomes lower at higher elevations (Colwell et al., 2016). PNG has one of the species diverse places on earth in for higher plant diversity (Figure 3.138). A common trend for tree species richness and diversity is higher in lowland to mid mountain areas declining with increasing elevation (Hartswhorn, 1995).

A study using a 1 ha plot enumerating trees ≥ 10 cm diameter at breast height (dbh) in the Crater Mountain in Eastern Highlands province revealed the site is one of the species riched area in the world, with 615 stems, comprising 174 species, 95 genera and 46 families (Weiblen, 1998). Estimates of the New Guinea Island's plant diversity are significant and range from 11,000 for PNG to 25,000 species for West Papua (Allison and Fraser, 2018).

Preparation of a species checklist for the known flora of PNG is currently in progress and comprises approximately 1,800 genera and 13,500 species of vascular plants were documented. Some reports states that of all the plant species, 60% of them are endemic to PNG (Wickham et al., 2014).

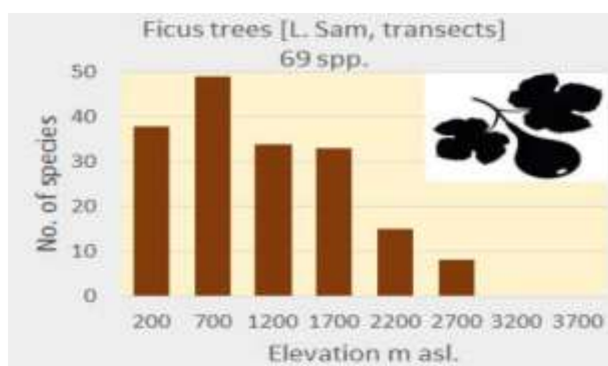

Figure 3.136: Species diversity & abundanceof Ficus spp (Legi, unpubl)

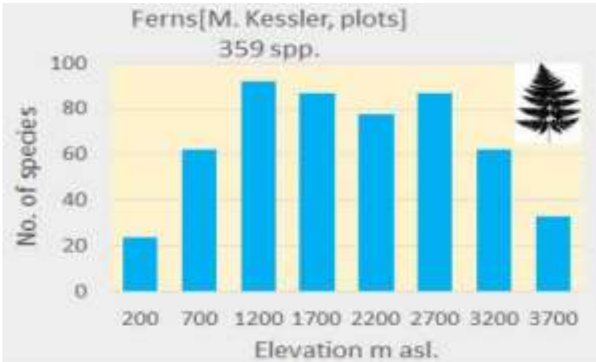

Figure 3.137: Species diversity & abundanceof Ferns (Colwell et al., 2016)

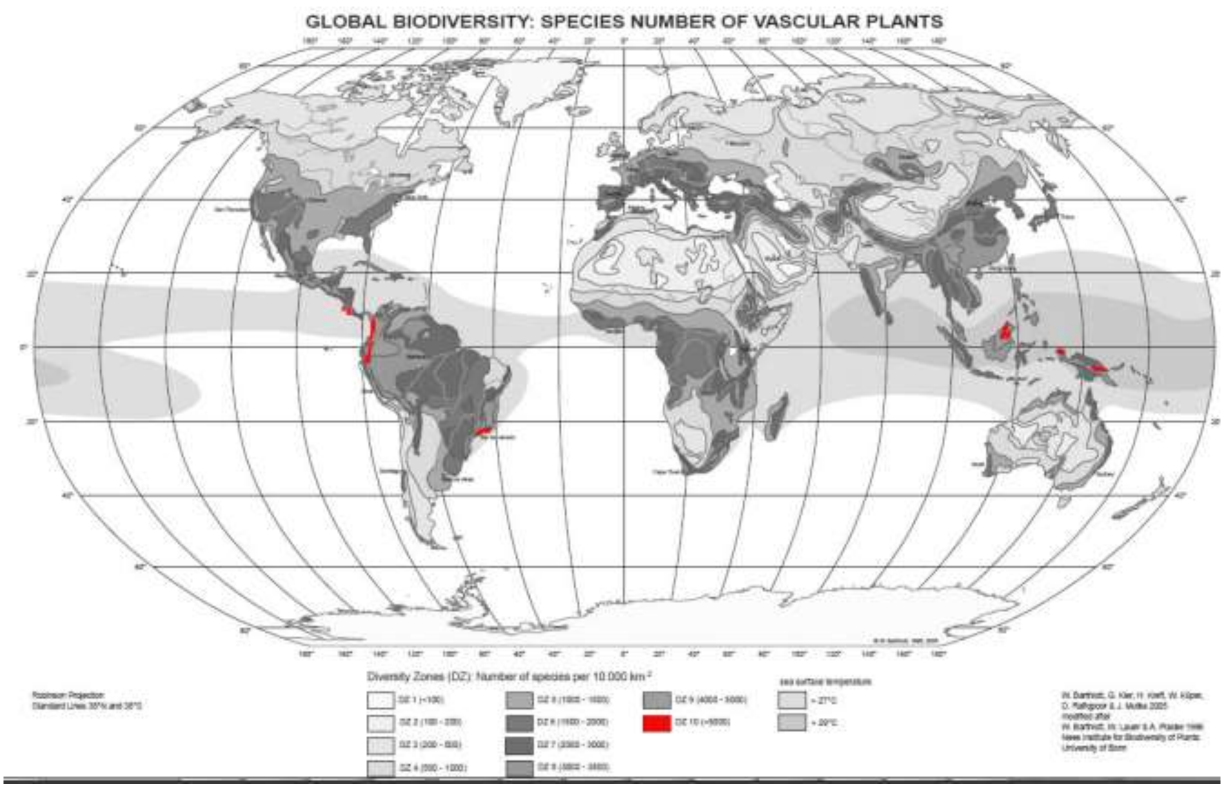

Figure 3.138: PNg has one of the significant global plant diversity of vascular plants (Source: adapted from Barthlott et al., 2007)

Another study in 1995 by WWF also shows the Kikori River Basin has outstanding species diversity and endemismhence the region has exceptional biodiversity richness (Hartshorn, 1995). Almost half the species of aquatic true bugs collected were undescribed by science. There was no correlation of elevation with three focal aquatic groups namely damselfly, aquatic bugs (Zygoptera) and Whirlygig beetle (Gyrinidae). The area also has 14 endemic fish species, more than any other areas in PNG, and five new fishes, was discovred, including a blind cave fish were newly discovered. In addition, 8 rare bat species and a high number of birds were also recorded.

The above studies revealed a trend where some species are confined to lowland than higher altitude or some are confined to specific mid elevations and hill tops or valleys than others. Food sources, predation, competition, local weather and temperature and rosting sites may also play other importants in inlfuencing this trend. Every year species new to science are dicovered because of lack of scientific research and the remoteness of some areas that does not allow the area to be biologically explored. Some species that are unique are also confined to certain ranges, communities and ecosystems.

In 2018, a total of 85 species were discovered during field surveys in the proposed Freda Mine Project Area in West Sepik province, where some of them have now been formally named. The majority of these species were from less well-known groups of plants, herpetofauna and invertebrates. Known distributions of these species may be a reflection of the limited scientific research focus on these taxa, rather than the actual distribution of these species (Coffee, 2018).

In 2015, a study commissioned by Exxon Mobil PNG LNG Limited in the Kikori River Basin and the Petroleum Development License area discovered 35 new species (Richards, eds. 2017). From a total of 1108 animal and plant species documented during the survey of the Hindenburg Wall region of Ok Tedi, Western Province, 89 species discovered were known or suspected to be new to science (Whitmore and Richards, eds. 2015). Globally about 20,000 new species are discovered and described every year (Primack, eds. 2010). Based on the above studies, it could be assumed that between 5 to 90 species are discover each year in PNG. Species such as the Northern Goura Pigeon (*Goura Sheepmakeri*) are found no where eslse in the world but only in PNG and is the world's largest pigeon.

Goura Pigeon, the largest pigeon in the world Goura

The high species diversity from the above studies indicate changes with altitude, with some taxa (e.g., ants and butterflies) strongly preferring lowlands, while others (frogs, geometrid moths, andferns) reaching their maximum diversity in mid-elevation forests. It is not only species diversity but also the identity of species that is changing, with almost zero overlap in species composition between the lowest and highest altitudes. This makes long altitudinal gradients very important centers of biodiversity for the Provinces, entire PNG and even internationally.

This trend is illustrated in Novotny & Toko (2016) showing Mt Wilhelm gradient elevated the total species diversity to 140 – 330% of the maximum diversity that can be supported locally, at a single elevation for various plant and animal taxa. The turnover of species from lowlands to high elevations also placed the Mt Wilhelm – Finisterre Mts region among the top six most species diverse regions in the world, considering plants (number of species per 100x100km squares, Figure 3.139)

Malaise trap in the Wanang forest (with Jonah Filip operating it) that campled >5,000 insect species in one year (Photo by V. Novotny).

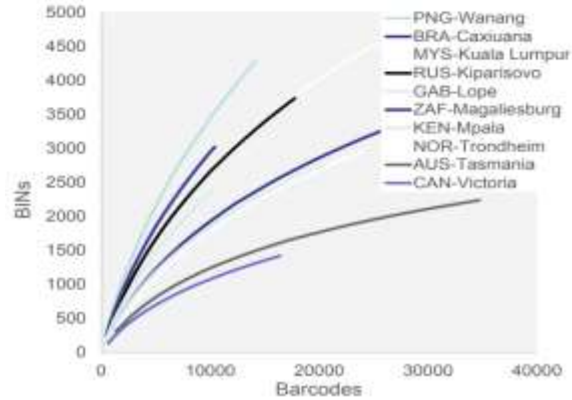

Figure 3.139: Global Malaise Program for PNG at Wanang Site compared to other global sites (Miller et al., 2017).

Moreover, rainforests in Madang, as elsewhere in PNG, are higlhy diverse in species. This is the case for plants (for instance, the 50 ha lowland rainforest plot in Wanang has >550 woody plant species (Anderson-Teixeira et al., 2015). The forests are very diverse also in insects, but that diversity remains poorly explored. For instance, a Malaise trap that captures insects flying through 1x2m sampling area in the forest understorey was operated in Wanang forest for one year. The analysis of insects, using molecular techniques, uncovered 4,275 species of insects, most of them unknown to science, in half of the one-year sample, comprising 14,127 individual insects (Figure. 3.139).

The Birdlife International defines Endemic Bird Areas (EBAs) as regions of the world that represent natural areas of bird endemism where the distributions of two or more restricted-range bird species overlap (Figure 3.140). A restricted-range species is defined as one having a historical breeding range of no more than 50,000 km. Since 1987, a total of 218 EBAs with most (77%) of them located in the tropics and subtropics were listed and PNG is one of them (Biodiversity A-Z, 2018).

According to Birdlife International, about 93% of the world's restricted-range species occur within identified EBAs; the remainder occur in 'Secondary Areas', defined by the presence of single restricted-range species whose distributions do not overlap with any others (Biodiversity A-Z, 2018). Over a quarter of all the birds of the world have restricted ranges, and more than half of them qualify as globally threatened or near threatened, largely due to habitat loss and alteration. Moreover, 70% of EBAs overlap with areas of endemic plants (Centres of Plant Diversity) which PNG is also one of them and are also important for other endemic taxa, hence EBAs tend to be priorities for broad-scale ecosystem conservation (Biodiversity A-Z, 2018).

Figure 3.141-3.146 shows species diversity and endemism of different species assemblages compared to the world. Figure 3.141 and 3.142 indicates PNG is one of the riches places on earth for freshwater fish endemism and diversity, with 20-55 species and 67-151 species respectively.

For Freshwater amphibians, Figure 3.143 shows endemism is between 10-14 species on lowland and increased to 15-18 species in higher altitudes. In terms of species richness, Figure 3.144 shows diversity ranges from 21-75 species.

Figure 3.145 also shows PNG has one of the highest diversity in terms of of freshwater turtles, with 4-9 species found different parts of the country while Figure 3.146 shows freshwater turtle endemism has 5 species. Most Freshwater turtle species are found in southern New Guinea, with a storng relationship toward Australia and the Gondwanalnd connection.

The above comparisons with the world has put PNG on the world map as a global hotspot for species diversity and endemism.

Figure 3.140: PNG is identified as one of the endemic bird areas of the world (Birdlife International, 2018)

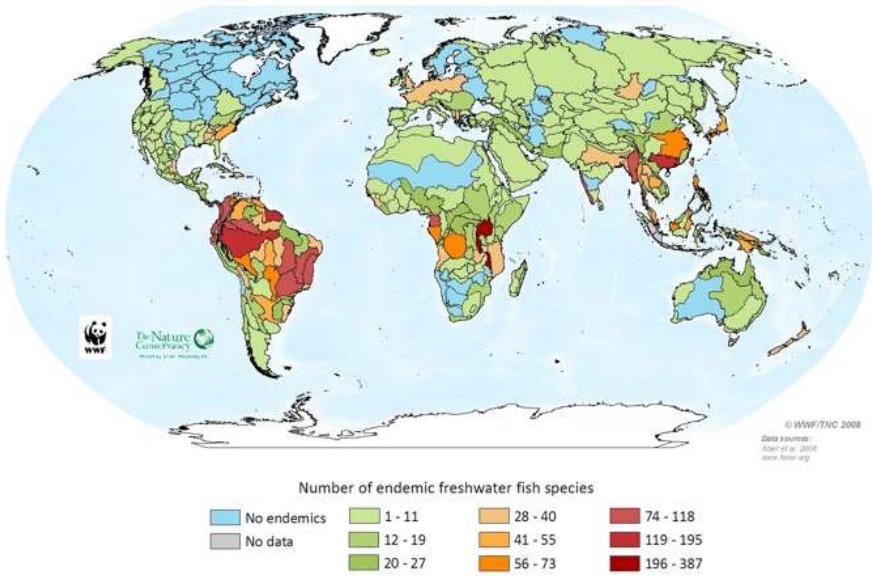

Figure 3.141: Number of endemic freshwater fish regions of the world (WWF/TNC, 2013)

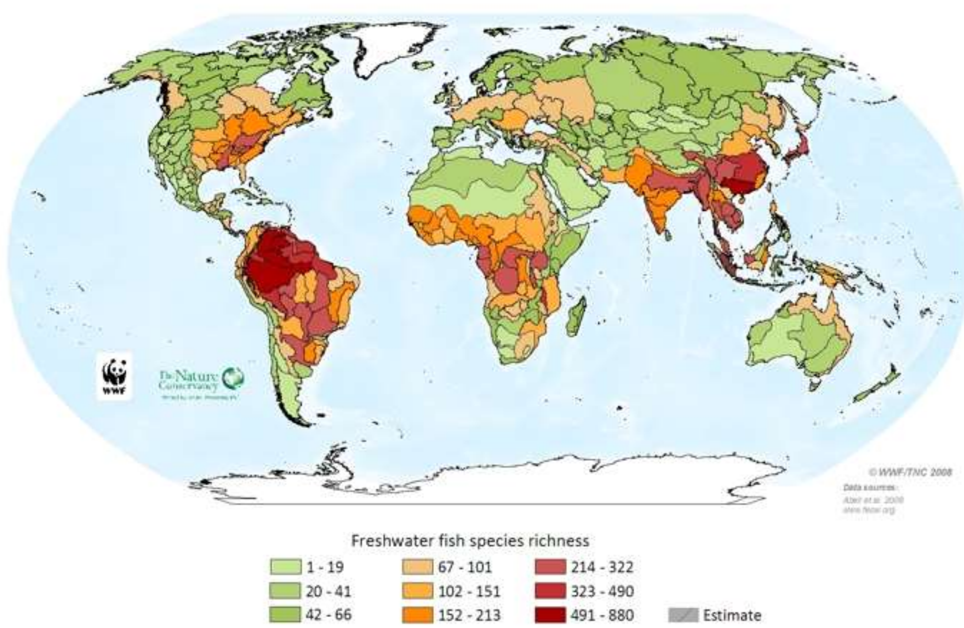

Figure 3.142: Number of species rishness of freshwater fish of the world (WWF/TNC, 2013)

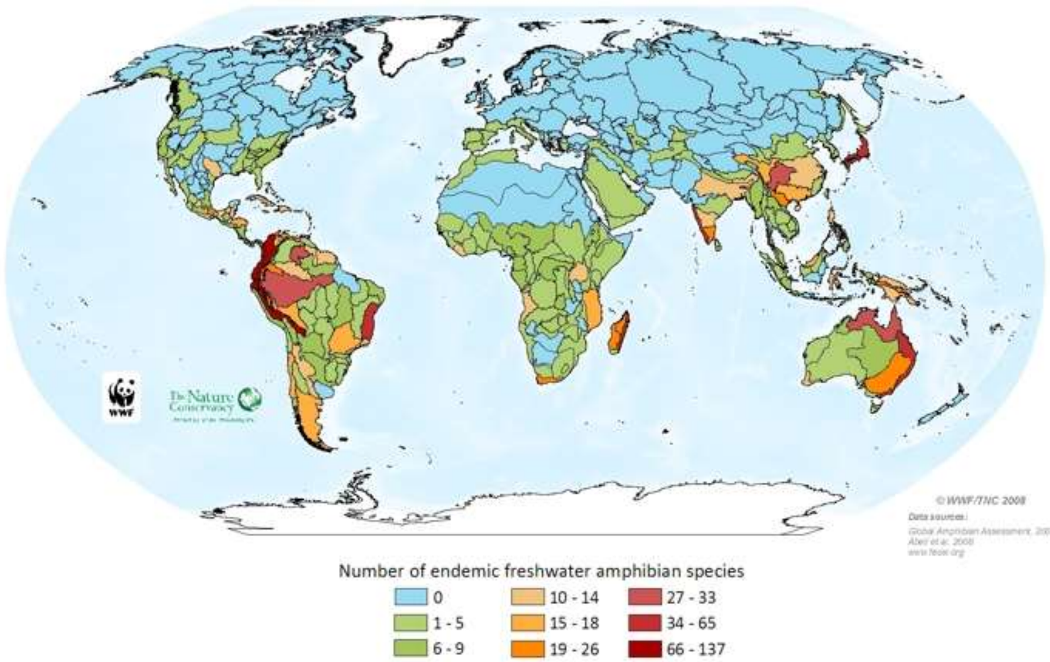

Figure 3.143: Freshwater endemic amphibians (WWF/TNC, 2013)

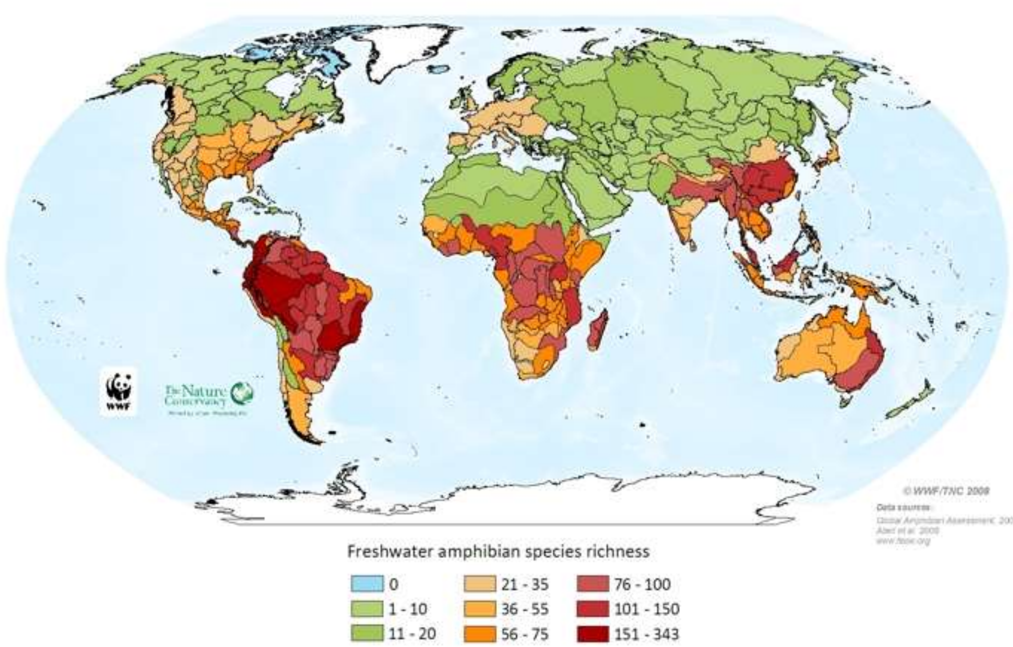

Figure 3.144: Species richness of freshwater amphibians (WWF/TNC, 2013)

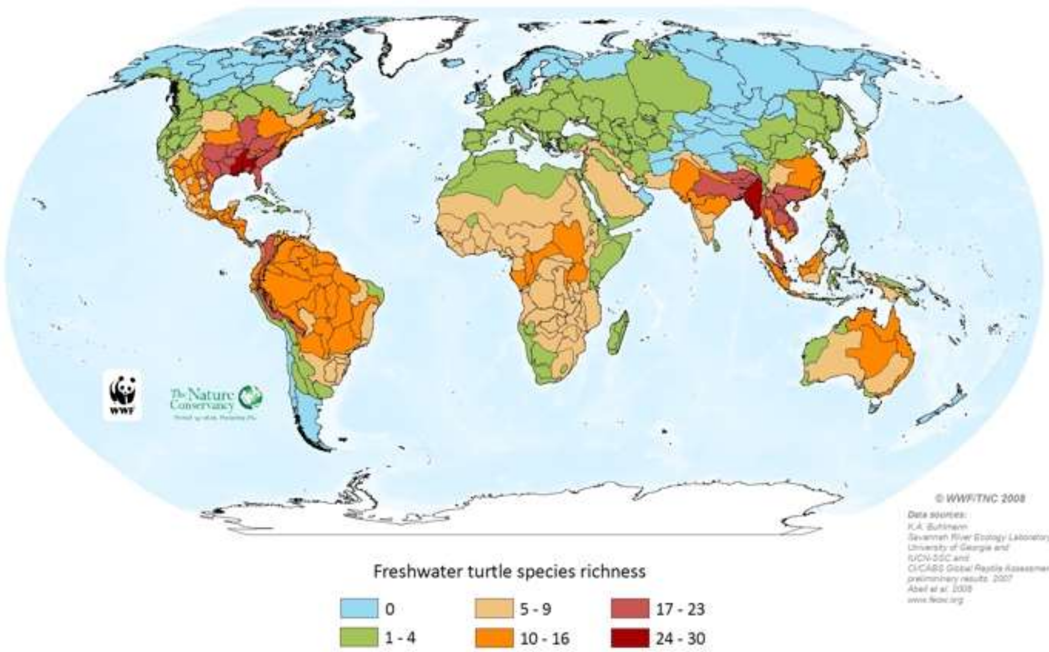

Figure 3.145: Freshwater turtle species richness (WWF/TNC, 2013)

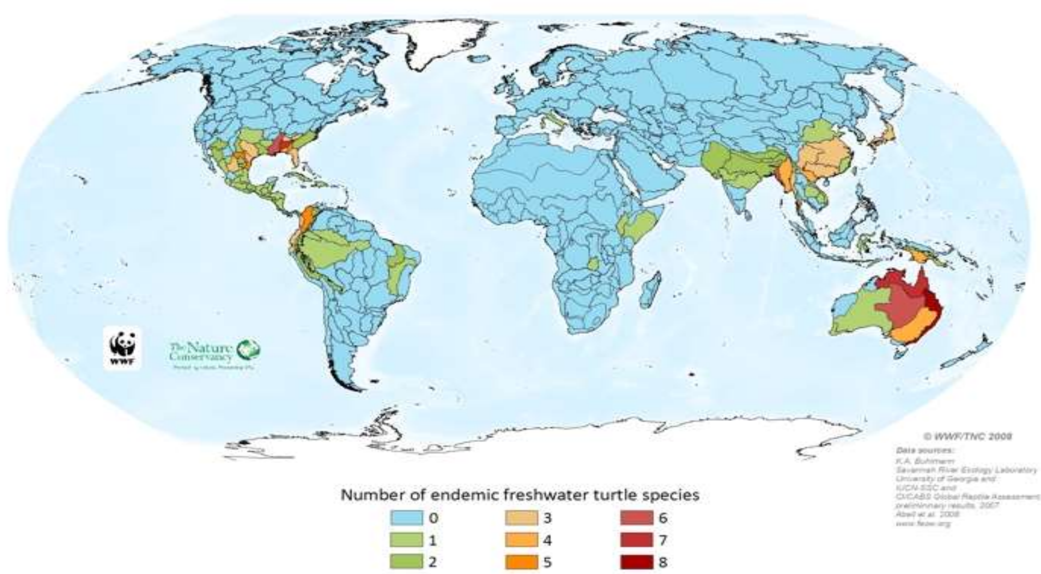

Figure 3.146: Number of endemic freshwater turtles (WWF/TNC, 2013)

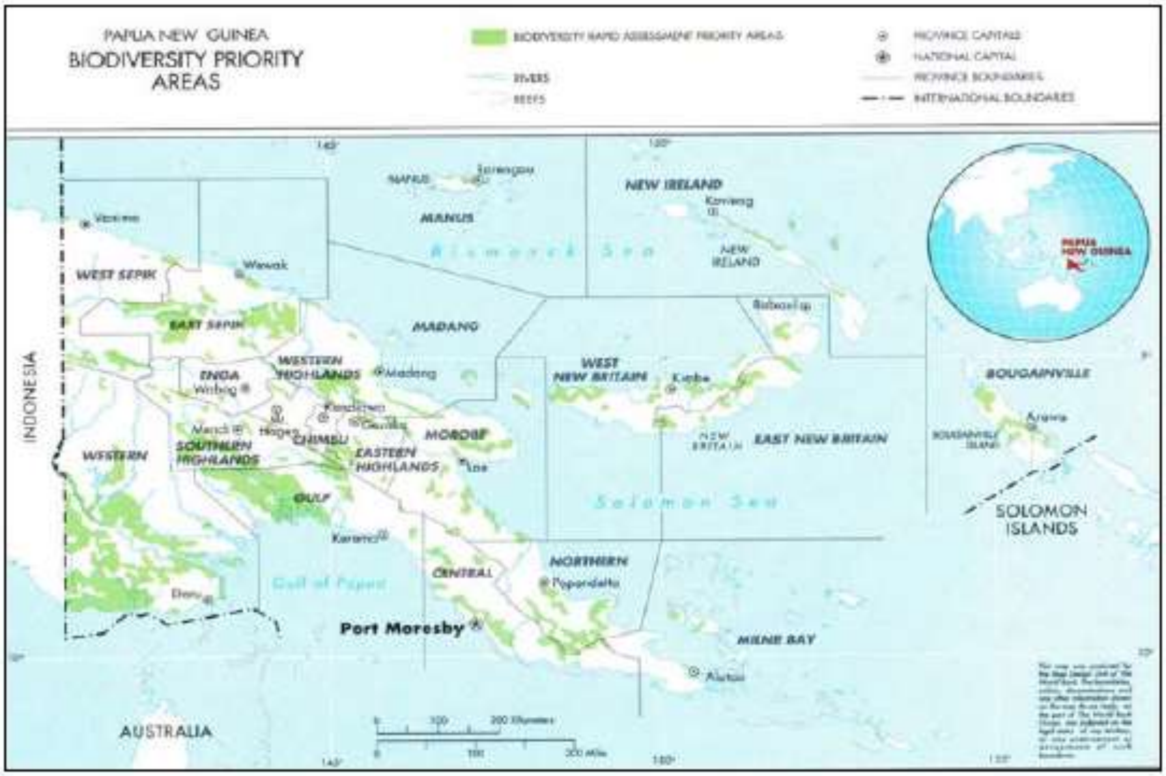

Figure 3.147: Biodiversity priority areas (World Bank, 2002; cited in SPREP, 2007)

Impact

Figure 3.147 shows high biodiversity priority areas pertaining to terrestrial areas where more conservation work needs to be underatken and species protected. Howvere, not the entire country will be protected because some are exploited by humans. PNG is situated in one of the megadiverse region of the world known as 'Coral Triangle' with high species diversity and endemism. PNG is known to have the highest number of species of coral reef in the world compared to the great barrier reef as discussed in Section 8.6. There are some world records for PNG species but only a handful are listed below:

- The world tallest tree in Klinki pine (*Auraucaria huntenii*);
- The world's only bird that roost under ground and is poisionous, the Hooded Pitohiu (*Pitohui dichrous*);
- The world's laregst pigeon in Goura pigeon (*Goura schepmekerii* and *G. victoria*);
- The world's largest bat, the Bismarch Flying Fox (*Pteropus neohibernicus*);
- The world's smallest parrots (*Micropsitta spp*);
- The world's longest lizard in the world (*Varanus salvadori*);
- World's largets treefrog (*Litoria infrafrenata)* and the worlds stinest frog (*Paedocypris progenetica*);
- The world's largest monetreme in the Long-beaked Echidna (*Zaglossus bruijnii*);
- The world's largest birdwing butterfly (*Ornithoptera alexandare*); and
- The world's largest moth in Herculas moth (Coscinocera Hercules)

With increasing population and development activities, most of these unique species are facing threat from extinction and depleting population. This is also coupled with increasing invasive species and diseases, impact of global climate change and increasing hunting and overexploitation pressures and economic development (Primack eds. 2010). Destruction of habitats instigated by humans activities, forest fragmentation and clearing, degradation of forest and marine ecosystems, international wildlife trade and cioomercial harvesting of species are also improtant factors in determining the survivorship of individual species or peopulation.

The onus is now ons CEPA as the government agency responsible for conservation and protection of the natural asset of PNG to ensure it work towards protecting the country's species and population from threats. Activities outlined in the NPAP and POWPA must be addressed swifly to avoid further loss to the species and their habitats. CEPA can also work with other agencies such as National Fisheries Agency (NFA), Department of Agriculture and Livestock (DAL), Mineral Resource Authority (MRA), Department of Petroleum and Energy (DPE), PNG Power Ltd, Department of Commerce and Industry (DCI, provincial and local level governments) and other government agencies to ensure the environment is managed sustainably and its future is not compromised

Response and Recommendations

To preserve the high diversity and endemism in PNG, the Protected Area must be managed sustainably with more funding made available. Increase funding, resources and capacity of CEPA, PA managers, and provincial conservation officers to do conservation work. More awareness must be made to educate the people about the rich biodiversity and culture PNG has. In addition, proper and stringent Environment Impact Assessments (EIA) and monitoring must be adhered to with governance issues addressed amicably. More researches need to be done and data collected made available so more inform decisions can be made by all. Preservation of species in ex situ must be encourage if under threat.

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8.7.4 ENDEMIC AND NATIVE SPECIES

Indicator Definition: Status and abundance of identified species

Status and Trend

The Goodfellow Tree Kangaroo (*Dendrolagus goodfellowi*) in Nature Park, Port Moresby

SDG/CBD Targets

SDG:1.1.1, 1.2.2, 2.1.2, 2.5.1, 2.5.2, 4.3.1, 4.7.1, 9.1, 9.5.1,12.2.1, 12.4.1, 12.4.2, 12.8.1, 13.3.1, 13.3.2, 13.b.1, 14.1.1, ,14.2.1, 14.3.1, 14.4.1, 14.5.1, 14.7.1, 15.1.1, 15.1.2, 15.2.1, 15.3.1, 15.4.1, 15.5.1, 15.7.1, 15.8.1

Aichi Target: 1, , 2, 3, 4, 5,6, 7, 8, 9, 10, 11, 12, 13, 14, 151.1.1

Status and Trend Discussion

Certain organisms can be used as biodiversity indicators to drive the conservation efforts when a specific data is unavailable. A forest for instance a high diversity of flowering plants may also have a high diversity of other life forms. Hence, areas with high diversity are often associated with high endemism (Primack, eds., 2010).

A species that is only occurring in an area and nowhere else, has a restricted range and is rare is qualified to be called an endemic species. This rarity gives rise to the word endemism where some species are found naturally in a geographical area and no other place. A species can be an endemic in a narrow area and is rare, covered a large geographical area and is abundant throughout it or lives in specialised habitats with smaller population (Primack, eds., 2010).

Island communities have unique ecosystems, flora and fauna

Many species on an island are different from those on the mainland to some extent. The theory of island biogeography on endemism was proposed that animals and plants on an island are limited to those types where their ancestors managed to disperse there, caused by isolation and their intrinsic dispersal ability (Begon and Townsend, eds., 2012). Thus the rate of revolutionary change may be fast enough to outweigh the effects of genetic material exchange with other populations.

With this picture in mind, it can assumed that there are pockets of 'islands' such as niche, and ecosystem existing on land, and in rivers and sea that individual species or population that gave rise to high species endemism and diversity in the tropics, provided there is ideal condition for the species to survive. Photo 1 shows an island at the background of the mainland.

A Study by Ceballos and Ehrlich (2006) shows the highest concentrations of species in the world are being found in northern South America, especially in the Amazonian lowlands, the Andes, East Africa, and Southeast Asia (Figure 3.148*A*). In contrast, although restricted-range species are found on all continents, but are concentrated in relatively few regions containing many islands, peninsulas, or island-like habitats such as mountaintops (Figure 3.148*B*). Furthermore, in the Americas, there are relatively continuous concentrations of restricted-range species (endemic) in a large region extending from central Mexico to the northern and central Andes, and in the Atlantic forests of Brazil. In Africa, restricted-range species are found commonly in the tropical lowlands of Cameroon in the west, in the inland and coastal forests of East Africa, in the Ethiopian highlands, and on Madagascar. Ceballos and Ehrlich (iterates that rstricted-range species in Asia are frequent in southern India and Sri Lanka, southwestern China, Vietnam, Taiwan, Malaysia, Indonesia, Philippines, New Guinea, and northern Australia.

As expected, the occurrence of centers of threatened species is concentrated in regions with high-impact human activities, and it follows to a certain extent the patterns of species richness. Threatened species are found throughout the world, with higher concentrations in tropical regions of the Western Hemisphere, Africa, and Asia (Figure 3.148*C*).

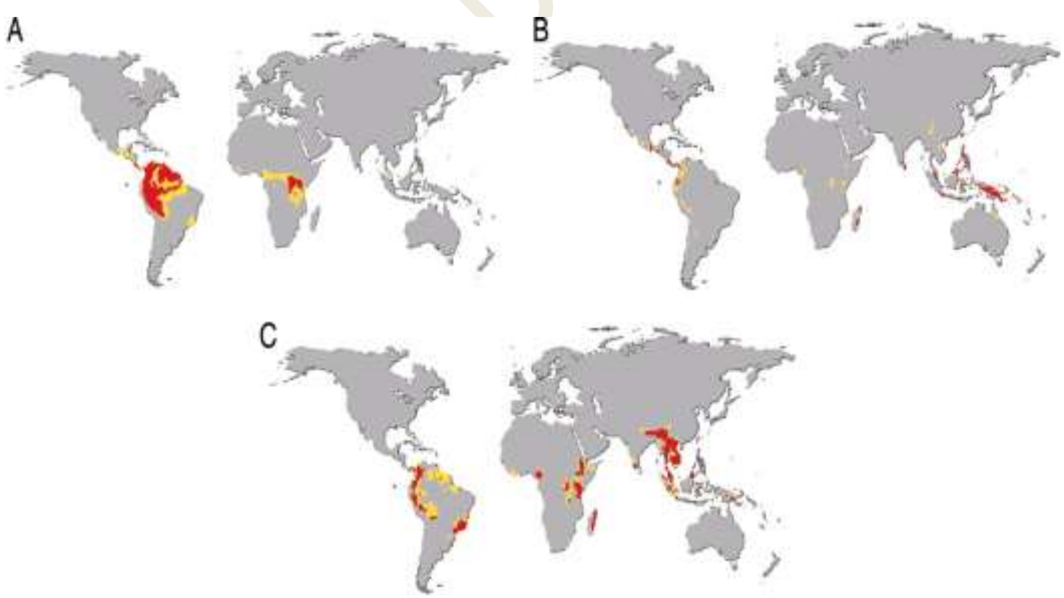

Figure 3.148: Hotspots of species richness (A), restricted range species (B), and threatehend species (C). The 2.5% hotspots are shown in red, and the 5% hotspots are shown in yellow (Ceballos and Ehrlich, 2006)

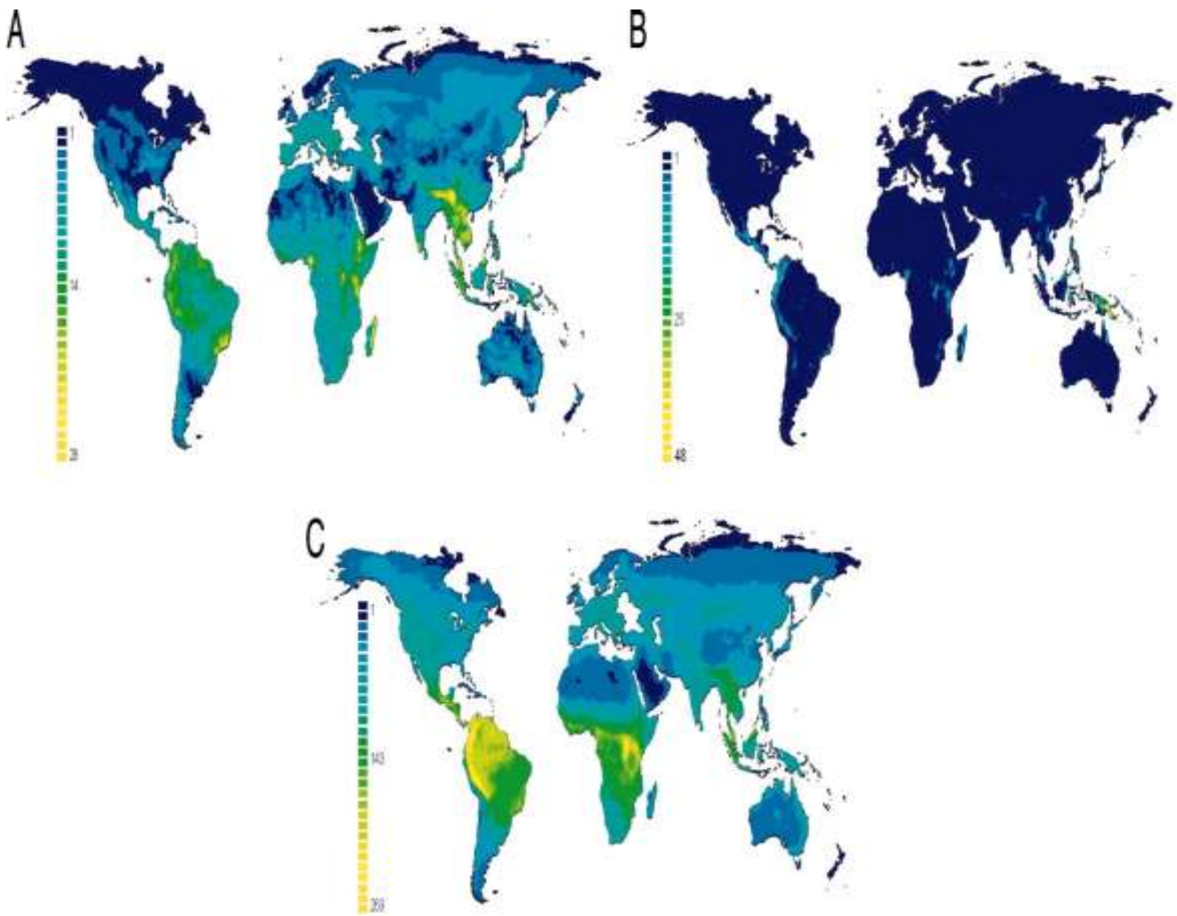

Figure 3.149: Patterns of species distribution of mammals throughout the world, showing spiecies richness (A), restricted range species (B), and threathened species (C). All scales are in terms of number of species per 10,000km gird cell (Ceballos and Ehrlich, 2006)

Ceballos and Ehrlich (2006) also shown in their study on mammals that unexpectedly, mammalian hotspots of species richness are found in only two primary regions (Figure 3.149*A*) in: (*i*) Central America and northern South America; and (*ii*) equatorial Africa, especially in the east. In contrast, restricted-range species showed hotspots, as expected, in limited areas scattered in Mexico, Central America, northern South America, Madagascar, Sri Lanka, Indonesia, New Guinea, the Philippines, and Taiwan (Figure 3.149*B*).

Restricted and endemic Doria tree Kangaroo (*Dendrolagus dorianus*) in an *in situ* conservation site in Adventure Park, Port Moresby.

Most species in PNG and their habitats, especially fauna are protected under the Fauna and Control Act (1969). This Act has been repealed under the CEPA Act 2014. A new Protected Area bill has been drafted in 2017 and is currently under review for enactment in parliament. This bill has to capture species. There are also other laws such as the Environment Act 2000, the Forestry Act 1993 and the Fisheries Act 1989 which also protect both fauna and flora. Other PNG protected species are manged under international Convention on International Trade on Endangered Species (CITES). Table 3.18 shows the list of CITES Appendix II species in PNG (can be traded) which are grouped or stated as individual species. There are over 400 species from 38 families of both plants and animals that listed are under CITES Appendix II as PNG protected species.

These species are native except the marine turtles, certain sharks and whale species, fish and turtles which also migrate around the world. Some of these native species are shared with neighbouring Papua province of Indonesia, Australia, Solomon Islands, Vanuatu and New Caledonia. The PNG's endemic Doria tree kangaroo (*Dendrolagus dorianus*), has aristricted range of occurrence which the population is restricted to the southern part of the PNG mainland.

It is estimated that there are 600,000 to over 1 million species (5-8% of world's total) are found in PNG. Many of these species are yet to be discovered or described of which over 300, 000 are believed to be insects while a large number of bacteria are yet to be fully studied and described.

Figure 3.150 shows the number of endemic or native species in PNG and the region that is under threat is about 118, mostly endemic, near endemic or shared with other countries in the world. From these species, 60 species are under threat from extinction, and are only confined to PNG. Other species are shared between PNG and the neighbouring countries, region and the world. 13 species that are threatened are shared with the Papua province of Indonesia on the Island of New Guinea and the other 11 are shared with the world. 7 species each are shared between PNG, Indo-Pacific and Asia Pacific, and 5 each with Australia and Indonesia wide. PNG and Solomon Islands shared 3 species while the rest of the region shared 1 species.

Impact

Eighty seven per cent of the PNG's population of PNG live in rural areas and depend on their land, forest, rivers and ocean for their livelihood and sustenance. PNG is also very rich in natural resource, including biodiversity. PNG also has a dual economy that is based on subsistence and exploitation and trading of its natural resources. Due to local and global pressures and threats, most of the endemic and native species will become vulnerable to extinction as their habitats and population become altered or destroyed, with the potential of causing irreversible damages and losses. Several drivers and threats identified in Section 5 all have potential to escalate the problem. Photo shows local native species are highly valuable for traditional regalia for *singsing* and cultural heritage.

Bird Plumes and turtle shells used as traditional regalia by Papua New Guineans (Photo by B. Bito)

Table 3.18: List of CITES native species and their common names managed under CITES Appendix 2

No	Taxa	Common Name	No	Taxa	Common Name
1	Reptilia	Salt Water Crocodile	21	Aves	2 Goura pigeon
2	Reptilia	Fresh Water Crocodile	22	Aves	Hornbill
3	Reptilia	All Monitor Lizards	23	Aves	All Sicklebill
4	Reptilia	Pig-nosed Turtle	24	Aves	Drongo
5	Reptilia	All 6 marine turtles	25	Aves	All Sharks
6	Repitilia	All Pythons	26	Aves	All sawfish
78	Mammalia	All Tree Kangaroos	27	Aves	Humphead Wrass
9	Mammalia	Dugong	28	Mollusca	Green Tree Snail
10	Mammalia	Black Spotted Cuscus	29	Mollusca	All Giant Clam Shells
11	Mammalia	Spotted Cuscus	30	Plantae	All Orchids
12	Mammalia	All Dolphins	31	Plantae	All Cycads
13	Mammalia	Spectacle Flying Fox	32	Plantae	Rosewood
14	Mammalia	Water Mouse	33	Plantae	Eaglewood
15	Aves	All Birds of Paradise	34	Plantae	Agarwood
16	Aves	All Lorikeets	35	Plantae	Sandalwood
17	Aves	2 cockatoos	36	Insecta	All Birdwing Butterflies
18	Aves	All parrots	37	Anemones	All Black and Acropora corals
19	Aves	Brahminey Kite			
20	Aves	New Guinea Harpy Eagle			

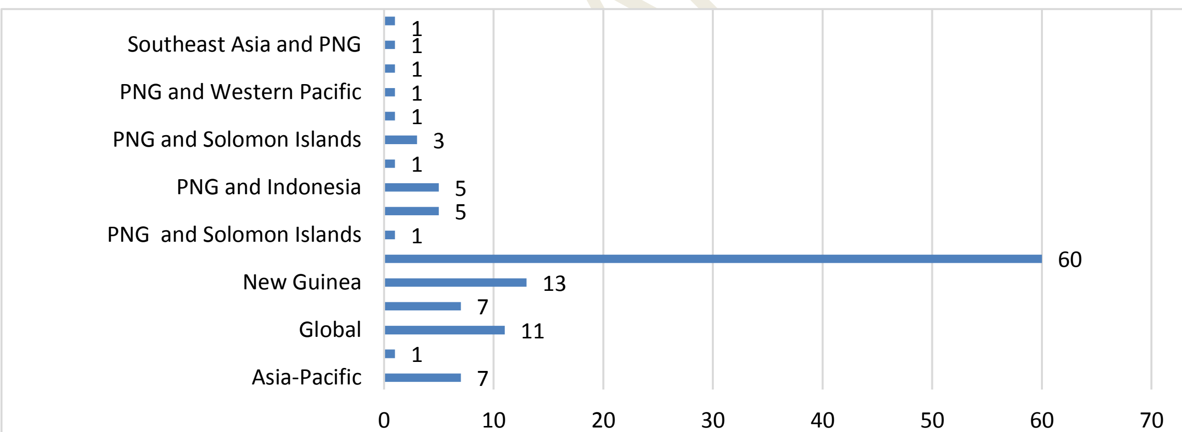

Figure 3.150: Number of critical endangered and endangered endemic species and species shared with the neighbouring countries, region and the world (IUCN, 2019)

Endemic species, only found in PNG, are of concern because of their limited geographic range and the niche they occupy. The assessment of the vulnerability, near threatened, threatened and endangered species is provided below in Section 8.7.5. The very nature of endemic species is that they are sensitive to extinction. A few of these endemic species only occur in certain habitats, island, atoll, mountains, rivers and ocean, thus making them extremely rare.

Response and Recommendations

A detailed Management plan should be put in place for a number of species and resources and funding made available. Also a proper national land-use and seascape plan should be promoted and capacity building provided to agencies. Education and awareness must be conducted as well. The new PA Bill (Act) should also capture species protection and management.

With the drafting of the National Biodiversity Strategic Action Plan and the current Protected Area Policy being in placed, it is highly recommended that conservation and management plans are prioritized for those endemic and threatened species. It is highly recommended that traditional knowledge on biodiversity is taught in the schools to empower people to conserve their biological assets. By doing so, the traditional knowledge and practice of conserving the natural surroundings can be revived to help preserve the Papua New Guinean traditions and culture.

Reference

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8.7.5 TOPIC/SUBTOPIC: THREATENED SPECIES AND SPECIES OF CONCERN

Indicator Definition: Status of species that are under threat from extinction and those species that are only found in PNG

Status and Trend

A villager standing in front of a regenerated log pond one year after logging operation in Lower Ramu River, Madang Province

SDG/CBD Targets

SDG: 1.2.1, 2.5.2, 4.5.1,, 4.7.1, 5.1.1, 6.3.1, 6.6.1, 8.3.1, 9.1.1, 9.2.1, 9.3.1, 10.1.1, 10.2.1, 12.2.1,12.4.2, 12.8.1, 13.1.3, 13.3.1, 14.1.1, 14.2.1,14.4.1, 14.5.1, 14.6.1, 15.1.2, 15.2.1, 15.4.1, 15.5.1, , 15.7.1

Aichi Target: 1, 2, , 4, 5, 6, , 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

Status and Trend Discussion

A species that is naturally occurring only in a geographical area and no other place is endemic to that location. Hence endemism is important in assessing the species' risk of extinction. When the population of an endemic species for instance in PNG's mainland and other outer islands go extinct, that particular species will now become globally extinct. Some species have wide range of distribution and high population and may become extinct in one area but continue to thrive elsewhere, hence the loss of one population is not catastrophic (Primack, eds. 2010).

Extinction is a fact of life but in recent times, man have become more aware to address the causes of the problem. Over exploitation, habitat destruction, global climate change, introduction of exotic species and pollution are propelling extinction, hence conservation of some species is important (Begon and Townsend eds. 2012).

Often estimates of threatened species are extrapolated based on limited data generated and it is usually better for some species than others. For instance, during the writing of this report, some timber tree species are listed as threatened on the IUCN Redlist because of high logging activities in PNG. Hence, the number of threatened species need to be revised for plants.

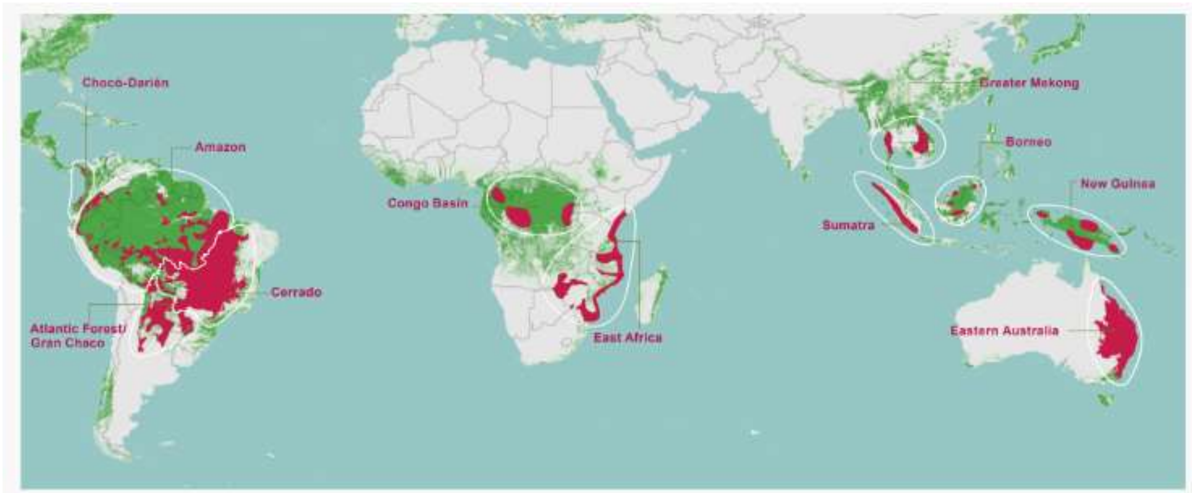

Figure 3.151: Countries with high deforestation rate (WWF; cited in Kilvert, 2018)

The IUCN Red list of Threatened Species for PNG is used to determine the changes in status of species which occur on the list. Some of these species are the focus of environmental effort through community-based conservation, including protected areas, management and species 'recovery' plans.

Figure 3.151 shows some species are under threat from habitat loss and PNG has one of the highest deforestation rate in the world. There is an estimated 29 million hectares of forested land remaining for logging in the country in 2008 from the 33 million hectares estimated in 1975 (Shearman et al., 2008). There was a loss of some 4 million hectares over a 30-year period which was partially attributed to shifting cultivation, conversion of forested lands to agriculture, logging, urban development, fire, infrastructure development, mining developments, and various natural disasters.

Unless these issues are not addressed amicably, some species may become extinct. The world's largest birdwing butterfly (*Ornithoptera alexandrae*) is endemic to Popondetta area in Oro province. Its habitatshave been destroyed by large scale logging, palm oil plantation and subsistence agriculture.

In recent times, those outstanding biodiversity values are undergoing various threats from the various development drivers and pressures discussed in Section 2. This has led to many species becoming vulnerable or threatened to become extinct. Under the IUCN Red List, a total of 540 species are threatened with 1 water insect species (*Rantus papuanus*) already extinct, 36 species are critically endangered (Cr), 83 species Endangered (EN), and 420 species are vulnerable (VU).

A newly hatched endemic and threatened Queen Alexandra Butterfly (*Ornithoptera alexandrae*), the largest butterfly in the world (Photo by Angelus Palik).

Table 3.19 shows the number of species that are of concern as Vulnerable (VU), endangered (EN), Critically Endangered (CR) and Extinct (Ex). Corals and anemones, and plants have the highest number of vulnerable species to threats with 151 and 134 species respectively.

Table 3.19: Number of species threatened (IUCN, 2019)

Taxa	Critically Endangered	Endangered	Extinct	Vulnerable
Bony Fishes	4	5	0	25
Frogs	1	0	0	10
Corals & anemones	0	6	0	151
Birds	1	5	0	37
Shellfish	0	0	0	2
Sharks & Rays	2	8	0	22
Sea Cucumbers	0	5	0	5
Insects	0	2	1	6
Fungi & Liverworts	1	2	0	0
Flowering plants	16	28	0	134
Crustaceans	0	0	0	1
Mammals	10	17	0	16
Conifers	0	0	0	2
Ferns	0	1	0	1
Reptiles	1	4	0	8
Total	**36**	**83**	**1**	**420**

Figure 3.152 shows flowering plants have the highest number of species that are endangered and critically endangered with at 28 and 16 species each, while and mammals have 17 and 10 species each respectively. In addition, corals and anemones have the hoghest number of vulnerable species with 154 and 134 species respectively, withbirds with 37 species, bony fish with 25 species, sharks and rays with 22 species, mammals with 16 species and frogs 10 species.

Table 3.20 indicates 119 species are of concern or under threat. A water beetle had already gone extinct, 36 species are Critically Endangered (CR) and 81 species are Endangered (EN). A detail list of the species that are of concern are tabulated in Appendix 9. The species population must be protected, revived or brought back to their carrying capacity of reproduction and self-sustaining. Figure 3.153 also shows graphically the status of those different threatened species of concern. Critically endangered species have 36 species followed by endangered species with 81 and 1 species became extinct recently. Moreover, Figure 3.154 shows Magnoliopsisa or Dicotyledons flowering plants has 30 species, Mammalia with 27 species, Monocotyledons plants with 14 species, Chrondrichthyes or sharks and rays with 10 species, and Actinopterygii or Finned fish with 8 species each. In addition, Aves or Birds and Antozoa or sea anemones have 6 species each while Reptilia and Holothuidea or sea cucumber have 5 each. Insects has 2 plus 1 now extinct, and finally Lecanoromycetes or fungi, Polypodiopsida or fern, and amphibian or frog have 1 species each under threat from extinction.

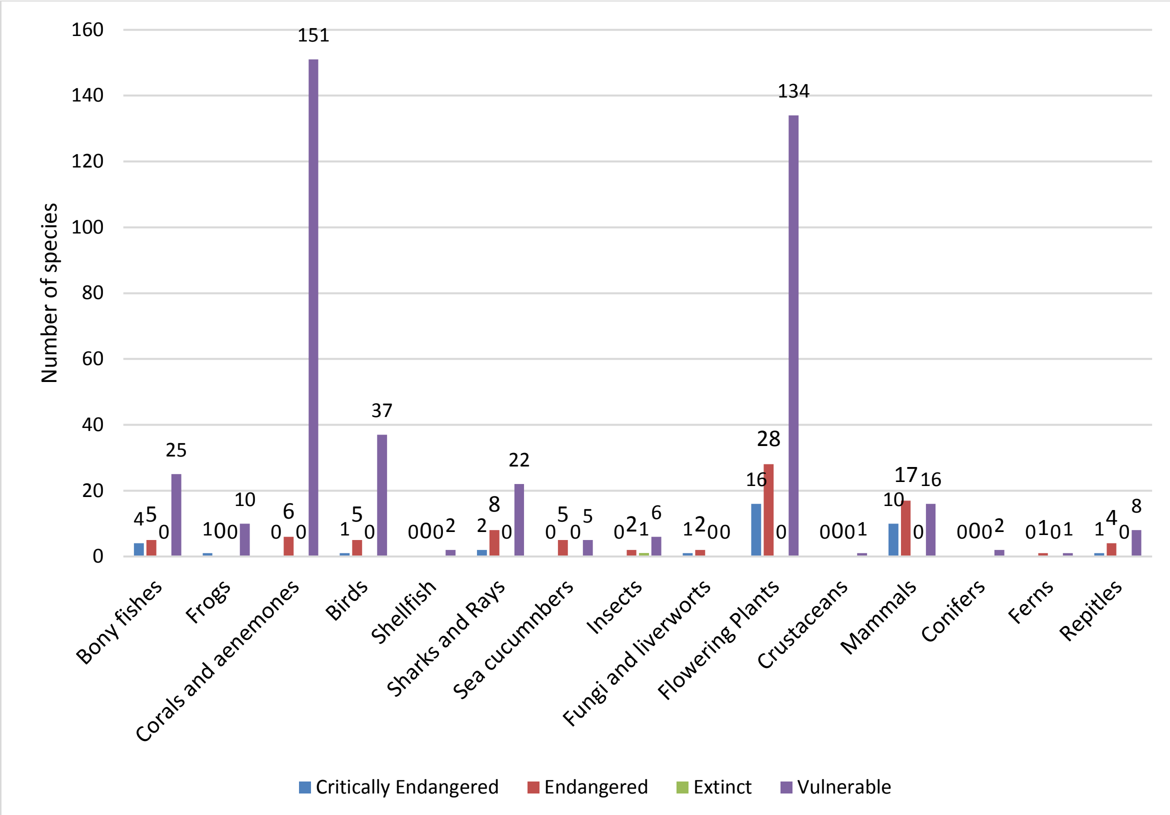

Figure 3.152: IUCN Red List for threatened species for Papua New Guinea (IUCN, 2019)

Table 3.20: Redlist of species that are extinct (EX), Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) for 2015 and 2019 (IUCN, 2019).

Year	Redlist	EX	CR	EN	VU	Total
2015	**Animals**	**1**	**20**	**42**	**257**	**320**
	Plant	**0**	**13**	**14**	**116**	**143**
2019	**Animals**	**1**	**20**	**67**	**283**	**371**
	Plant	**0**	**16**	**29**	**137**	**172**

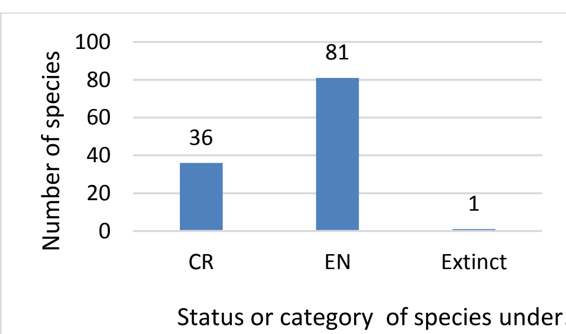

Figure 3.153: Critically Endangered (CR), Endangered and Extinct species (IUCN 2019).

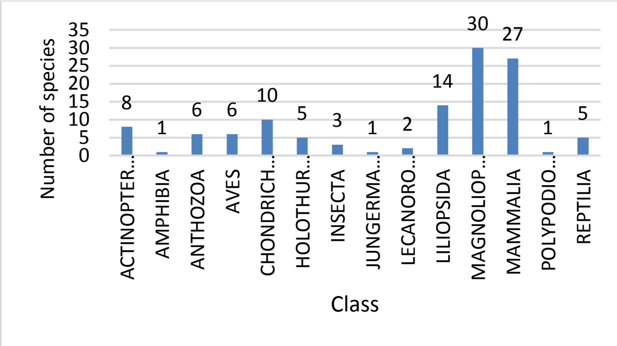

Figure 3.154: Number of Critically Endangered, Endangered and Extinct species by classes (IUCN, 2019).

Impact

The rate in which PNG's biological assists are facing imminent threat is more prevalent today than in the past despite large scale natural climatic events that happened during the ice age that caused massive extinction of species worldwide. With increasing development activities coupled with increasing population, over hunting and fishing, introduction of pest and diseases and global climate change effects, many species are bound to go into extinction than never felt before in recent past (see Section7.0).

Tropical canopy research crane, Baitabag, Madang Province (Photo by V. Novotny)

There are many species that are of concern that need suitable management both in situ and ex situ. This means more research need to be conducted to know the status of PNG's threatened species. PNG is one of the few countries in the world that has a Canopy Research Train operated by New Guinea Binatang Research Center, at Baitabag, Madang Province. Experiments are conducted on plants insects studying food webs and interactions between plants, insect herbivores, fungal pathogens and vertebrate predators. Other research are also conducted. When status of individual species or population is understood or known through research, better decision making can be made to conserve, preserve or revive the affected population.

Response and Recommendations

Papua New Guinea's (PNG) biodiversity is continuing to face threats from climate change, development activities, habitat loss, pest and diseases, exploitation and invasive species. Although there are solid baseline and ongoing monitoring of the current status and trends of many threaten species in PNG, more studies and monitoring need to be conducted, and more training and funding is required. Photo 3 shows camera trapping can assist in monitoring endangered and threatened species abundance and population. Education of communities, school children and the public must be conducted. Also development activities must have proper plans to ensure critical ecosystems species of concerns are protected from negative impacts.

Camera trapping monitoring of native species at Varirata National Park (Photo by J. Dege).

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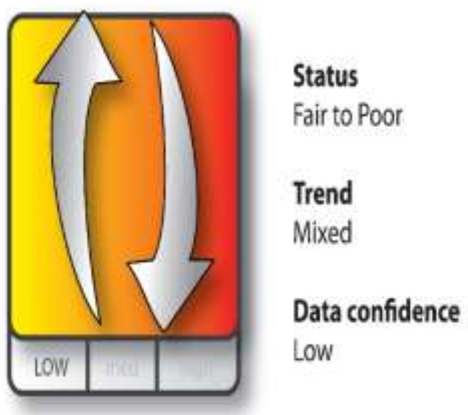
8.7.6. TOPIC/SUBTOPIC: INVASIVE OR EXOTIC SPECIES

Indicator Definition: Number of priority sites with multi-invasive taxa management programmes.

Status and Trend



Horses were introduced into PNG more recently. A boy siting on a horse in Varirata National Park

SDG/CBD Target

SDG:2.5.23.3.3, 3.3.5, 3.b.2, 4.1.1, 4.2.2, 4.3.1, 5.1.16.5.1, 6.5.2, 9.1.1, 12.2.1, 12.8.1, 13.1.2, 13.1.3, 14.2.1, 14.5.1, 15.1.1, 15.1.2, 15.5.1, 15.8.1

Aichi Target: 1, 2, 3, 4, 9, 12

Status and Trend Discussion

The description of an invasive, alien or exotic species is discussed in Section 6.17. An invasive species can be any kind of living organism—an amphibian (like the cane toad), plant, insect, fish, fungus, bacteria, or even an organism's seeds or eggs—that is not native to an ecosystem and causes harm to the environment, the economy, or even human health. Invasive are species that grow outside their natural range and reproduce quickly, and spread aggressively, sometimes at the expanse of a native species, with potential to cause harm, thus are given the label 'invasive'. An invasive species does not have to come from another country.

Some invasive species do not establish themselves quickly in their new habitat. This is because the environment which allow them to become established in their new home is not conducive for their establishment, or because they arrive in insufficient numbers (Primack, eds., 2010). Some species also develop adaptive traits to withstand predation and being suppressed or taken over by agreesive invasive species. Their behavioural patterns somewhat make them resilience to withstand competition from their rival (Begon and Townssend, eds., 2012). They can develop aleopathy substances and other defence mechanisim to survive or to avoid catastrophic events.

Some species reproduced rapidly so only the weaker ones die out. This is a behaviour pattern that exisiting between competitor. Other species have a wide variety of dietary requirement hence they cannot succumb to starvation while other species develop menhanisms to co-exist with the invaders and live in equlibirum with their competitor. Such behaviour may develop over time or immediately depending on the reponse of individuals and the population to the new species.

Until the 15th century, European colonisers travelled the world bringing in new species like birds, fish like trout and mammals to places such as New Zealand, Australia, North America and South Africa (Primack eds., 2010). They also brought pathogens and bacteria as well to those new places. Consequently, a large number of plant and animal species were also introduced while some species were accidently transported. In return, the colonisers also brought back some of the species upon returning to their country or elsewhere. As movement increase over time, more species become dispersed widely. Eventually these species settled in the new host country and adapt quickly, some become problematic immediately while others sprung up when the environment they occupy become conducive for their growth. Up until recently, many invasive entering new areas have been transported around the world as movement of people become rapid with better and efficient transport systems. Consequently, this movement patterns affects many species around the world and in local areas they were introduced. This resulted in establishment of qurtintine services to man all port of entry such as airports and sea ports.

The first know invasive species in PNG are domestic cats and dogs and feral pigs that the first human who arrived in PNG brough along with them. A recent review by Allison & Tallowin (2014) indicates among alien invasive species reported in PNG, are cane toad, 5 species of birds and 4 mammals being common, including feral cows and 22 exotic fish species.

The current number of invasive plant species in PNG is not known. There are those which interfere with agricultural, pastoral or horticultural activities and are found in subsistence gardens and commercial agriculture and those which invade natural plant ecosystems altering them. Henty and Pritchard (1975) treated 146 species as weeds in *Weeds of New Guinea and their Control*. This has not been revised systematically since. Currently with the assistance of SPREP (South Pacific Environment Program) NAQIA is establishing a database of Invasive Species in Papua New Guinea.

The current number of invasive plant species in PNG is not known but is estimated to be over 400 species. These species mainly interfere with agricultural, pastoral or horticultural activities, and are found in subsistence gardens and commercial agriculture, plus those which invade natural plant ecosystems thus altering them. Henty and Pritchard (1975) treated 146 species as weeds in *Weeds of New Guinea and their Control*. This has not been revised systematically since. Currently with the assistance of SPREP (South Pacific Environment Program) NAQIA is establishing a database of Invasive Species in Papua New Guinea.

A pathway for invasive plant species in the rainforest is through the opening of the canopy by logging and access tracks. Theses species can be introduced by machinery that has not been inspected before entry into an area of operation. There are at least 39 invasive species in rainforest (Kiapranis & Banka n.d, cited in GoPNG, in press), however the amount of change that these have caused in the rainforest ecology is not known.

Recent surveys of invasive species have been made on the Kokoda Track, a major trekking route made by groups coming mainly from Australia. In 2015 there was no evidence of any new-to-PNG exotic pest species having been introduced by trekkers along the track, but it is likely that the high volume of people walking along the track are assisting the spread of the 83 known exotic plant species along it. For plants around 250 species may become problematic, depending on where they occur with 54 weeds of major concern (*per com., Warea Orrapa*). Allison and Tallowin (2014) report 90 species of weeds on the Kokoda Track.

A tentative list from NAQIA is shown in Figure 3.155 indicates there are 1 star fish, 28 fishes, 16 insects, 3 snails, 1 bacteria 1 fungus and 429 plants of major concern as alien species. For insects, the number of pest could be between 50-100 species whereas for pathogens, fungi and bacteria, between 50-100 species (*pers. com., Warea Orapa*). These species are dispersed throughout the country, while some species sometimes are more dominant in a particular locality or region.

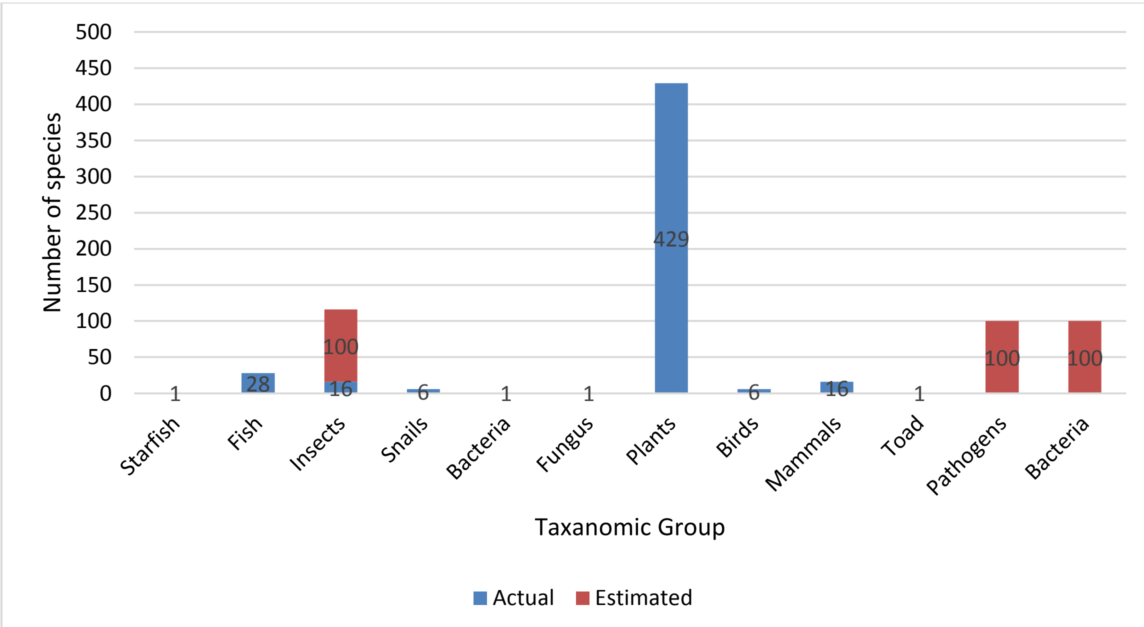


Figure 3.155: Actual and estimated number of alien or invasive species

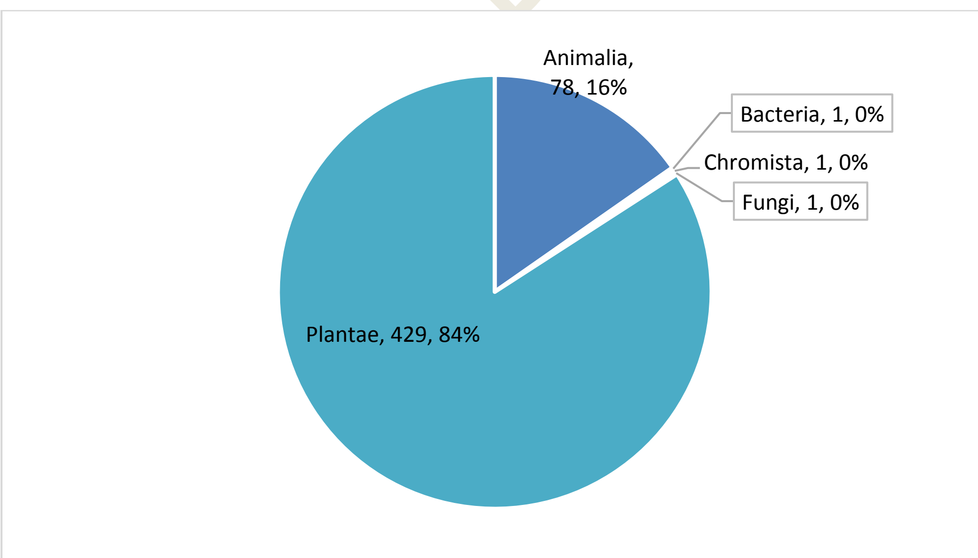


Figure 3.156: Percentage breakdown of major classes of invasive species.

Figure 3.156 shows plants contains the majority of invasive species with 249 species (84%) followed by animals with 78 species (16%) and others. The list of these species is in Appendix 10 showing 478 species identified by NAQIA but there may be other species yet to be discovered and classified as invasive as stated above.

Some native species can become pest as well. For example, Paper Bark trees (*Melaleuca* spp) in the Bensbach area in the South Fly district of Western Province have invaded the flood plain thus causing changes to the ecosystem function and ecology.Another species of beetle, *Brontispa longissimi*, is native to Indonesia (Aru Islands, Maluku Province and possibly Papua Province, formerly Irian Jaya) and also PNG, including the Bismarck Archipelago, where it seldom causes serious problems (Rethinam and Singh, 2007). The beetle has recently caused disease-outbreak right across the Asia Pacific including PNG affecting many coconut trees and the copra industry. Other beetle species such as *Tetrastichus brontispae* have been introduced from Solomon Island into East New Britain has cause severe damage to coconut as well.

Pigs are PNG's traditional wealth associated with Papua New Guinea, and some diseases are spread by them

Introduction of new species are causing massive species loss and habitat changes. According to the Melanesian Spearhead Group (MSG), island ecosystems are the most vulnerable where about 70% to 90% of terrestrial species are going extinct (Sherley, 2016). Approximately 53% - 67% of extinction is caused by Invasive Alien Species (IAS), comprising of mainly plants with 89%, animals with 10% and the remaining percentage other taxa. The management of IAS costs around USD$1.4 million annually and its impacts are most observable in the areas of health, agriculture, tourism and trade (Sherley, 2016). Some invasive species introduced to the Pacific including PNG are very aggressive and are discussed briefly below. Some invasive species are hosts to various diseases that can affect humans, for instance, chicken, ducks, pigs and rats.

Some species that are agressive or harmful to the environment in PNG include trees and shrubs namely *Acacias*, African tulip tree (*Spathodea*), wild tamarind (or lead, *Leucaena*), *Lantana camara* (Lantana), guava species (*Psidium*), *Miconia* (velvet tree), red sandalwood tree (*Adenanthera*), Koster's curse (*Clidemia*), *Lantana*, *Sida acuta and Sidar hombifolia,* Giant sensitive plant (*Mimosa pigra*), *Chlomonella*, and *Piper aduncum* are causing issues to local habitats and species (Sherley, 2000). Vines namely mile-a-minute (*Mikania*), passion-fruit species (*Passiflora*), *Merremia* and grasses such as elephant grass (*Pennisetum*), *Paspalum*, including aquatic plants namely water hyacinth (*Eichhornia*) have also done damage to the ecosystems. Some invasive species of plants and animals will be discussed briefly below about their impact on the environment they occupy.

The presence of *Milkania micrantha* is in over 15 provinces has caused substantial damages to gardens and plantations affecting crop yield for instance pawpaw, banana, young cocoa, and palm oil (Day et al., 2012). Figure 3.157 shows more than 20 respondents stated that roughly 30-60% of the yield from subsistence farming and other farming was affected. Another weed, *Chromolaena odorata* was first reported officially in PNG in 1970 on the Gazelle Peninsula of the New Britain Island, but was present earlier in the 1960. *Chromolaena* affects a number of different land uses, namely, oil palm, cocoa and coconut plantations affecting harvesting and production, pastures of cattle grazing areas, subsistence food gardens; disturbed forests, roadsides and fringes of settlements and villages (McFadyen 2002; Orapa et al. 2002; cited in Bofen et al., 2004). *Chromolaena* now occurs mainly lowland areas in 12 provinces, showing varying levels of infestations. Although it was controlled by biological control between 1997 and 2003, it has the potential to spread to other parts of the country.

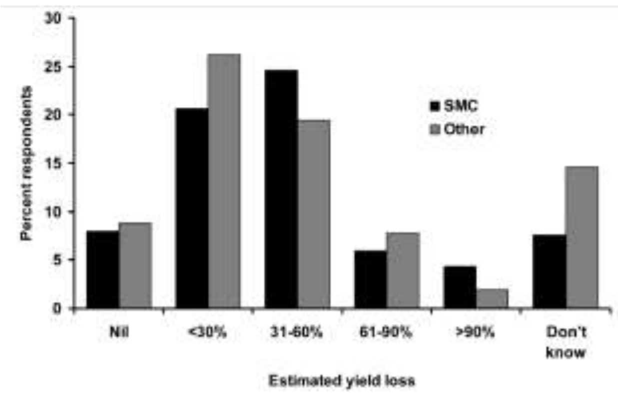


Figure 3.157: Percentage of respondents of subsistence mixed cropping (SMC) and all other cropping practices (Other)who estimated various percentage losses of yield caused by invasive weed, *Mikania micrantha* (Day et al., 2012)

The species such as the water hyacinth (*Eichhornia crassipes)* and *Salvinia molesta* for instance has altered the water column and clog waterways, restricting sunlight to enter the water column, hence causing oxygen deficiency and impact of aquatic life and function (Shearman, 2000). They also severe transportation of riverine people who uses water canals to manoeuvre easily were afeccetd.

The Papuan Black snake is under threat from introduction of cane toads in Port Moresby area (Photo by A. Fraser)

In terms of animals, several species have been introduced recently such as the Rusa deer (*Cervus timorensis*) which was escaped from its famr acrss the boarder from Merauke, Indonesia into Western Province. The species is native to Thailand and is grazing grass species that resulted in invasion of Melaleuca species on on floodplain thus affecting the grazing grasses for local wallaby species such as the Agile Wallaby (*Macorpus agilis*).

Many inland subsistence communities in PNG, face a lack of protein in their diet. As a result fish such as trout *Oncorhynchus mykiss*, carp *Cyprinus carpio*, tilapia *Tilapia rendalli* and *T. mossambicus*, and 'super' tilapia, have been introduced across the country by government agencies, church groups and others to improve the protein source of rural communities from the 1960s to the present. Consequently, these introduced exotic species have often invaded nearby waterways progressively altering the natural ecology, irreversibly.

For instance, within the Sepik River fish stocking projects of exotic fish were implemented in 1987–93 and 1993–97, through a PNG Government and United Nations (UNDP/FAO) partnership. Although these species were selected on the basis of their potential to occupy ecological niches not filled by native fish, the actual impact of these introductions is poorly documented, although there is preliminary evidence that there is a declines of some native species due to the spread of exotics (GoPNG, in press).

The other spread of fish is by fishers themselves who see species as potential protein. For example in the Fly River system it is thought that both climbing perch and walking catfish were introduced by villagers travelling from other parts of the country. Both species are valued as food fish since they can survive out of water for long periods. Villagers travel from village to village carrying fish wrapped in moist leaves, often throwing any excess fish in the nearest waterway. Both climbing perch and walking catfish are also likely to compete with native species for both food and space. There are currently no management plans in force to halt the spread of either introduced species (GoPNG, in press).

In Lake Kutubu WMA (the lake is the second largest lake in PNG and home of 12 endemic rainbow fish), the introduction of Tilapia (*Oreochromis mossambicus*) has resulted in the drop in population of those 12 special fishes below their population carrying capacity. More recently, the Super Tilapia (*O. niloticos*) was introduced and has shown signs of out competing the native species thus affecting their tropic level.

The Stripe Snakehead (*Channa striata)* is a big fish and can feed on anything from fish, frogs, crayfish, snakes and insects thus endangering their population. This species was introduced from Indonesia ‘crawling its way’ into PNG’s main river systems in the Sepik and Western Provinces.

The climbing perch also feed on aquatic invertebrates that can affect the trophic level and food chain thus causing ecological imbalance. The only toad species (*Bofus marinus*) was belived introduced into PNG during the World War II to feed on Mosquitoes. Cane toad exudes toxic liqud from its skin when attached by predations. Eventtually, many species died from it when biting or feeding on it. The population of Papuan Black snakes (*Psuedechis papuanus*) has declined in Port Moresby but in recent times have bounced back probably because Papuan Black snakes have developed resistance over can toads over time.

In terms of economy, invasive species can cause severe impact on production, livelihood and trade and economy. More recently in 2006, 2013 and 2017, the Cocoa Pod Borer (*Conopomorpha cramerella*) and Coffee Berry Borer (*Hypothenemus hampel*) became widespread threats to cocoa and coffee trees across the coastal and lowland provinces and the highlands region of PNG respectively.

In 2008, an outbreak of weevils, *Oribius* spp. (*Coleoptera: Curculionidae*) were reported in the Simbu Province coffee growing areas, destroying coffee cherries by feeding on cherries and foliage of the coffee plant, thus causing substantial losses in the economy and livelihood of the people (NAQIA, 2008). Another unknown pest called the Bogia Coconut Syndrome, associated with Phyoplasma (*circa Zophiuma pulillata*) also emerged in the early 2008 in Madang Province and parts of east Sepik and Morobe Provinces affecting coconuts as well as banana trees.

Impact

Generally, many introduced species become invasive and compete for space, food and available resources with the native species thus displacing them or causing them to go into extinction. In island communities and habitats, the isolation has encourage evolution of unique representation of species, and at the sometime these species are more vulnerable to depredation by invasive species that affects the tropic levels of native species (Primack, eds., 2010). The inability of native species to repose to the aggressive behaviour of invasive may affect them to compete or become resilient.

Eradication of invasive can be difficult because of the high costs involved. Unless the species is detected early and right measures were undertaken, the damage could be tremendous and severe. Hence, the government, through NAQIA, the PNG Cocoa Board, the Coffee Industry Corporation (CIC) and Coconut Cocoa Research Institute (CCRI) and other government agencies such as the Department of Health and CEPA have developed management strategies to contain the spread of the pests through border surveillance work, rehabilitation of plantations, developing new clones that are resistant to the diseases and other management measures to stop the spread. In 2008 for instance, the Avian Flu hit the global news headline and NAQIA was effectively conducting border surveillance work. Currently, the country is yet to develop an Invasive Species Management Staregey for the country. Many areas of the world are strongly affected by exotic species and have responded to develop measures to counteract the problem caused by invasive species.

One of the success story of an invasive species program was in the Sepik River in the 1980s. NAQIA reported that the aquatic weed, *Salvinia molesta*, became a huge problem for the Sepik River and its tributaries and lakes after entering the country in 1962 (Julien and Orapa, 1999). Many river people were affected because the waterways were blocked with massive mats of the weed. Also, aquatic conditions also were affected thus affecting the livelihood of the local population for several years. Finally, the weed was successfully controlled by the introduction of a water weevil (*Neochetina bruchi)* by CSIRO of Australia. Another species the Water Hyacinth (*E. crassipes*) also became a problem but was also successfully contained (e.g. Morata Swamp in Port Moresby). The consequences of these weeds have caused huge ecological, social and economic losses.

Managing or controlling the invasive species is often challenging. Removing exotic species using biological agent, chemical, or by physically removing them can be done. Howvere, it requires time, money and resources. Sometimes control measures such as a biological agent or control and chemical usaged have their own impacts. For instance, when a biological agent is released from its natural range to consume the pest and hopefully control its numbers (Primack, eds., 2010), it can target other native species as well. Hence physical removal or use of chemicals and other measures are sometimes undertaken to control environmental invasive species but the cost if implementation is usually very expensive.

Though some species have be managed or contained using either biological and chemical control, or other methods, some remnants are still present in the environment and may become a threat to native species when the environment become condusive. These invasive pests and diseases can costs the country substantial amount of money in millions of Kina or dollar.

NAQIA concentrates its work in monitoring and controlling the main entry points into PNG across its international borders in vessel/wharf inspection and aircraft/airport (incoming passenger/cargo) inspection. There are strict requirements of items coming into the country such as meat, dairy, eggs, fresh fruit and vegetables, plant and soil, live animals and laboratory material along with some products derived from these (GoPNG, in press).

The main points of maritime entry into PNG are the ports of Port Moresby and Lae and to a lesser degree other coastal marine ports. This is followed by cruise and expeditionary cruise vessels with varying voyages that currently take in Milne Bay, East New Britain and other provinces. Yachts also enter PNG waters such as within the Louisiade Archipelago.

There is also localised coastal traffic between Western Province and Australia through the Torres Strait plus (land and sea) to Indonesia, between West Sepik Province and Indonesia (land and sea) and between the Autonomous Region of Bougainville and the Solomon Islands.

Entry by air is mainly through POM, Jacksons Airport Port Moresby, with near 200,000 passengers in 2015 and 2016 (PNGTPA, 2017) with 50% from Australia & NZ, 25% from Asia and 25% from other points of origin.

NAQIA in Port Moresby has the capacity to inspect near 30% of incoming selected containers to this port. In 2015 a Container X-Ray Scanning facility at the Motukea Wharf in Port Moresby became operational, improving inspection capability.

The border between PNG and Indonesia in the Western Province is currently not well resourced. As a result there is movement of trade across this border especially deer and potentially Piku, Pig Nosed Turtle, that has a market in Indonesia and possibly making its way into illegal wildlife trade (Traffic, 2014; cited in GoPNG, in press).

The PNG-Indonesia land Border is a major biosecurity threat zone because invasive species in the Asian Region which have been introduced into West Papua by Indonesians are able to cross into PNG. Examples include the walking *Anabas* fish, macaque monkeys, several serious invasive plants, coffee berry borer, CRB and cocoa pod borer. There is lack of concerted national coordination to address issues of IAS, including funding sourced to do surveillance work.
Some ports of entry and airports are also likely sources of entry of exotic species which sometimes enter the country undetected. The Solomon Island-PNG boarder is a week link including the Torres Strait and PNG Boarder. However, survelience work in the Torres Strait Island is effective than elsewehere because of effective monitoring by the Australian government qurintine authority.

A wide range of other viruses are entering PNG boarders. For instance, more lately, NAQIA is providing high monitoring for Blue Tongue virus, *Trypanosoma evansi* (Surra) Foot and Mouth virus. In country, pig samples are also tested for Classical Swine Fever, Porcine Reproductory and Respiratory Syndrome Virus, Swine Influenza, Aujeszky's Disease and Transmissible Gastro enteritis virus (NAQIA, 2008). Chicken samples are tested also for Newcastle Disease Virus and Avian Influenza virus. Crocodile samples were tested for *Trichinella* worm and dog samples were tested for *Ehrlichiosis*. NAQS samples from chickens, pigs, and cat were collected and tested as well.

More studies into viruses and bacteria are needed to determine their impacts on the environment and people. History has shown animals such as cats, dogs, pigs, wasps, snakes, cane toad (*Bafus marinus*), and Giant African Snail (*Achatina fulica*) have cause massive losses to the economy, livelihood and biodiversity. Cray fish and other invasive freshwater fish have also equally caused damaging losses to other local species and their habitats.

There is little information on insects and other hard-bodied bugs. Ants also present one of the greatest threats to many native species (not just other insects or bugs), and their effects on native communities have been relatively well-documented. Certain mosquitoes may transmit the one-celled organism which causes avian malaria, one of the major causes of death in PNG. Malaria is currently one of the major causes of deaths in PNG.
It is fortunate that PNG does not have any monkeys and Myna (*Acriotheless tristis*) loose around the country. Their presence would endangered many species, especially birds where their eggs can be preyed upon, including out competiting other species as well in the tropic level.

Rana frog Species at Varirata National Park (Photo by A. Fraser)

Many frogs or amphibian species around the tropics and the world have gone into extinction through the introduction of Amphibian Chytrid Fungus (*Batrachochytrium deondrobatidis*). It appeared in the US in 1961 and Australia in 1978 and yet to enter PNG. The virus originates from Africa. Acording to IUCN, 1,895 of the planet's 6,285 amphibians are in danger of extinction, making them the most threatened group of vertebrates known to date (IUCN, Nature 2009; cited in Bowe et al. 2009).

PNG is the last frontier for frogs and if this fungus enters the country, it is most likely many species in the higher altitude will be lost because the fungus prefer cooler climate in high altitudes, between 600-1200m a.s.l. Figure 3.158 and Figure 3.159 indicates the potential of extinction of PNG frog species could be as high as 73 species, being more prominent with higher altitude families. The Microhylidae may go into extinction with 38 species, Pelodryadidae with 22 species, Ceratobatrachidae with 2 species and Ranidae with 2 species, and 1 each for the other families.

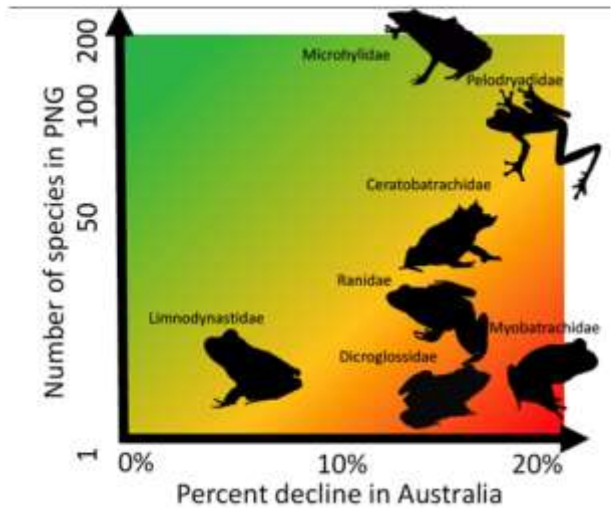


Figure 3.158: Expected frog extinction in PNG and Australia with introduction of Chytrid Fungus (*Batrachochytrium deondrobatidis*). (Source: Bower et al., 2019).

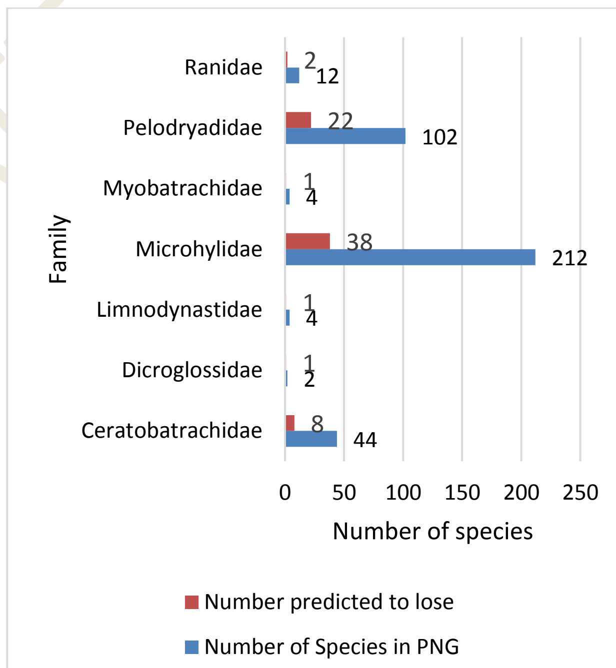


Figure 3.159: Number of Frog species predicted to be lost through introduction of Chytrid Fungus (*Batrachochytrium deondrobatidis*). (Source: Bower et al., 2019)

In conclusion, more studies are required and better strategies needed to be put in place, including resource and funding to tackle invasive or exotic species before PNG loses its biological assets and incurred higher costs on other social and economical values. Some species have already become household species such as the common house rat (*Rattus rattus*) and the Geko (*Hemidactylus frenatus*) feeding on human food and insects respectively and must be well managed before they there is an outbreak of diseases or other issues.

Response and Recommendation

In order to address invasive species, prevention, eradication, containment and asset based protection and management must be encouraged. There is a need for developing an invasive species management strategy for PNG since there is exiting regional and international framework.

Collaboration, capacity building, baseline monitoring and research, awareness, legislation and policy and management action of invasive species are major set-backs that need to be improved. In order to address invasive species, prevention, eradication, containment and asset based protection and management must be encouraged. Most possible measures could include protection of gene bank and *ex-situ* conservation.

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8.8 THEME 7: BUILT ENVIRONMENT-CONSUMPTION & WASTE

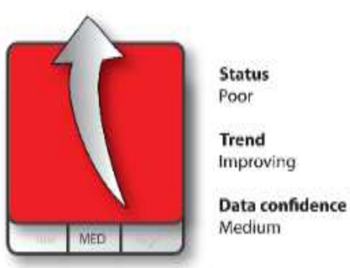
8.8.1 Overview

This chapter gives an overview of the consumption and waste production rate of PNG, waste management and energy consumption. The Report focuses on the status of consumption and waste on; Household waste capture rate, Per capita generation of municipal waste, Household waste recycle, Access to quality sewerage treatment, Transport Energy, Solid and liquid waste management and Energy consumption management. Though data are scattered or readily available, reporting is done on the current condition of each indicators based on the current data and information availability in the country.

The increased exponential potential growth rate in PNG is excreting pressures on the government's and local municipality authority's development and infrastructure plan in meeting the demands and the consumption rate of the people. Since 1980 the population of 3 million people doubled to 7.3 million in 2011 in 31 years (NSO, 2011a). According to the World Bank, 86.96% of population lives in rural areas which most government services are not accessed (Trading Economics, 2016). Between 1980 and 1990 census, the population growth rate was 2.3% but reached 3.1% between the 2000 and 2011 census growing by a massive 40%. It is projected that by 2021, at the current growth rate of 3.1%, the population would reach 10,185,454 (NSO, 2011b). The rural population constitute about 87.5% compared to 12.5% for urban areas in 2011. With increasing urbanisation and pull factors, people have more access to imported goods, including white goods such as fridges, washing machine, and vehicles. The main impact of urbanisation is the strain on accessing better services (e.g. electricity, power, and improve sanitation) given the increasing population.

Although electricity and water supply systems have improve over since 1975, per capita energy consumption has increased as well, so too the demand for better efficiency, services and infrastructures. Waste production and consumption rates highly depends on the population and its demand. The energy consumption and waste production status of PNG is fair but in deteriorating trend based upon the current data provided. Solid (household) and liquid (sewage) wastes are having a negative impact on the environment but there is lack of data to justify this claim. Waste management facilities and recycling rates are inadequate and urban and rural foreshores are polluted by excessive nutrients and fecal coliforms from sewerage discharges.

8.8.2 BUILT ENVIRONMENT-CONSUMPTION AND WASTE HIGHLIGHT

TOPIC	STATUS & TREND	KEY FINDINGS	RESPNONSE & RECOMMENDATION
HOUSEHOLD WATSE CAPTURE RATE		There are no proper storage wastes bins in residential areas. Absence of waste monitoring is evident and many residents are illiterate on waste management.	Installation of proper storage designed waste bins in residential areas (mainly hotspot) are needed. A monitoring strategy should be developed that monitors the residential waste storage areas. More awareness and education programs on waste management. Must be conducted widely using right mediums
PER CAPITA GENERATION OF MANUCIPAL SOLID WASTE		No proper documentation of waste in PNG but annually approximately 102,565 tonnes of wastes are dumped in Baruni in Port Moresby. These wastes cause air and water pollution and may cause degradation of ecosystem and other health issues.	Capacity building is required by respective authority to minimize wastes, supported by awareness raising.
HOUSEHOLD WATSE RECYCLE		Absence of capacity building to recycle, reuse and reduce of waste are common because of lack of facilities for recycling. Hence there is high illiteracy of waste reduction/conversion of waste into other useable resources	Government to support building new recycling facilities in partnership with private entities. Capacity building on importance of wastes, conducting awareness and train locals to generate revenue on waste (waste into resource) must be promoted.
ACCESS TO AND QUALITY OF SEWERAGE		Most sewerage systems are rundown or old that leads to blockage/leakage that need renovation of upgrade. Most urban areas and rural area still use pit toilets which is unhygienic.	There is a need to upgrade old sewerage systems should be rehabilitated and more awareness raising and education of masses of people in using and constructing pit toilet is required.

ENERGY CONSUMPTION		There is a big need for PNG to take a next step to improve or else in the great risk of deteriorating	More need to be done by PNG to prioritized renewable energy sources to replace traditional lighting fuels with high-quality, renewable sources that will replace fuel burning.
TRANSPORT ENERGY		PNG is experiencing high rate in imported used cars resulting in increasing number of privately owned vehicles some of which are not road worthy.	Provide efficient road networks and PMV’ connecting rural and urban areas and within urban areas to reduce increase private transport in reducing more fuel consumption
SOLID AND LIQUID WASTE MANAGEMENT		Solid and liquid waste management needs more data and information of waste generation to design effective technologies to manage.	There is a big need in addressing waste management issues and develop effective strategic plans to help address waste issues.
ENERGY CONSUMPTION		PNG has very potential renewable resources that needs more exploitation in meeting the energy demand for its Country	Effective planning required to cater for the increasing demands through more initiatives in harnessing of our renewable potentials

8.8.3 HOUSEHOLD WASTE CAPTURE RATE

Indicator Definition: Percentage (%) of total household waste captured by authorised provider.

Status and Trend

SDG/CBD Targets

SDG: 11.3.2, 12.3.1, 12.4.1, 12.4.2, 12.4.2, 12.5.1, 12.8.1, 12.1.1

Aichi Target: 3, 4, 8, 10, 14

Status and Trend Discussion

Household waste basically represents all types of wastes that are produced or originated from a household, private homes or apartments. These are basically solid wastes comprising of garbage and rubbishes, such as bottles, cans, clothing, compost, disposables, food packaging, food scraps, newspapers and magazines, and yard trimmings. It may also contain household hazardous waste. Household waste is also called domestic waste or residential waste according to the Business Dictionary (2019).

Household waste is the largest contributing segments of wastes in the urban and rural areas of PNG. Thus, it requires the government or local authority's immediate action or management strategies to accommodate the inevitable household waste in an environmental friendly manner. The aim to reduce other environment, social and economic risks in urban and rural areas of PNG that might occur haphazardly. Identifying the annual rate of the household waste in the land fill may enable the government to develop sustainable waste management strategies in a particular areas. However, currently there is lack of data and information, however if available, the information is too sketchy.

The household waste in PNG accounts for the second largest waste production source after GHG emissions from land-uses and energy sources such as transport and power generation combined. Basically, household wastes come in three categories which are: 1**) Rural residence**: these are mostly customary residential areas where people residing in rural or remote areas of PNG where government services are hardly accessed; 2) **Urban settlement area**: these are mostly unorganized and populated areas in PNG; and 3**) Suburb residential area**: these are areas in urban cities where it mostly organized and government terms and conditions are applied and followed.

Due to lack of availability of reliable information on household wastes in rural areas the Report will focus on household wastes in urban areas, particularly in the capital city of Port Moresby. Urban settlement and suburb residential areas are two major areas that account for almost 90% of household waste (environmental unfriendly) in PNG (NCDC, 2010). Most Papua New Guineans live in rural areas and depend entirely on the natural environment, small scale subsistence agriculture and farming activities to sustain their daily life. Despite most rural areas are highly populated than urban areas of PNG which account for 13.04% of population, serious wastes are not generated from rural residential areas (Trading economics, 2016). Wastes generated in rural areas are biodegradable and are mostly or likely to be used as compost and are environmental friendly if properly disposed. There may be rising usage of other manufactured goods but less compared to urban areas. Most rubbish in rural areas are buried in pits or burned by the residents and are no little concern or uses.

Urban settlements are an integral part of urban areas and its growth accounts for half of households or domestic wastes. With increasing urban drift and economic boom in urban areas, the population growth in settlement areas has also increased rapidly and proportionally to waste generation, which demands better waste management. Hence, the level of waste generation and management is becoming a real concern.

The absence of government or local municipality authority interventions in urban settlements areas are mostly likely to happen because the exponential increase in rate of population may exhausts the government budget or strategies to cater for the people's welfare and needs. However, most authorities usually come up with some basic waste management strategies to control wastes in settlement areas. For instance, all waste are piled along a designated area for a private waste collector to collect weekly

Table 3.21: Volume and waste generators in Port Moresby from January to December, 2003 (NCDC, 2010)

No.	Type of Waste Generators	Monthly Tonnage	Quarterly Tonnage	Yearly Tonnage
1	Settlement	67.20	201.60	806.40
2	Village	48.00	144.00	576.00
3	Public Place Cleaning	230.40	691.20	2,764.80
4	Medical	9.60	28.80	115.20
5	Commercial/Industrial	1,824.00	5,472.00	21,888.00
6	School Waste	12.00	36.00	144.00
7	Domestic/household	2,381.28	7,143.84	28,575.36
8	Others	43.20	129.60	518.40
	TOTAL	**4,615.68**	**13,847.04**	**55,388.16**

Photo 1: Household waste piled along the road for pick up (B. Bito)

The suburb residential areas are an integral part of urban development and are most organized where the standard of living in these areas often meet the government and local municipality authority's standards. These residential areas provide huge amount of waste but are mostly controlled by the government or local municipality.

There are instances where littering are seen outside the city perimeter because some residents probably do not want to pay fees for garbage collection, hence litter elsewhere. Also waste contractors are not picking up waste on time and that triggered illegal dumping of waste elsewhere by residents. PNG has over 21 unregulated disposal sites and two controlled sites located in Lae and Port Moresby (PRIF, 2018).

Table 3.21 provides the summary of waste in Port Moresby in 2003 where waste collected was roughly 55,388.16 ton or 50247.294 tonne per annum (NCDC, 2010). The volume from household and commercial waste are the major sources of wastes with 28,575.35 ton and 21,888.00 ton respectively. The next highest collection comes from public place cleaning with 2,764.80 ton followed by settlement with 806.40 ton. The village collection are from urban villages in Port Moresby where 576.00 ton was collected compared to other solid waste with 518.4 ton. At the bottom of the order, the school and medical waste comprised of 144 ton and 115.2 ton respectively.These waste figures has increased remarkable in the last 19 years. In addition, Figure 3.160 depicts the percentage of tonnage of solid wastes derived from Table 1. Majority of the waste comes from domestic or household and commercial or industrial waste with 51.59% and 39.52 % respectively. Public cleaning wastes constitute of 4.99% of all wastes produced while settlement has 1.46%. Wastes from village comprise of 1.04%, other waste has 0.94%, and schools and medical waste comprised of 0.26% and 0.21% respectively.

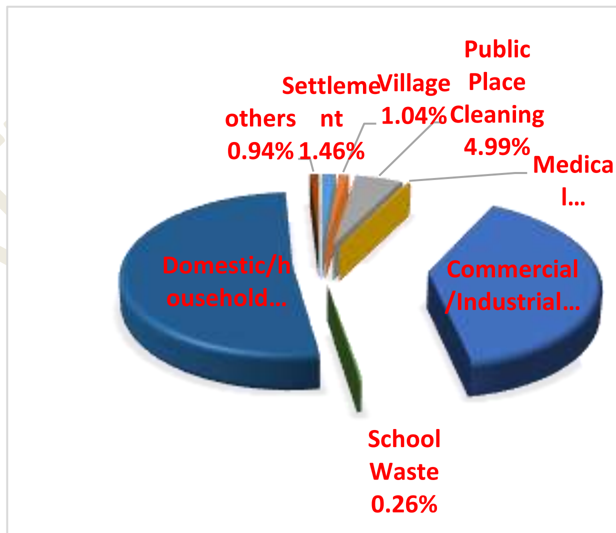


Figure 3.160: Percentage ofvolume of waste generators in Port Moresby, January to December, 2003 (NCDC, 2010)

Since there are no national acounting for wastes, it can be assumed that commercial and household wastes are the major contributors of waste in PNG followed by settlements and rubbish collected from public places. In 2014, material composition of waste collected by the JICA J-Prism Project in Port Moresby show waste are mainly from vegetable or putrescible comprising 31% of all wastes, followed by paper with 19%, plastics with 11 % and others which are less than 10%. Moreover, large amounts of litter also comprise of kitchen waste with 45 tonne, followed by paper with 27 tonne, plastics with 16 tonne, and bettlenut with 8 tonnes (JICA, 2014). In 2018, the J-Prism project recoded some good data for waste in Port Moresby and PNG.

Baruni Dump Land fill (J-Prism project of JICA, 2015)

Figure 3.161 shows the waste flow chart in Port Moresby in 2018 on a daily basis. Total or 100% of waste generated per day is 320 ton (290.299 tonne) per day which is equivalent to 116,800 ton per annum or 105,959.135 tonne per annum (JICA, 2018).

This almost double that of the NCDC record of 2003 stated above. Majority of the wastes come from Household waste with 172.8 ton per day (54%), Commercial waste with 117.5 ton per day (36.7%), Market waste with 24.9 ton per day (7.8%) and Public Area Cleansing with 4.9 ton (1.5%).

From these waste, Self-disposal waste contributes to 9.1 ton per day (2.8%) of total Household waste that has a disposal rate of 5%. In addition, from the total waste generation, material recovery (reuse or recycle) is 0.3 ton per day and 310.6 ton (97.1%) are discharged waste, with a further 3.2 ton per day (1%) recovered, reused or recycled.

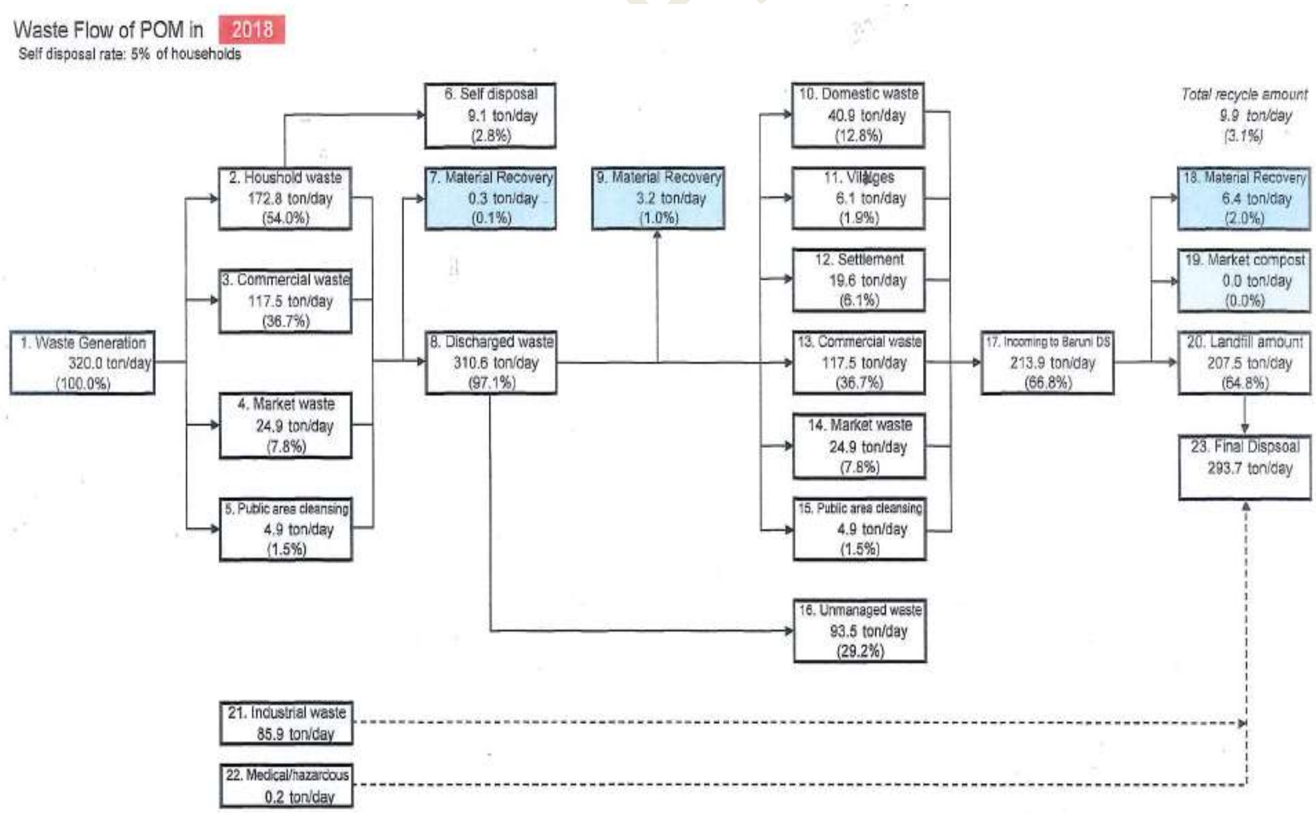


Figure 3.161: Waste flow chart diagram for Port Moresby (JICA J-Prism project, 2018).

The discharged waste comprised of the Domestic 12.8% (40.9 ton/day), Villages with 1.9% (6.1 ton/day), Settlement with 6.1% (19.6 ton/day), commercial with 36.7% (117.5 ton/day), Market with 7.8% (24.9 ton/day), and Public Area cleansing with 1.5% (4.9 ton/day). The Unmanaged waste consist of 29.2% (93.5 ton/day).

Finally, the total waste entering the Baruni Dump is 213.9 ton per day (66.8%). From this, 9.9 ton per day (3.1%) are Material Recovery with 6.4 ton per day (2%) while 0% is market compost. The remaining Landfill amount of 207.5 ton per day (64.8%) is combined with an additional contribution from industrial waste embrace of 85.9 ton per day and medical and hazardous waste supply 0.2 ton per day to produce the final disposal of 293.7 ton into Baruni Dump. Photo 2 shows the landfill area in Baruni Dump. Photo 3 shows a typical coastal village littered with plastic wastes.

Most household waste are stored into the waste storage bin pans or cage located along the main road or outside a residential area. People with no waste storage bins stored their waste mostly in open areas in their backyard or front yard, for the waste collectors contracted by the city authority to collect and transport them to main land field sites.

Plastic waste in a coastal village of Port Moresby (J-Prism, 2014)

The typical waste bin area that most of the urban residential areas and household keep their wastes for the waste collectors to collect, and transport away for disposal at the main land fill. In public places, garbage bins and pans are installed. Most wastes are collected every two days or can be sporadic.

Main waste storage area located around the city (E. James)

A high number of waste bin areas in suburb areas are deprived or are not sustainably designed and built and this allows for dogs to remove waste from the bin pans and spill them everywhere. During rainy seasons, scattered rubbish are wash away thus contributing to pollution of the surrounding environment. There are also instances where most wastes are burnt or disposed into the nearby drains or outside the city perimeter when waste are accumulated in a particular household. Waste contractors either used small trucks or mechanised waste trucks for collecting and transporting wastes to the main land fill.

Photo 5: NCDC Household waste collectors/contractors (Edwin James)

Impact

Wastes are hazardous to human and the surrounding environment when not managed or disposed properly. There are several alarming health issues that arose as a consequences of mismanagement of household wastes (Abul, 2010). When wastes are accumulated in a particular area, it develops bad odour and instigate population boom and transmission of germs and bacteria that causes sickness when transported by parasitic vectors.

Solid waste disposal sites are found on the outskirts of the urban areas, causing children to become sick. This is due to the incubation and proliferation of flies, mosquitoes, and rodents; that, in turn, are disease transmitters that affect population's health, which has its organic defences in a formative and creative state (Abul, 2010).

Burning of household wastes also pollute the air and this affects the surrounding environments and the people. It may become hazardous for people living closer to land fill sites (Martens et al., 1998).

What to do with solid waste has long troubled governments, industries, and individuals. Lack of awareness and education on management of different forms of waste is lacking in most suburb residential area, urban settlement, and rural residents. Separation of rubbish and household waste into different waste forms or types are lacking in PNG because most waste and put into the same rubbish bin.

Consequently, this affects determination of different waste percentage, volume or weight collected by the contractor. Thus a better data collection method and practices must be developed and residents must be made aware in order for PNG can to become resilient to manage its waste.

Response and Recommendations

The best alternative to control household wastes is to come up with long term integrative strategies to manage wastes. The waste in urban residential areas particularly the settlements and suburb areas can be effectively managed. That is, government authorities should:

- Install proper storage bucket or bin pan in every location required in residential areas (mainly hotspot). And make sure waste are not accumulated but picked regularly;
- Develop monitoring strategies basically to monitor the storage bucket and bins to make sure they are emptied by the contractors in a timely basis;
- Carry awareness to reduce unnecessary disposal of wastes in public places and separate wastes into different types; and
- Educate people to reduce waste as possible at the source starting with school children and mothers.

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8.8.4 PER CAPITA GENERATION OF MANUCIPAL WASTE

Indicator Definition: Annual per capita generation of municipal solid waste

Status and Trend

Logging ship at the log pond, Western Province (Photo by W. Mondu)

SDG/CBD Targets

SDG: 9.3.1, 11.1.1,11.3.2, 11a.1, ,12.1.112.3.112.5.1, 12.6.1Status and Tr

Aichi Target: 1,3, 4, 14

Status and Trend Discussion

As PNG's population increases rapidly, the rate of consumption and production of wastes will also increases. Global waste trajectory is projected to peak before the turn of the century in 2100 (Hoorweg et al., 2014). The generation of wastes in most urban areas are becoming an issue because they can become environmental unfriendly and may cause extra burden in terms of managing waste.

At the global scale, waste can be reduced by 30% if a more aggressive sustainable growth is followed rather than current business as usual scenario (Hoorweg et al., 2014). In industrial and developed countries, waste generation is parallel with industrial production, for instance consumption of fossil fuel (Bardi et al., 2014).

In contrast, the increasing economic activities in the urban areas and importation of goods into PNG are driving waste generation escalation in cities. Urban drift may also trigger exponential increase in population in urban areas thus thus causing rise in waste generation. The informal sector in Port Moresby and most parts of PNG provides avenuefor both residents and rural villagers to earning money to make ends meet and to increase their purchasing and selling power. At the end of the day, people then purchase manufactured or local produce and consequently wastes are generated.

Theere are three main source of municipal wastes generated and they are mainly industrial, commercial and household waste. The household sector contributes more wastes than the other two sectors. Since there are no data available, this Report will look at the city of Port Moresby to draw some conclusions.

Port Moresby has only one land fill area called Baruni Dump were all solid wastes in all parts of the city are dumped. Annually, approximately

102,565 tonnes of wastes have been disposed into the landfill and the rate of production of wastes is expected to increase as the population and economic activities increases (Wangi, 2013).

Increasing population in the city has led to increase in informal sectors

In the past years, probably most if not all wastes in Port Moresby were incinerated and this had caused huge pollution in the surrounding environment. This practice has become a serious health and environmental concern to the publicliving closer to the dumpsite. More recently in February 2011, the Japanese International Cooperation Agency (JICA) through the J-Prism project worked with National Capital District Commission (NCDC) to upgrade the landfill at Baruni Dump at a cost of K12.5 million (JICA, 2014). The upgrade of the land fill has minimized the incineration process. In the neighbourhood of Baruni near the National Research Institute at the Rainbow suburb, incineration of hospital wastes is also conducted.

Since the J-PRISM project commenced, three waste audits were conducted in partnership with residents, offices, hotels, supermarkets, wholesalers and retail stores. A good representation of households representing of low, middle and high income levels, and commercial entities were selected and a full day for a week was committed to do the assessment (JICA, 2014).

Figure 3.162 shows material composition of wastes in Port Moresby are mainly vegetable or putrescible comprising 31% of all wastes followed by paper with 19%, plastics with 11 % and others which are less than 10%. Moreover, in NCDC large amounts litter comprise of kitchen waste with 45 tonne, followed by paper with 27 tonne and plastics with 16 tonne. While many of the citizens of NCDC enjoy chewing the bettlenut, about 8 tonnes are produced every day by them.

Furthermore, a waste composition survey was conducted by the NCDC in Port Moresby in 2011. Based on the distribution of primary material groups, it was found that the urban household waste generation rate was 0.36kg per day, comprising over 30% organic waste and over 18.5% plastic waste (PRIF, 2018). The World Bank (2019) estimated PN produces the highest GDP of waste per capita compared to other Pacific island nations at nearly US$19bil (World Bank, 2019).

In June 2018, CEPA launched the plastic waste coastal clean-up campaign under the theme 'beat plastic pollution' and for every month until December visited coastal villages in NCD and Central province collecting plastics. This initiative will eventually lead to banning of plastic bags in PNG in the future.

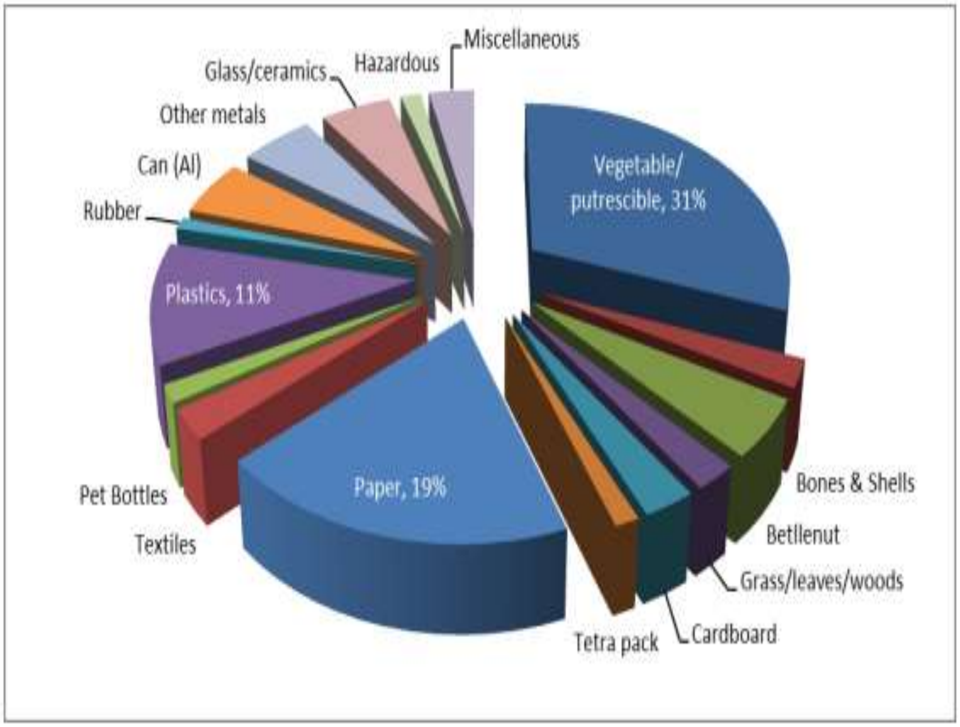

Figure 3.162: The main material composition of solid waste found in Port Moresby (JICA, 2014)

Figure 3.163 shows the physical count of plastic bags washed up onshore and collected from two coastal villages of Boera and Papa outside Port Moresby on two occasions. It shows that the count of plastics varies between 73 and 93 pieces in Boera and 128 and 100 pieces for Papa villages respectively. This trend shows the number of plastic waste collected varies between the periods of two months, however still quite high. These plastic products are either dumped by the villagers whose houses are built over the sea or the waste are coming from other villages or city drainage washed ashore.

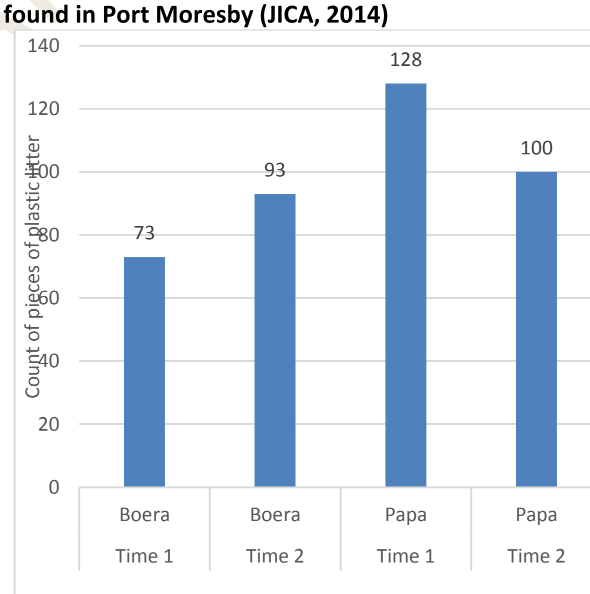

Figure 3.163: Plastic waste collected once from Boera and Papa villages in Port Moresby in the month of October and November 2018 (CEPA, 2018)

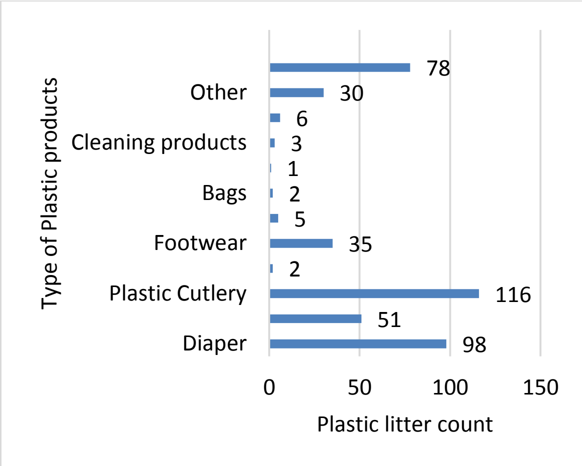

Figure 3.164: Plastic types and litter count for two months for Boera and Papa villages (CEPA, 2018)

From the type of plastic types collected from the two villages, Figure 3.164 shows plastic cutlery wastes are the main waste collected with 116 pieces followed by diaper wastes with 98 pieces followed by others non-categorise wastes with 78 pieces, take-away packages with 51 pieces, footwear with 35 piece and others with 30 pieces each. All other plastic wastes are under 6 pieces collected over the two months by the CEPA team.

This trend portrays variation in the uses of products by each individuals as common disposable items or products. The PNG Environment (Control of Biodegradable Plastic Shopping Bags) Regulation 2010 controls the manufacture and importation of biodegradable plastic bags through the issuance of an environment permit. Bags are required to be labelled and must meet the standards of the CEPA before a full ban is enforced in the future.

Figure 3.165 indicates waste mismanaged or disposed discriminatory in the pacific is highest in PNG with, Solomon Islands, Fiji and Vanuatu compared to other pacific countries. Australia and New Zealand are next after the top four plastic polluters in the pacific. It is predicted to triple in PNG and doubled in all other countries by 2025. Approximately 246t are mismanaged daily with the figure expected to rise from 89,835 tonne in 2010 to 242,328 tonne in 2025. The rate of increase depends on the coastal population of each countries.

In order to understand the wastes from different classes of people, J-Prism found out that the buying power also influences wastes output. Figure 3.166 shows the percentage of waste production by three different class of people in the three districts of Port Moresby (Moresby Northwest, Moresby Northeast and Moresby South) over three years between 2011, 2013 and 2014. The average waste per person per day is 0.38kg/per/day.

However, in 2015, the municipal solid waste amount generated in NCD in 2015 doubled to 0.68 kg/day/person within two years or 281 tonnes/day generated residents of NCD (JICA, 2014). It can be noted that the amount of disposable waste depends on the spending power of each household and the demand or need of products they consume per household. For instance, the high income class generated 40% (0.46kg/per/day) of all waste compared to the middle income and low income earners who both contribute 30% each (0.34kg/person/day).

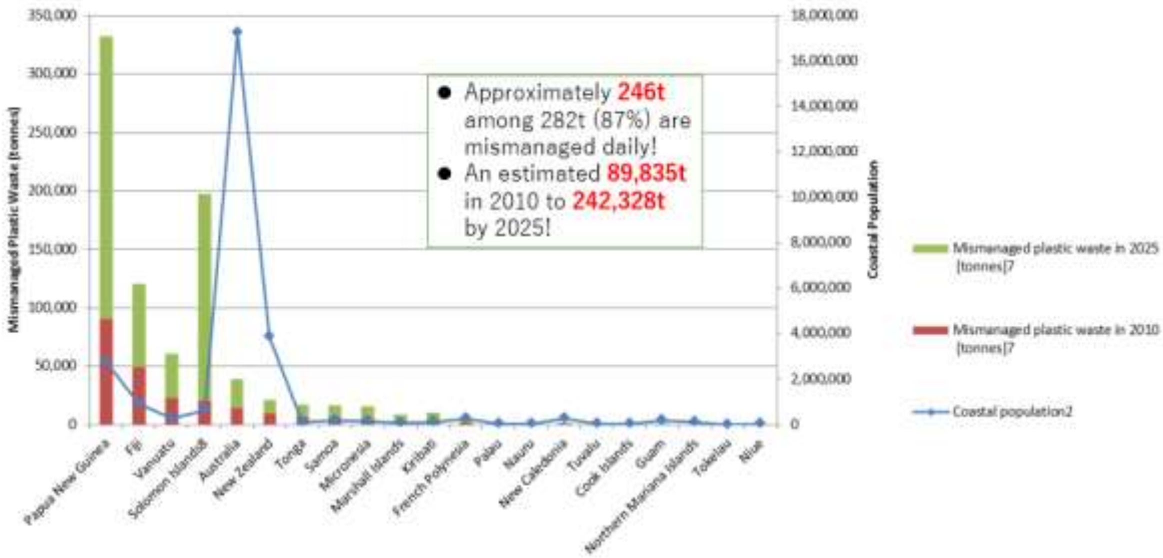

Figure 3.165: Mismanaged plastics in SREP member Countries (Jenna et al. Science, modified by Kelsey, SPREP in 2015)

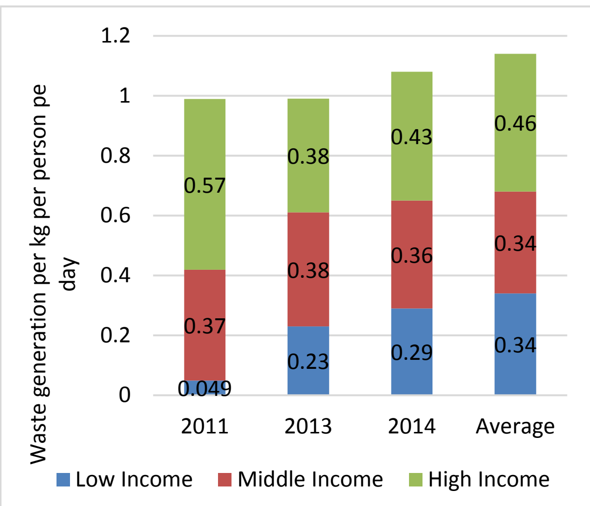

Figure 3.166: Waste per person per kilogram per person per day for different income classess of people in Port Moresby between 2011 and 2014 (JICA, 2014)

Impact

Irresponsible waste management can pose greater threats to the well-being of the people and the surrounding environment. There are some impacts identified as a result of continue improper wastes management. As waste accumulates over longer period of time, it develops germs and viruses that has the potential to affect the health and well-being of people, especially young children and those who are sick. This may result in growing number of people seeking medical assistance as a result of sicknesses and diseases coming from wastes. Accumulation of chemical or solid waste in river system and open areas can also cause the degradation of ecosystem that may result in pollution of marine and aquatic system thus affecting both plants and animals and other ecological functions. Consequently, these issues emerging from waste becomes a threat to the government, which adds more pressure on it to make budget available to fund measures to contain municipality wastes.

Hence, money that were supposed to be used on other development activities and programs will be spent on issues that can be solved or managed at the first place. For instance, dumping of waste, enforcement of bettlenut ban and waste collection in Port Moresby has cost NCDC roughly K13mil per annum (NCDC, 2019). One of the main challenges and contributing factors to the poor management of solid waste is the lack of consistent data on the composition and quantity of solid waste being produced. In order to implement an effective solid waste management program, quantitative data on the composition of waste being within Port Moresby and other centers must be obtained. Lack of responsibility in dumping wastes, awareness and education is also affecting the government or municipality to play its role in curbing waste management.

A basic household survey should be carried out in the wider communities in future to determine how much wastes is consumed, used or purchased on average. Conducting waste audits are ideal for determining the amount of waste such as plastic and other wastes currently being carelessly discarded. Data on consumer habits to compare against the quantity of waste generated as household domestic waste are required but currently are lacking in the country.

Response and Recommendations

In order to minimize unnecessary government spending on waste and other environmental and social threats, it is very important to minimizing wastes. Government or responsible authorities, including NGOs and donor agencies, should conduct more awareness to encourage people to be responsible with their wastes.

Provide capacity building and facilities to authorities as well as residents or locals to minimize unnecessary disposal of wastes and practice better consumption habits. Urban areas should develop sustainable waste management strategies, plans or policies to cater for wastes and shared across the growing cities of PNG. Iindividual municipality governments across PNG must embark on technical capacity building to minimize waste as cities populations are growing.

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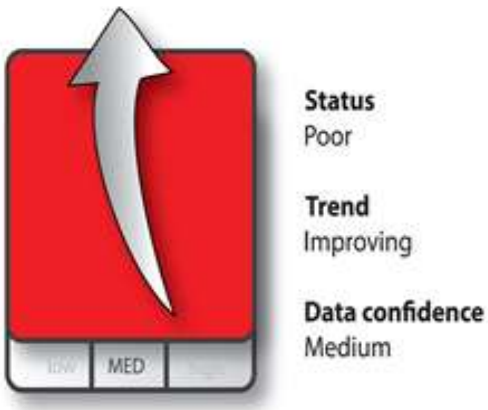
8.8.5 HOUSEHOLD WASTE RECYCLE

Indicator Definition: Waste recycling rate

Status and Trend



SDG/CBD Target

SDG: 9.2.29.3.3, 9.4.1, 9.5.1, 9.b.1, 11.6.1, 12.5.1

Aichi Target: 4, 8

Status and Trend Discussion

Household waste or domestic waste are type of wastes produced by a household or residential area. These wastes are usually dominated by plastic bags and bottles, rag clothes, tin cans, diapers, food waste and many more. Reliable data is not available on the amount and composition of municipal solid waste (MSW) in PNG. The average for all Pacific island countries, including PNG per capita household MSW generation rate could be about 0.45 kilograms (kg) per person per day (ADB, 2014). Since PNG has a high population that most pacific countries, its waste per capital is higher as shown for Port Moresby at 0.68kg per person per day (JICA, 2014). Thus it can be deduced that waste disposal and consumption varies in different parts of the country based on GDP, urbanization rate, population and other factors. In Port Moresby, Lae, and other cities, MSW generation rates are most likely higher than most rural areas which are considerably lower.

Figure 3.167 represents the perception of thoses surveyed and who are responsible for waste collection in Port Moresby and their total evaluation marks in terms of understanding of solid waste management expectations (JICA, 2014). The survey shows an increase of 70% in understanding of solid waste collection by counterparts as individual skills have increase the expection of management of solid waste. In addition, their expection of final disposal of solid waste management is above average at 53% while all other expectations are between 60-68%.

This study shows that with increase in technical capacitiy waste management, waste can be minimised. Hence, more awareness and training is needed for Papua New Guineans to manage solid waste in the country at the manucipality, residential, industrila and settlement, including rural or village level. The need is there for household waste in the country to be managed, recycled and reused. However, most waste are mainly disposed by burning, irresponsible dumping or by disposing them in the major landfilled by the town or city authorities, such as the Baruni dump (Landfill) or in Lae's Second Seven rubbish dump.

Given there are limited availability of data and information, observations and other relevant sources shows that most of the household wastes are not recycled because they are not of use to the people. These wastes are usually burnt or dispose at certain open areas, backyard and into the drains which may result in accumulation of wastes. Despite several labels being displayed on goods for recycling, people normally dispose them as long as their usage has been degraded or the product is used up. There are no incentives for recycling accept few. There are certain metals (copper, aluminium, and scrap metal) and bottles that are sold by people to certain companies who then resell or export them overseas for recycling. This has become a norm for the people living in urban areas. Waste that are of economic use that can be recycled or reuse are plastic containers, bottles, tin cans (aluminium) and waste metal and copper. Waste that are of personal use are plastic containers, waste timer or plywood, rubbish collectors and cardboards. These wastes are usually recycled or reused from the household by the some companies in PNG.

NCDC is keen to improve the level of waste management services, especially in the areas of waste collection. Thus, it recently worked with JICA in the upgrading of the City's only landfill at Baruni Dump to manage the city's waste. On average, NCDC spends up to K13 million a year on waste collection alone. Waste collection services are done for domestic households, business houses, health care facilities (medical waste), settlements, markets, schools, offices, and the Motu-Koita villages. Most of the waste collection services have been outsourced to some 30 waste collection operators who collect wastes on a scheduled roster with NCDC managing their contracts. A more concerted effort by NCDC into the management of Baruni was done in order to making it more controlled to receive all types of wastes. These wastes are now processed, spread, compacted and covered. NCDC is still continuing to make more improvements.

However, it was seen that the waste from Baruni are not recycled. The recycling is mainly done by the scavengers in and around the land fill for their personal use or to resell. Some wastes listed above are carefully collected and used or are stored, intended for accumulation and revenue generation for the scavengers.

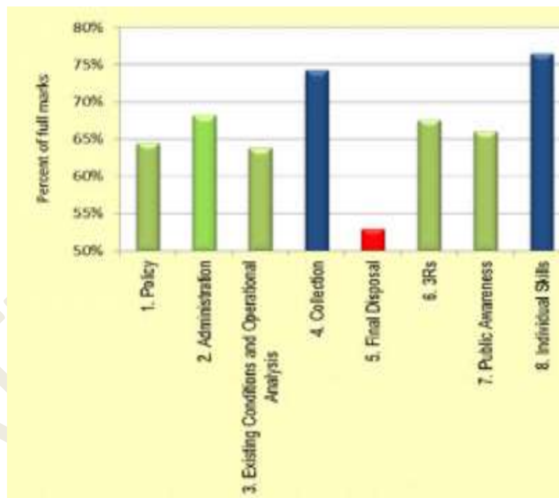


Figure 3.167: Total evaluation marks of the counterparts surveyed in terms of understanding of solid waste management expectations, 3 R= reduce, reuse and recycle or recover (JICA, 2014)

Figure 3.168 shows the material flow chart percentage of PNG's imports and exports of 15 material categories. The study was done over a seven-year period from 2010 to 2016 for imports with exports study of exports done between 2015-2016of for recovered recyclable materials (FRIF, 2018). Imports of beverage containers made of all types of material peaked in 2011, bottles for water, flavoured water and fruit juice have dropped considerably while some (e.g., polymers of ethylene in pellet form, used to make plastic bags), have remained steady. The import of malt beer has remained stable over the years, while aluminium containers have shown a rapid decrease since 2011. Paper and cardboard products have remained steady overall, with the

increase in some paper rolls being offset by a decrease in certain sizes.
Data for e-waste (electrical wastes) is available only for 2011 and 2012, while no data for renewable energy equipment is available.

In terms of exports, a large portion of used motor oil (98%), scrap steel (2%), and small quantities of polyethylene terephthalate (PET) bottles are exported, indicating that a large proportion of imported materials remains on shore.

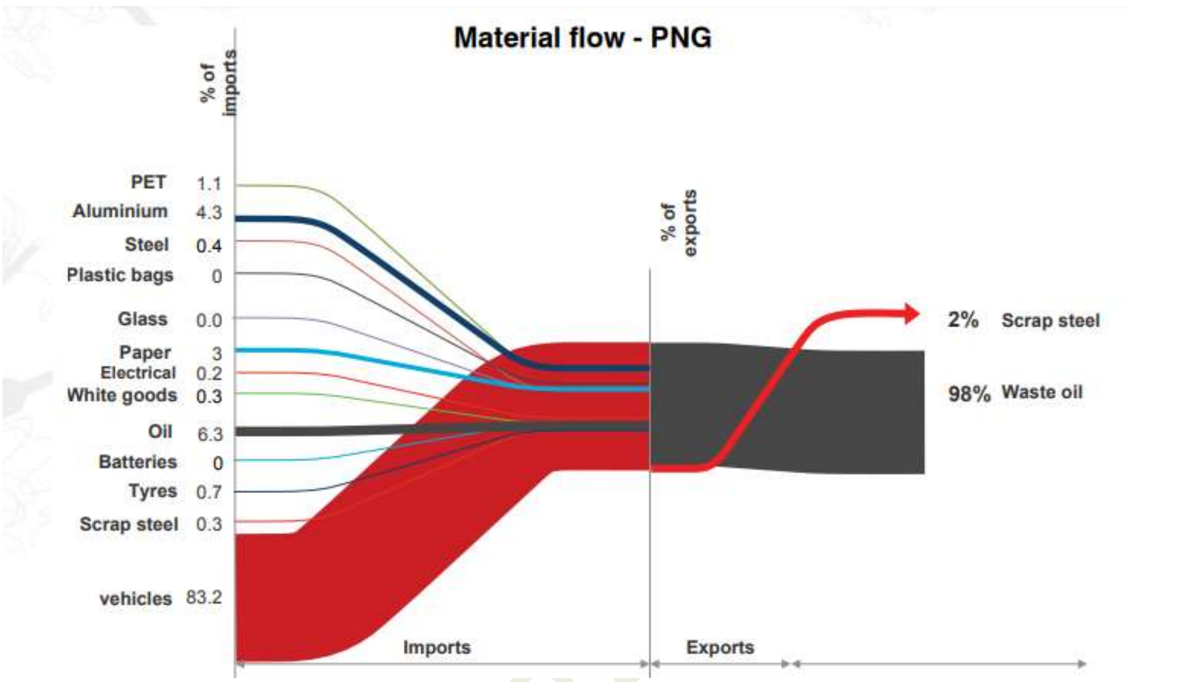


Figure 3.168: Percentage of inflow of imported goods into PNG (Prince Consulting 2017; cited in PRIF, 2018)

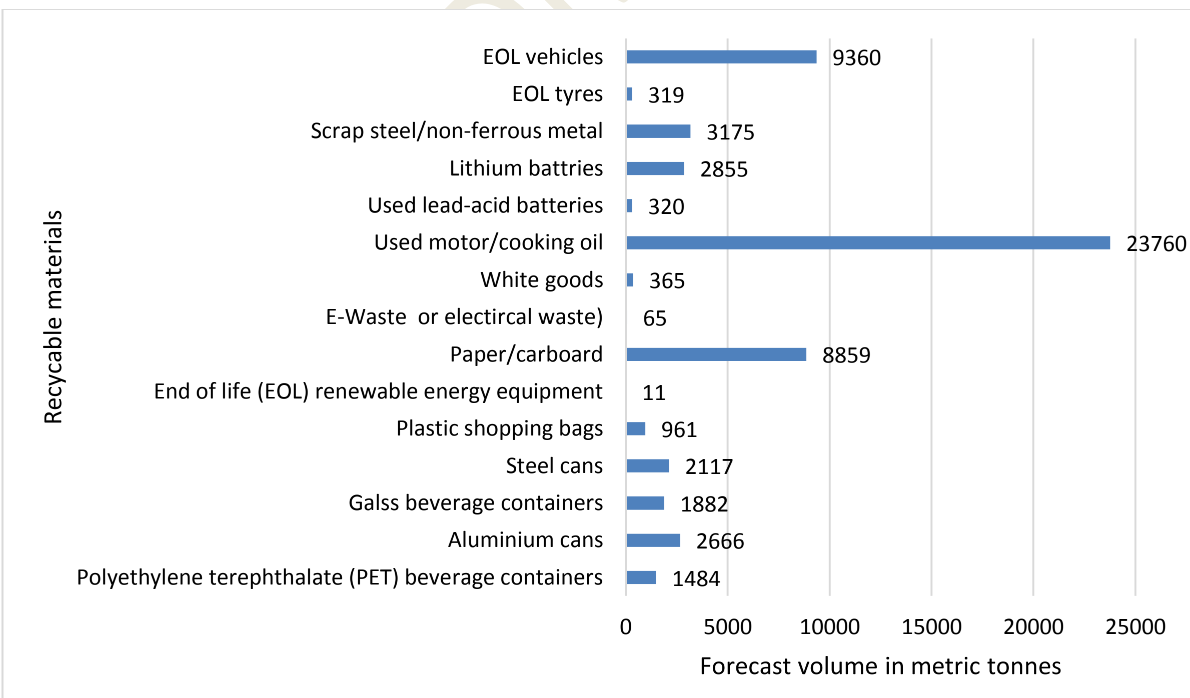


Figure 3.169: Forecast recyclable materials and their metric tonnes (PRIF, 2018)

The number of imported or locally produced goods will grow in the future so too the need for recycling. Figure 3.169 shows the forecast values of 15 recyclable materials in metric tonnes (PRIF, 2018). Used motor/cooking oil has the highest value with 23760 tonnes followed by EOL vehicles with 9360 tonnes, and paper and cardboard with 8859 tonnes. Next biggest contributors are scape metals with 3175 tonnes, Lithium batteries with 2855 tonnes, Aluminium cans with 2666 tonne, glass beverage containers with 1882 tonnes and PET bottles with 1484 tonnes. The remaining materials will increase but at a smaller scale.

In PNG, recycling is a new concept but in recent pasts, bottles (beer and soft drink) have been redeemed for cash and re-used. Tin cans and scape metals and aluminium cans were also collected and redeemed for cash for recycling overseas. Eight years ago in 2011, a PNG owned company based in Port Moresby, known as Total Waste Management, was established and has ventured into waste recycling. The company has been designing and operating a number of engineered landfill across PNG (Business Advantage PNG, 2019). In 2013, the company had shipped over 15 shipping containers of hazardous waste overseas, recycled more than 400,000 plastic water bottles and removed more than 500,000 litres of restricted wastes per annum around Port Moresby alone.

There are two main ways wastes are recycled in PNG. The first is recycling at source and the second is recycling from the land fill. In mining and oil and gas fields, wastes are either recycled on-site or exported overseas for recycling because there are no or lack of recycling facilities in PNG. This is done because of stringent donor and corporate social-environment protocols, however this will not be discussed here in detail. Waste re-used at the site may include restricted or non-restricted waste. For instance, some wastes from the PNG LNG project are buried in large engineered landfills while others are managed by burning in high temperature incinerators or are reuse (non-hazardous) in local communities and school. In addition, up to 1 million litters of waste oil are sent to Australia annually for recycling and more than 2million litres transferred to local businesses for reuse or recycling in country (PNG LNG, 2019). Also, more than 500,000 scrap metals are given to local companies for recycling and wastes tyres for reuse as barrier for wharves, erosion control and land reclamation.

Impact

Wastes need to be reduced in order to protect the well-being of the environment and the people. There are waste impacts such as pollution (e.g. foul odour, visual eyesore, and pollution of stream) and diseases transmitted by vectors that can affect the well-being of the people and the environment in the near future when not reduced or recycled. In the foreseeable future, there is possibility the rate of consumption will increase tandemly with population growth, hence resulting in increasing rate of waste production. As the rate of consumption and production increases, more pressure on the land fill will result in increased burning, consequently emitting more GHG into the air that may affect the condition of the surrounding environment and people.

Lack of education and awareness and responsibility to manage waste by the general public and industries will also impinged the good work of the local municipality where rubbish are disposed-off indiscriminately. Most household and industrial wastes are dumped and not recycled or reuse into other useful products. Hence, when more waste are accumulating, more pressure will be exerted on the governments and local municipality's budget resulting in more spending to curb wastes.

Serious repercussions might occur as well where people, especially sick people, can become affected by the footprint of the waste pollution. In order to avoid the issues arising from waste management and usage, the government and authorities responsible should encourage companies and locals to do waste recycling or built proper facilities and capacity of people to do waste recycling.

Response and Recommendations

Awareness and training on waste recycling, reuse, and waste reduction or management may change the mindset of people, municipalities, and businesses to ensure everyone is responsible for their wastes. Technology that recycle waste must be developed with more focus on a sustainable technology that reduces or convert wastes into energy, and at the same time generating revenue as well.

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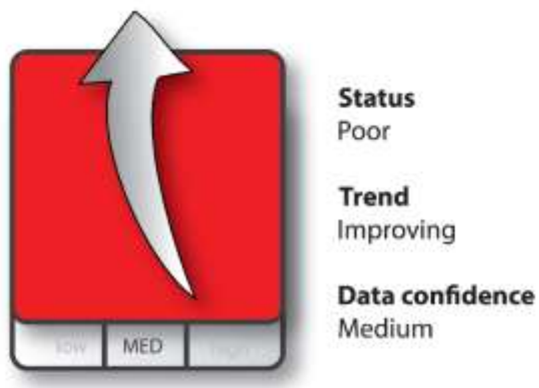
8.8.6 ACCESS TO AND QUALITY OF SEWERAGE TREATMENT

Indicator Definition: Percentage (%) of households connected to central sewage system.

Status and Trend



Joyce Bay Sewerage Treatment plant in Port Moresby South (Photo by JICA, 2019)

SDG/CBD Targets

SDG: 3.9.2, 6.1.1, 6.2.1, 6.3.1, 11.1.1, 12.5.1, 12.6.1

Aichi Target: 3, 4, 5, 8

Status and Trend Discussion

PNG is a developing country of approximately 8 million people. Table 1 shows the life expectation for males and females is 64 and 68 years old respectively. It is a country with high probability of deaths for children under five years old with 53 deaths per 1000 live births being reported and death of young and old people of 15-60 years old is 250 and 191 per 1000 (WHO, 2019). PNG's total health expenditure per capita stands at roughly K109 million, with health alone consist of 4.3% of the total GDP and rising. Table 3.21 tsummaries a breif summary of the health sector.

Table 3.21: PNG national statistics summary (WHO, 2019; https://www.who.int/countries/png/en/)

Total population (2016)	**8,085,000**
Gross national income per capita (PPP international $, 2013)	**2,430**
Life expectancy at birth m/f (years, 2016)	**64/68**
Probability of dying under five (per 1 000 live births, 2017)	**53**
Probability of dying between 15 and 60 years m/f (per 1 000 population, 2016)	**256/191**
Total expenditure on health per capita (Intl $, 2014)	**109**
Total expenditure on health as % of GDP (2014)	**4.3**

Personal hygiene is one of the most important factors in determining the standard of living of a country and population. Since the 20th century, western European health status was primarily determined by environmental factors, especially hygienic conditions and housing standards (de Hollander and Staatsen, 2003). The public health transition to modern way of living has also brought unfavourable social and life-style factors that have gradually become the most significant causes of avoidable health loss.

2005 was the beginning of the "International Decade for Action: Water for Life" with renewed effort to achieve the Millennium Development Goal (MDGS) to reduce half the proportion of the world's population without sustainable access to safe drinking water and sanitation by 2015 (Moe et al., 2006). Unfortunately, PNG did not meet most of its MDG targets because of funding constraints and now a new Agenda 2030 was adopted known as the Sustainable Development Goals. UNICEF and WHO estimate that over 1.1 billion people lack access to improve water supplies and 2.6 billion people lack adequate sanitation. Providing safe and basic sanitation to meet the SDGs will require substantial resources, technology solutions and political will. The PNG Development Strategy Plan 2010-2030 and the MTDS3 also look at improving the health of the population.

Figure 12.170 shows access to sanitation in PNG and the Pacific in urban areas is considerably higher than that in rural areas with Kiribati, PNG and Vanua having the lowest levels of access to a basic sanitation service. Under the WAsH Policy 2015-2030, the government is embarking on improving water and sanitation in PNG. There is also urgent need for improve management of sewage system in PNG.

Figure 3.171 shows the projected demand for faecal sludge management services in PNG and the Pacific region. There is a need for PNG to improve pit or other forms of toilet by 14%, septic tank toilet by 21% and sewer system by 20%. Hence the PNG government has taken measures to address these issues.

Figure 3.172 shows the government development expenditure between 2011 and 2017 under MTDP3. The budget in the health and utilities sectors is focused at 7% and 8% of the national budget respectively (GoPNG, 2018).

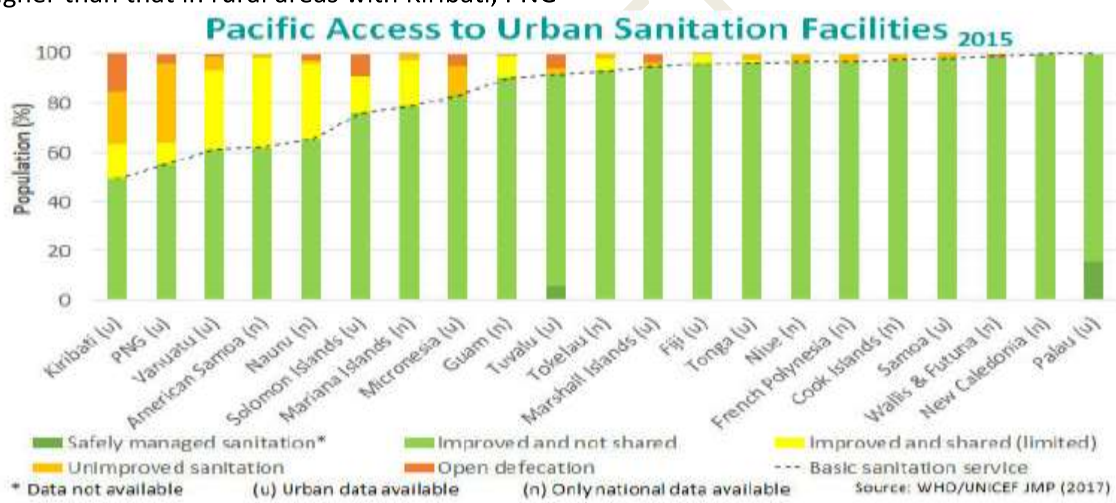


Figure 3.170: Access to basic urban sanitation services in the Pacific countries in 2015 (ADB, 2019)

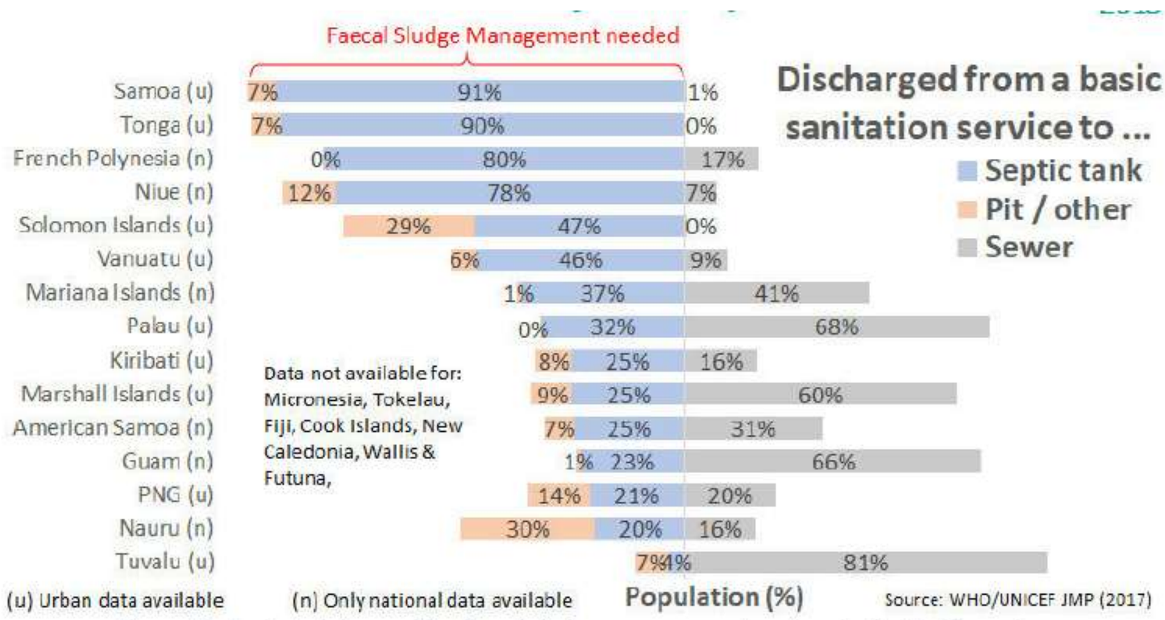


Figure 3.171: Projected demand for faecal sludge management services in PNG and the Pacific region (ADB, 2019)

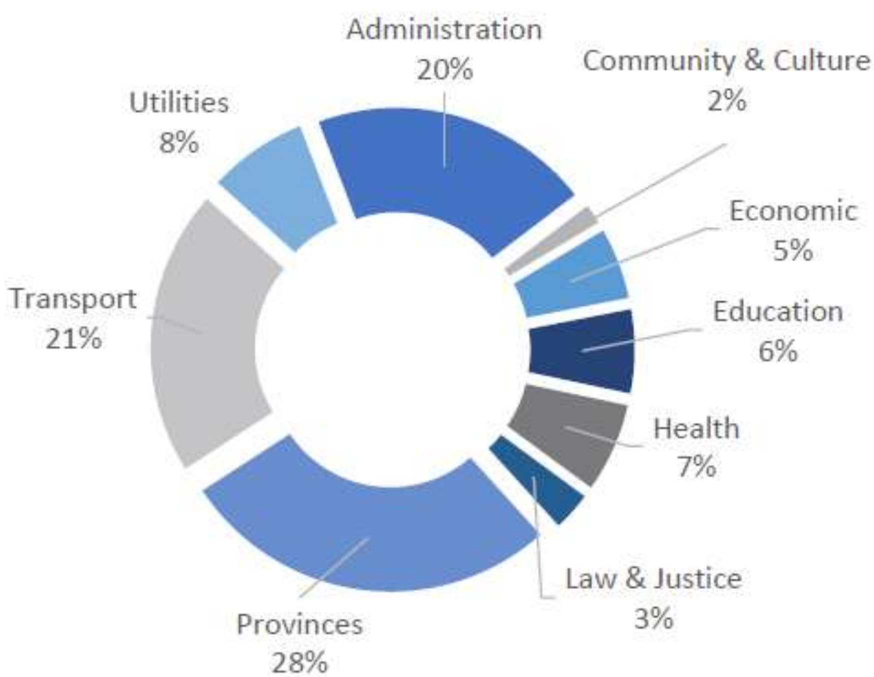


Figure 3.172. PNG government budget development expenditure for 2011-2017 (GoPNG, 2018)

Figure 3.173: Water PNG Operational smajor towns and cities in nineteen sites across PNG (WPNG, 2019)

Table 3.22: Projected budget allocation for implementation of MTDP 3 by sectors (GoPNG, 2018)

MTDP III Sector	MTDP III Sectoral composition	MTDP 3 Requirements					
		2018	2019	2020	2021	2022	Total
Administration	10%	540.8	490.0	556.2	615.3	618.0	2,820.3
Community & Culture	1%	72.8	71.0	75.2	69.8	60.5	349.3
Economic	12%	631.3	686.9	627.9	648.5	648.6	3,243.2
Education	8%	355.9	385.3	446.6	490.7	502.9	2,181.4
Health	9%	462.2	432.7	490.7	520.4	572.5	2,478.4
Law & Justice	5%	183.9	263.3	275.3	240.7	268.3	1,231.3
Provinces	29%	1,343.8	1,493.2	1,586.8	1,640.8	1,691.5	7,756.1
Transport	19%	684.3	809.9	933.9	1,134.4	1,536.7	5,099.2
Utilities	8%	369.1	294.0	371.0	459.7	549.4	2,043.2
Total	**100%**	**4,643.9**	**4,926.2**	**5,363.6**	**5,820.2**	**6,448.5**	**27,202.4**

Table 3.22 indicates the budget is expected to increase between 2018 and 2022 in order for the government to achieve its indicator targets in health and utilities, thus propelling improvement in the quality of life, including water and sanitation.

The government of PNG plans to improve drinking water from 33% to 50% and rural and urban sanitation from 13-20% and 58-80% respectively by 2022 (GoPNG, 2018). Howvere, lack of government intervention or proper urban planning may hamper provision of better water supply and sewerage systems. Like the previous sections, this chapter focuses mainly on Port Moresby. In many developing countries, suitable sewerage system is a major challenge that everyone faces, and most residents use pit or lateral toilet. Access to sanitation between 1990 and 2003 declined slightly from 20% to 19% (GoPNG, 2015). Each year, access to water and sanitation services deteriorates in proportion to the increasing population, meaning that more people are without water supply and sanitation today than they were two decades ago.

Figure 3.173 shows Water PNG (WPNG) is currently operating seven (7) wastewater treatment facilities in the country, mostly in major towns. Lae city has two plants, one at Taraka and another near at the main wharf. Water PNG is also operating 27 sewer pumping stations, with a combined diameter conveyance sewer length of 130 km, of which 75km is pressure sewer and 55 meters is gravity sewer. Almost 90% of the waste treated consist of domestic grey water. There are some industrial waste water and storm water that passes through all these systems, which were designed and built exclusively for domestic waste.

In addition, WPNG only treats wastewater and not solid. Sludge Management and Treatment is very minimal and periodic treat them when there is isolated desludging of biological ponds. WPNG is not involved in any Septic Tank Desludge Business, but few private companies are doing that.

The city of Port Moresby, the nation's capital, like other urban centers across PNG has been experiencing rapid urbanization, instigated primarily by an influx of migrating population and increase socio-economic activities. This trend has increased the volume of sewerage and sewage effluents as well. Consequently, there is a dire need for the existing sewage system to be upgraded in order to reduce, and ultimately prevent untreated sewage from being discharged into the sea or neighbouring environment. Almost half of the population in Port Moresby dispose of their faecal waste via networked wastewater systems (sewerage or storm water drains) of which only 10% is safely transported and treated (ADB, 2019).

The improvement of sewerage system is imperative to save the beautiful yet fragile marine, terrestrial or aquatic ecosystems from being compromised. Improving the sewerage system is one way to protect livelihoods and sources of income of local people who are dependent on their environment especially costal fishery, and to mitigate health risks of contracting infectious diseases resulting from unsanitary conditions.

Generally, the following are basic process used in most reticulated systems to control or manage sewerage systems (SOPAC, 2007). The waste is either: (i) channelled to a fabricated package or pond system for treatment before disposal into a surface water body or (ii) screened, macerated and discharged at depth into the sea through a sub-marine outfall. In major mining, logging and agriculture development camps and towns, reticulated water supply and sewage disposal and treatment facilities are provided.

The main sewerage systems in the Port Moresby is managed and monitored by the Eda Ranu are mostly deprived and neglected. Like many other urban centers, the city encounters frequent backflow or sewerage blockage which takes many months and years with limited remedial actions. However, Eda Ranu is working with the assistance of other donor agencies to rehabilitate and improve the existing sewerage systems in the city.

In some parts of the city, there are proper sewerage treatment plants. In Moresby South, there is an advanced sewerage plant that treats wastes produced in that particular area before being disposed into the nearby environment.

The K400 million Joyce Bay Sewerage Plant funded by JICA is one of the excellent sewerage project in Port Moresby that sustainably cater for sewage in the southern part of Port Moresby and accommodates a large number of population.

Similar sewerage plant should be implemented in all other parts of Port Moresby and the country as well so that wastes are minimized. Another JICA project is now underway to build water supply and treatment plants across PNG.

The Eda Ranu Limited operates the NCD wastewater and sanitation systems. It comprises of biological lagoons and sewerage system that treats wastewater prior to direct discharge into marine at depths below 125m below surface of water or the environment.

The PNG Waterboard operates all systems outside of Port Moresby with combinations of biological lagoons and sewerage systems for treatment and direct disposal into marine environment at various levels below surface water. In the ten towns that the PNG Waterboard operates, there are individual treatment systems for wastewater and sanitation (SOPAC, 2007). The Port Moresby's run down sewerage treatment area (lagoon pond) in Moresby Northeast at Morata swamp is currently undergoing rehabilitation work.

Although Water PNG (WPNG) is operating in most urban centres inPNG, it does not have the full coverage of the towns with sewerage systems. WPNG is currently operating in 14 provincial capitals in Lae, Madang, Mt Hagen, Wewak, Kundiawa, Waback, Alotau, Popondetta Daru, Kokopo, Rabaul, Kimbe, Kavieng and Lorengau. It also has operations in 9 smaller towns namely, Finchaffen, Mutzing, Kainantu, Maprik, Yangoru, Bereina, Kwikila, Bunu and Biala.

Most centers such as Lae, Kimbe, and Kavieng still have majority of residents using a septic system, which is of concern since they depend on groundwater for water supply (SOPAC, 2007). Large residential compounds have small biological waste treatment units constructed to manage the wastewater and sanitation produced.

In Madang and Western province, residents in the New Town area and Daru town still use pan toilets that are regularly collected and disposed at a designated sites for treatment and eventual discharge.

Rehabilitation of Morata Sewerage pond (Eda Ranu, 2018)

Major educational institutions in the country have small sewerage treatment system servicing only their set-ups whereas for institutions in the NCD, all are connected to the city system (SOPAC, 2007). In squatter settlements within and on the fringes of urban areas, most people use standard, poorly constructed pit toilets with only minority using septic toilets. For those using septic toilets, sseparating the grey water from the black water will improve the efficiency of leach pits dramatically increasing the time between empties for septic tanks (ADB, 2019).

In rural areas, pit toilets or direct disposal into the environment (land or marine) is the means of removing human waste. Most rural and urban settlement toilets are pit latrines of the standard variety with minimum allowance for odour and fly control. For dry pit toilets, excessive moisture in the pits destroys the aerobic digestion process rendering the pit contents unsafe (ADB, 2019). Limiting the intrusion of water, improving air flow and reducing their use for just urination will greatly improve the efficiency of dry pit toilets.

For the water borne toilets, ADB (2019) iterates that the high density of the soil in Port Moresby means that all the effluent cannot be absorbed by the leach drains leading to either the discharge of effluent to the storm water or the premature filling of septic tanks with effluent (not sludge). Most incidences of diarrhoea, dysentery and typhoid are directly linked to the poorly designed and constructed pit toilets and improper personal hygiene (SOPAC, 2007). Waste from domesticated and wild animals could also influence poor water quality in rural areas.

Most systems (99%) are biological oxidation ponds and septic systems, utilizing simple but effective biological process to treat all domestic and some industrial waste. In Lae, a mechanical system is in place but there is only primary waste separation before discharge to the sea using the marine outfall. WPNG does not have any high technical mechanical sewerage treatment system in place, except the system developed by JICA in Port Moresby by NCDC.

Table 3.23: The current system and annual discharge volume for both domestic and non-domestic, and trade wastes in PNG

Location	System	System Type	Discharge Volume	No of Connection
LAE	Voco Point/Taraka	Marine Outfall, Waste Separation Only at Voco Point. At Taraka Biological Ponds	4300 ML / Yr.	2,171
Madang	Sewerage Pond	Biological Pond	501 ML/Yr.	143
Mt Hagen	Wara Kum Sewerage Pond	Biological Pond	318 ML/Yr.	421
Alotau	Septic Discharge	Septic	9 ML/Yr.	191
Kundiawa	Sewerage Treatment Plant	Trickling Arm Filtration	21 ML/Yr.	45
Popondetta	Sewerage Treatment Plant	Biological Pond	64 ML/Yr.	17
Kimbe	Sewerage Treatment Plant	Biological Pond	79 ML/Yr.	188
TOTAL			5292 ML/Yr.	3,176

Likewise in all systems, there is not separation of the wastewater accepted, conveyance and, treated. Both industrial and domestic wastewater is treated utilizing the same System. WPNG discharge of treated waste is mostly to inland streams and rivers and in Lae and Port Moresby, as a marine outfall.

Table 3.23 shows the current system and annual discharge volume from both domestic and non-domestic system including trade waste. The current system and annual discharge volume for both domestic and non-domestic and trade waste across PNG ranges from 9-4300 megal liters per year (Ml/yr) depending on the population, connections and the type of system. Most Biological pond systems produces less while marine outfall such as Lae account for the highest with 4300Ml/yr, with the highest connection of users with 2,171 connections.

Annual waste and discharge from sewegae totalled 5292Ml/yr.

It is estimated that 60% of the total wastewater discharged is generated from institution, commercial and industrial areas. In very small operations such as Alotau, Kundiawa, Popondetta and Kimbe, sewer connection is confined to commercial and some institutional properties. Domestic households continue to use septic systems.

Sewarge holding ponds (Photo by Water PNG)

Bigger operations such as Lae, Mt Hagen and, Madang have varying degree of both domestic and non domestic sewer connection. In Lae, a high percentage of the waste is is discharged from industrial and commercial areas, because a larger portion of residential areas are not connected to the sewer system.

Most industries and commercial properties do not have a recycle plant, therefore when there is sewer connection, 100%, of their waste is discharged, to the sewer system.

The capacities of all these systems have not changed since its construction, irrespective of the continuing trend of increases in population and water use. WPNG Investment is Sewerage Projects is negligible compared to its investment in Portable Water Supply Projects.

WPNG does not accept any solid waste into any of its existing sewerage treatment plants. This also includes hard oil and grease cakes or sludge. The disposal of these oil and grease sludge is the responsibility of the generator. WPNG is not involved in any sort of supervision or control and management. It is only responsible for what goes into its sewers and Treatment Plant and the final discharge to the environment from its STPs.

Moreover, WPNG's sludge treatment and disposal is done periodically, where biological ponds are mostly de-sludged after 6-7 years, iven the size and magnitude of operation. All its de-sludged sludges are treated (dry bed) and disposed on site (buried). All septic tank desludging is not handled by WPNG, and it is a private arrangement with the property owner and a contractor. WPNG only accept septic tank effluent disposal at its Solid wates Treatment Plants (STPs).

Currently the government through PNG Water PNG is establishing water supply and sewage facilities in the urban areas throughout the country and has development targets for the next decade. Ideally, in the urban scenario like Port Moresby and Goroka, better facilities are constructed, with the probability that revenue will increase considerably thus enabling Water PNG to re-invest some of the money into improving water supply and sanitation facilities throughout the country.

The mission of WPNG is "t*o be the leading benchmark provider of water supply and sanitation services in Papua New Guinea*". It also has a vision that "*by 2030 75% coverage of all provincial towns will be achived and 60% of all district towns progressing to the ultimate achievement of 100% by 2050*".

The MDTP III (2018-2022) goal 7.4 seeks to improve access to Safe (drinking) Water, Reliable and Affordable Sanitation and Hygiene Facilities through the implementation of the WASH Policy. Achieving 100% sanitation has been targeted in the WASH Policy 2015-2030 as the first of the priorities under Strategy 4 and the MDTP III has prioritised investments to upgrade the Port Moresby Sewerage System as well as establish the National Water Sanitation and Hygiene Authority (ADB, 2019).

Figure 3.174 shows the intergovernmental linkages to implement the WAsH Policy effectively across the country from the national level down to the local level. This program needs partnership with developers, government agencies, NGOs and development partners working together to ensure the DSP 2010-2030 water and sanitation targets are met. The government plans to provide an estimated K302 million (US$ 120 million) annual investment in infrastructure, operations and maintenance to achieve that target (GoPNG, 2015). This could enable reaching the Public Health (Drinking Water) Regulation 1984 standards that was adapted from the WHO International Standards for Drinking Water, 1971 by the PNG government, namely:

- For chlorinated and otherwise disinfected supplies, the water entering the system must have a zero coliform count. Once in the system, 90% of samples taken shall not contain any coliform organisms in any sample of 100ml and no sample should contain more than 10 coliforms/100ml;
- There should be no *E. Coli* in any sample;
- For non-disinfected supplies there should be no *E. Coli* in any sample and no sample shall contain more than three coliform organisms per 100ml; and
- Additional toxic contaminant and aesthetic standards apply and are detailed in the Regulations.

Also improvement of latrine facilities must be undertaken to ensure they are safe, convenient and sustainable followed by good and improved hygiene practices.

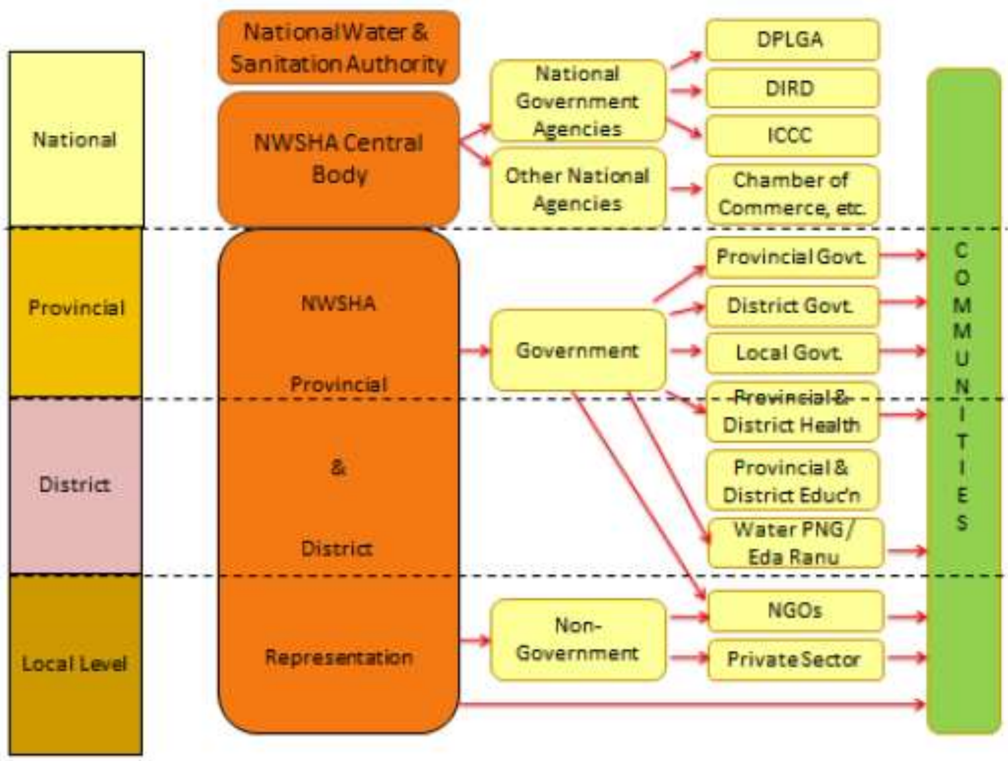


Figure 3.174: Intergovernment linkages to implement the WAsH Policy 2015 (GoPNG, 2015)

Impact

Sewage is one of the most significant sources of marine pollution in urban centres in the Pacific region and has caused critical environmental and public health problems resulting from the disposal of human excrement. Globally, sewage is a major component of marine pollution from land-based activities, which account for roughly three-fourths of all pollutants entering the world oceans (Rapaport, 1995).

Land-based sources of marine pollution are contributing to an alarming decline in the health of the marine ecosystems and their ability to provide for human needs. There are minimal sewerage impacts in the outer islands and isolated communities, mainly due to less human population and feral or domesticated animals however, those villages having toilets over the sea may have some issues. There was a case in Port Moresby at Ela Beach and Ferguson Harbour where *E. Coli* content was very high very high. The laboratory tests of water collected daily from various points along the beach and the Fergusson Harbour area between December 1997 and this March 1998 indicate a strong presence of fecal coliform at 1,000 parts to every 100 milliliter of water at some points (Kuble and Koinia, 1998). The pollution is five to ten times more than the WHO recommended safety limit in recreational waters, which is 100-200 parts of this particular bacteria to every 100 milliliters of water.

In recent time, there was an exponential increase in population of people coming to urban areas and Port Moresby is no exception. The city is expanding at a faster rate, with new settlements emerging, and areas that were once covered with trees and grassland are now being converted into new residential areas. Consequently, this will actually exerted a strain on the government urban planning and financing, which result in absence or decline of important basic government services, including proper sewerage system.

Most areas of Port Moresby are experiencing backflow of sewage as a result of sewerage blockage. The networked wastewater system failures in Port Moresby are caused by the congestion of the sewers with foreign objects and overloading with water. Almost all the other half of the population reside in non-networked or informal settlements using on-site sanitation systems with only 4% safely transported and treated (ADB, 2019).

The on-site sanitation system failures are also primarily caused by the failure to manage the effluent (liquid) rather than the sludge (solids). Figure 3.175 shows the shit flow diagram of urban residential settings in PNG where only 12% of the urban population can be assumed to have access to a 'safely managed' sanitation service (ADB, 2019). The major risks occur to the 50% of urban dwellers that rely on toilets that fail to safely contain faecal waste (predominantly dry pit). The secondary risk occurs to urban dwellers that are exposed to the unsafe transportation of the wastewater of 21% of the population with access to sewers and septic tanks. The tertiary risk occurs in the environmental exposure to the unsafely treated wastewater of 16% of the urban population with access to sewers and septic tanks.

Figure 3.176 shows the shift flow diagram for urban settlement where only 6.8% of the urban population residing within informal settlements can be considered to have access to a 'safely managed' sanitation service (ADB, 2019). The major faecal exposure risk occurs to the 89% of informal settlements that rely on pit toilets which fail to safely contain faecal waste. The secondary risk occurs to the citizens exposed to the unsafe emptying and transportation of the wastewater of the 4.2% of the informal settlements with access to flush toilets.

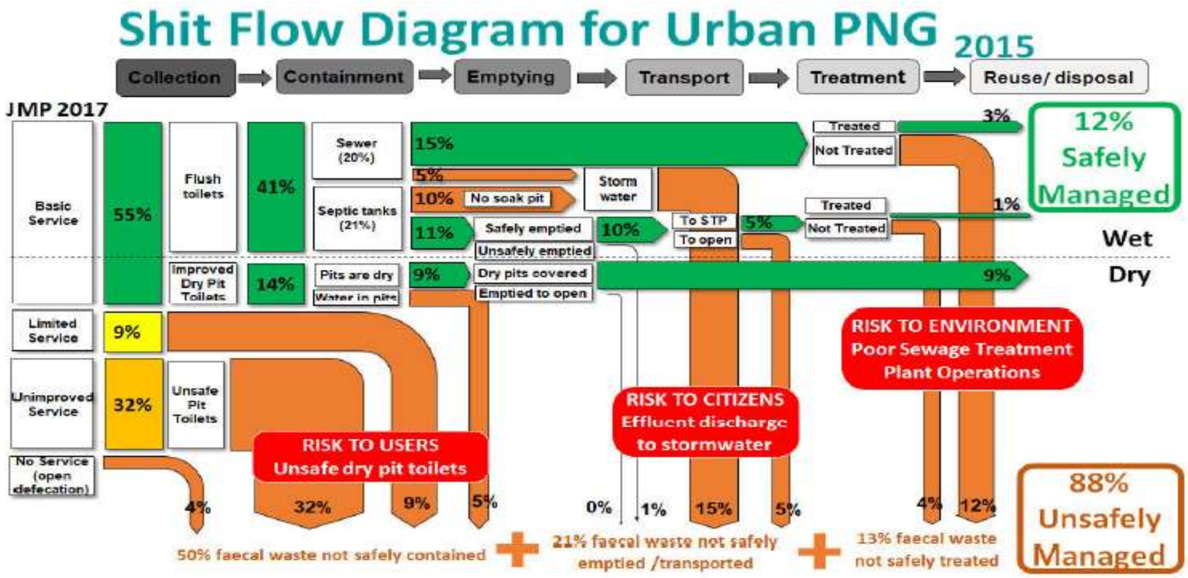


Figure 3.175: Shift flow diagram for urban PNG (ADB, 2019)

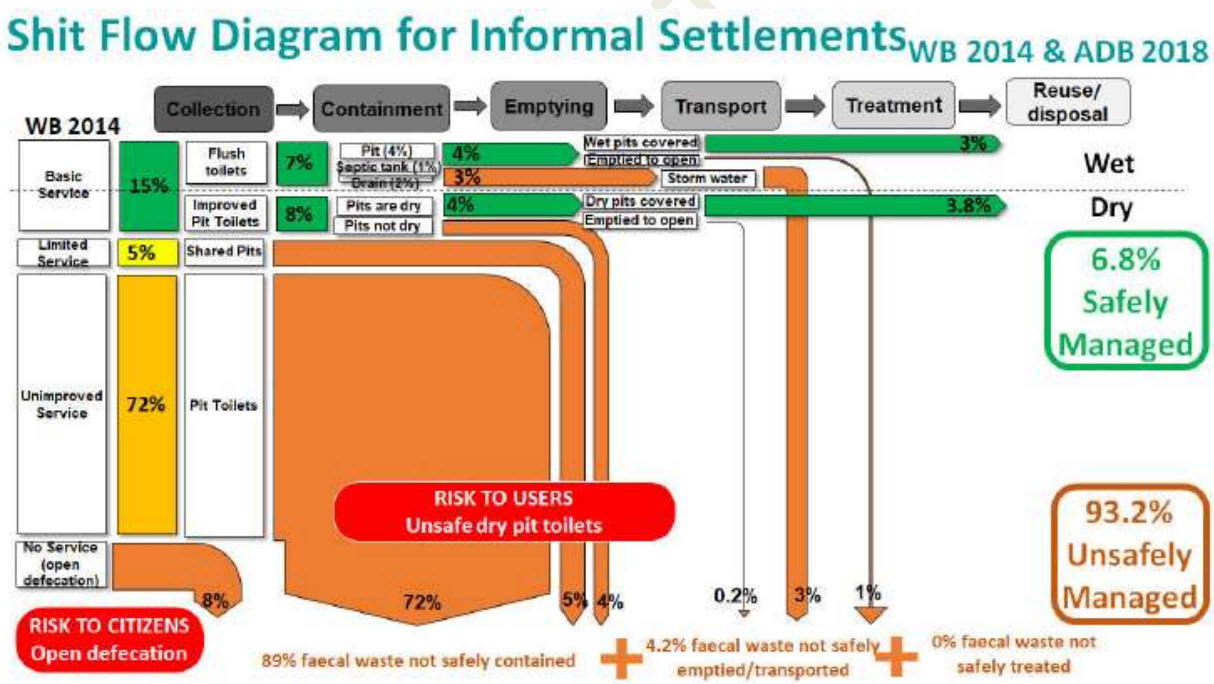


Figure 3.176: Shit flow diagram for urban settlement (ADB, 2019)

The backflow is causing the sewage to flow into the drain system, along the main roads which produces unpleasant smell. Blocked sewage pipe overflow in Port Moresby is a common sight. This is causing nuisance and eye sore for the public and spoils the surrounding environment. As a result of uncontrolled sewerage exposed in the drain systems, it accumulates and has potential to exhaust the carrying capacity of the ecosystem. The accumulation of untreated sewage generates germs and bacteria that can affect the well-being of the community. In the end, the government then spends the extra money it needs to do other things to cater for the affected people.

Blocked and leaked sewage overflowing along the road (By Theckla Gunga, EMTV)

Generally, inadequate sewage disposal, poor sewerage management and sanitation causes eutrophication of coastal waters which are harmful to biota and human wealth (Braga et al., 2000). Dying reefs, pollution of ground wells, spreads vector borne diseases, outbreaks of gastrointestinal disease, and other environment problems are also caused by sewage disposal. D

Dying algae seen in rivers and streams and enrichment of surface waters results also from sewage disposal (e.g. Eppley et al., 1972) can be seen in many places in Port Moresby and the country as a result of bursting sewer pipes and direct disposal. Sewage, and other forms of pollution from land-based activities, add to the degradation of the environment. ADB (2019) states that while networked gravity sewerage systems will continue to form the backbone of the water borne faecal waste management systems in Port Moresby, the effectiveness of both on-site and networked water borne systems could be improved by: -

- Reducing fats, oil & grease (FOG) in wastewater discharges;
- Reducing biodegradable kitchen, laundry and bathroom residues within the wastewater discharges;
- Preventing non-biodegradable sand and plastics from entering wastewater systems;
- Reducing the percentage of water that enters septic tanks and sewers: improves the efficiency of the wastewater transfer and biological treatment systems;
- Improving the isolation of septic tanks and sewerage from the stormwater drains;
- Improving the effectiveness of wastewater treatment facilities; and
- Improving wastewater / faecal sludge transport systems.

Since dry pit toilets will continue to be the dominant faecal sludge management system for urban settlements in Port Moresby (and rural settings throughout PNG), ADB (2019) suggests the design and operation of dry pit systems could be improved by:

- Reducing moisture levels in dry pit latrines;
- Improving air flow within the pit;
- Reducing odour generation; and
- Ensuring that full toilet pits are covered.

The challenge for the government now is to educate the population and improve the design and operation of all systems. The design and management of dry pit to limit the level of moisture within the dry pits is important. In addition, the on-site management of wet faecal sludge from water borne systems is complicated. This is normally influenced by the density of the soil that limits leaching, exacerbated by the large volumes of water supplied to households (with large household sizes increasing the leaching challenge) and compounded by the entry of non-biodegradable products such as fats, detergents, and pads (ADB, 2019).

The inability of the soil to absorb all the septic tank effluent may results in either the effluent being discharged into the storm water drains or the premature filling of septic tanks with liquid. As a result, septic sludge tankers often empty and transport faecal effluent rather than faecal sludge. For networked water borne sewerage systems, they are often stifled by silt, fat and solids, hampered by collapsed or bypassed sections and overloaded by large volumes of wastewater that results in the transfer of faecal waste into the stormwater system (ADB, 2019). This worsens in the wet season when rainwater enters the sewerage system displacing sewage back into the stormwater system.

Response and recommendations

The rundown sewerage system across the country should be rehabilitated, repaired and maintained to avoid any unnecessary leakages. In addition, there should be effective monitoring system in place by respective responsible authorities to minimize any environmental and social issues arising from sewerage systems. In rural communities, more awareness must be done to discourage disposing waste into the streams, rivers or sea and animals kept in enclosures. Also ensure activities and indicators captured in the WAsH Policy 2015 is implemented to reverse the current decline and significantly accelerate access to water and sanitation services thereby promoting long-term hygiene behaviour change.

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8.8.8 TRANSPORT ENERGY

Indicator Definition: Percentage (%) of energy used by the transport sector

Status and Trend

SDG/CDB Targets

SDGs: 7.1.2, 7.2.1, 7.a.1

Aichi Targets: 8, 10

Status and Trend Discussion

PNG is still a country that is yet to be fully connected by effective maritime, land and air transport systems. The challenges are isolation, lack of vital infrastructures and services, geographic barriers and high fuel costs which are hampering the transport sector over decades. The ADB has committed US$ 1.04 bil to aaddress transport and logistical bottlenecks that would enable PNG to reduce time and costs associated with doing trade and improve domestic infrastructure and services (ADB, 2018). ADB was instrumental in delivering to make it safer and more efficient thus meeting international standards between rural areas, urban centers and international destinations. Infrastructure spending in PNG potentially play an important role in economic growth (Lowy Institute, 2013), and in recent years, expenditures on transport sector upgrade and rehabilitation have risen dramatically in recent years.

The growing Papua New Guinea's economic development in demand for quality coverage of state transport network for trade, services and the travelling public. Currently, PNG has one of the lowest road densities in the world where the total road network is 30 000 kilometres (km), of which 8460 km are state roads. Only 28% of the 8460 km of state roads are in a good condition in 2010. A comprehensive program of rehabilitating existing roads and constructing new roads would expand the state road network to 25,000 km by 2035 (GoPNG, 2010). 28.7% (2512km) of road are in good condition and by 2030, the government plans to improve the road 100% because thousands of kilometres of roads have not been maintained. Congestion on roads in the urban areas will be a growing issue as the number of passenger vehicles is expected to increase rapidly with rising income levels growing demand.

Studies have also indicate that road transport is amongst the sectors most vulnerable to climate change (Lowy Institute, 2013; ADB, 2018). Over the years, major road infrastructures have collapsed or deteriorated. Some parts of the country are yet to be connected by roads. The Highlands region is a major contributor to the PNG economy through its agricultural and mineral exports. It is also home to 40% of the country's population, who rely almost entirely on the road network for movement of people and goods. The government and its development partners have invested significantly in improving the road network (ADB, 2018). However, a lack of regular maintenance has led to an overall degradation of the Highlands core road network. The same scenario is the trend right across the country where most provinces are in dire need for assistances from the government and other development partners.

Vulnerability to climatic events is also uniquely pronounced for PNG's 800,000 coastal villagers, due to their reliance on small ports for the timely delivery of perishable food (ADB, 2018). About 60% of maritime population depend on water transportation for the delivery of goods and services. The water transport system's services and infrastructure will also require upgrading. Port Moresby, Lae and Kimbe are the economy's busiest seaports, accounting for more than 80% of its cargo. Between 2010 and 2035 it is projected the cargo throughput at all Papua New Guinea's ports will increase five-fold under rapid development (GoPNG, 2010).

It is also projected that cargo throughput at all of PNG's ports will increase five-fold by 2030. The aim to improve coastal shipping is to ensure it comes safer and more efficient, and passenger capacity will increase. Domestic benefits include greater access to goods, services, and economic opportunity, while the region will benefit from safer, more efficient trade.

Meanwhile, the aviation industry will continue to play a vital role in the development of the country. For many remote parts of Papua New Guinea, air transport is their only possible link with the main centres. However, most regional airports do not meet international standards and need to be developed to handle larger planes and increased passenger numbers. Safety standards would be s improve by 70% where the airports can handle larger planes and increasing passenger numbers. Work is now currently underway for upgrading of most urban airports and rural airstrip.

The PNG's aviation industry also provides essential support for tourism, business, trade, and social cohesion. However, deteriorating infrastructure and constrained institutional capacity threaten the certification of many of PNG's airports. The Civil Aviation Authority's development plan provides a framework for addressing existing gaps, but the agency requires technical and financial support to implement them successfully (ADB, 2018). The Civil Aviation Development Investment Program (CADIOP) was approved in December 2009 to address critical constraints. It comprises a total of four tranches, with a total funding allocation of approximately $480 million. The investment program is overseeing upgrades to 19 priority national airports, supporting institutional reform, and building public and private sector capacity to ensure the long-term maintenance of all corresponding infrastructure.

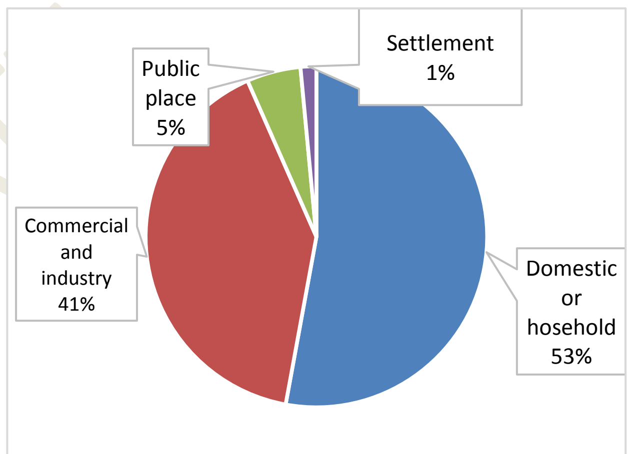


Figure 3.177: Major Transport energy requirement by sectors (EU, 2016)

Given the status of the transport sector, improvement in infrastructure and efficiency would also lead to rising energy consumption. Given the increase in infrastructure development, the need for uses of effective transport systems has also increase. This means the amount of GHG and other ODS emissions are also increasing rapidly. Use of fossil fuel and air conditions in different transport mode will also increase. Figure 3.177 shows land transport is the major energy user with 73%, followed equally by marine and aviation sector with 13%

each and other transport modes with 1%. Currently PNG is experiencing high rate in privately owned cars as a result of increased importation of cheaper used car that can be purchased at affordable price. This is seen in the increase in the number of land transport consuming more energy than combined with air and sea transport. The energy demand in the transport sector is expected to increase at an average annual rate of 2.3% over time (Lowy Institute, 2013). This demand will be met almost entirely by oil-derived fuels.

Hence, the need for promoting renewable sources of energy, review current mitigation policies, create subsidies for transport systems and increase awareness and education are some important options.

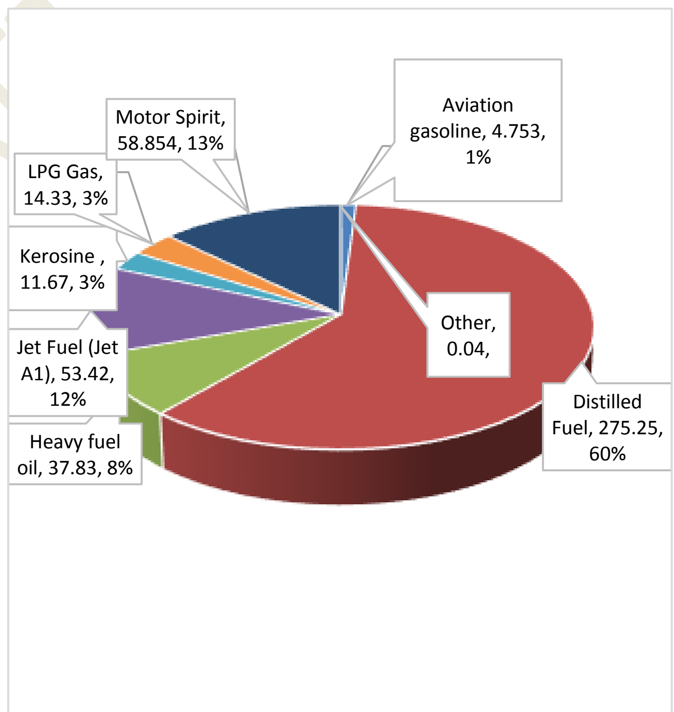
Figure 3.178 a shows the importation of fuel into PNG in 1997 whereas Figure 3.178b is for the year 2000. The major fuel imported into the country is Distilled Fuel which increases by 26% from 60% (275.25 mil L) to 86% (672.27 mil L). The next highest fuel imported comes from Heavy Fuel which decreases by 1% from 8% (37.83 mil L) in 1997 to 7% (50.96 mil L) in 2000. Motor Spirit made a big drop from 13% (58.58 mil L) in 1997 to 1% (4.91 Mil L) in 2000. Gasoline and Jet Fuel dropped from 1% (4.75 mil L) to 0.04% (1.69 mil L) and 12% (53.42 mil L) to 4% (28.51 mil L) from 1997 to 2000 respectively.

The PNG government has already made a commitment for PNG to "decrease GHG emissions at least 50% before 2030 while becoming carbon neutral before 2050" (GOPNG, 2014). This mean PNG has to reduce its carbon footprint from the transport sector as well which is one of the major contributor to GHG emissions in PNG.

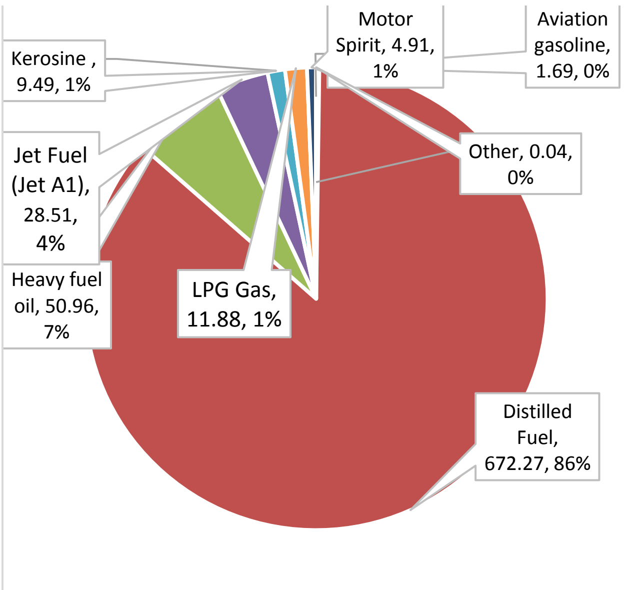
The use of fossil fuels in the country is mostly in power generation and transportation. While transportation is totally dependent on it, power generation is heavily weighted towards it too. Transport accounts for approximately 60% of all imported liquid fuels into the country for domestic consumption. Air and water transport uses approximately 20 to 10 % respectively for all transport fuels ADB, 2018).

However, road transport is a major user of imported fuels, especially petrol followed by diesel. With an increase in the number of privately owned vehicles in PNG, this has contributed to the high increase in fuel consumption rate of the country.

A total of 2436.2 Gg CO2e- GHG emission was emitted using different fuel types in 2000, with the major fuel type used is the LPG followed by gasoline and gas/diesel oil (GoPNG, 2014).These fuel are mainly used by the transport sector with the bunker fuels GHG estimate for year 2000 for aviation and marine industry is 144.5 Gg CO_2e-.



(a)



(b)

Figure 3.178: Petroleum fuel imports to Papua New Guinea in 1997 (a) and 200B in millions of litres (Figures from PNG Customs and DPE; cited in GoPNG, 2014)

Overall, the commercial energy demand for PNG in 2000 364 ktoe. The industry sector accounts for 60%, transport 17% and agriculture/residential/commercial use with 24%. The Petroleum industry provided 40% of energy consumption and other energy forms (mainly electricity) constitute 60% (GoPNG, 2014).

The government must guard the economy against exogenous shocks

A service station working refuelling a vehicle

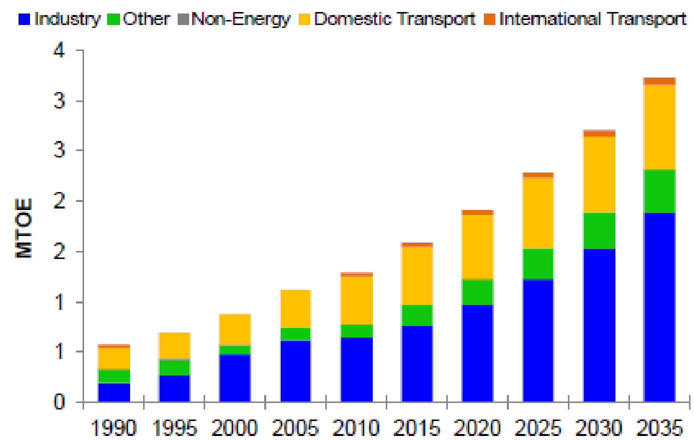


Figure 3.179: Projection of business as usual (BAU) energy demand for different sectors for PNG from 1990 to 2035 (APEC, 2013)

Policies that captures energy are Vision 2050, MTDS 3, PNG National Energy Policy 2016-2020, and the National Climate Compatible Development Management Policy 2014 provides the platform to address transport energy. Figure 3 .180 shows the business-as-usual (BAU) final energy demand is expected to grow at 3.8% per year over the outlook period. The industry sector will account for 59% of final demand in 2035. Final energy intensity is expected to decline by about 28% between 2005 and 2035, with the industry, transport and services sectors projected to see a substantial improvement in their energy intensity. For the transport sector the final energy demand is expected to increase at an average annual rate of 2.3% until 2035. This demand will be met almost entirely by oil-derived fuels.

PNG is also expected to increase its energy consumption. Figure 3.181 shows PNG's primary energy supply between 2010–2035 is projected to grow at an annual rate of 4.5%. Oil, which was the predominant form of energy before 2010, will be increasingly supplemented with natural gas and new renewable energy (NRE), mainly geothermal. PNG has historically been a modest oil exporter, but could become an oil importer after 2020 (APEC, 2015). Furthermore, Figure 3.180 shows PNG's CO_2 emissions from the combustion of fuels are projected to reach 14.8 million tonnes in 2035, roughly 2.8 times increase from the 2010 level of 5.5 million tonnes. In 2035, electricity generation and other transformation (primarily own-use in LNG liquefaction plants) are projected to contribute the largest shares of CO_2 emissions with 4.0 million and 4.2 million tonnes, respectively, followed by industry with 3.6 million tonnes and transport with 2.5 million tonnes (APEC, 2013).

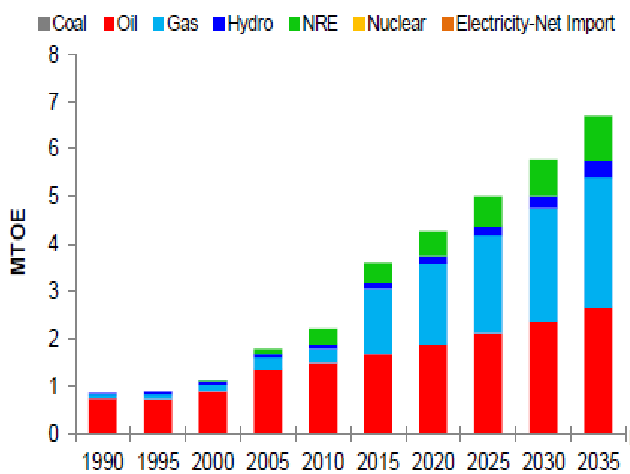


Figure 3.180: Projection of business as usual (BAU) of primary energy supply for different energy sources for PNG from 1990 to 2035 (APEC, 2013)

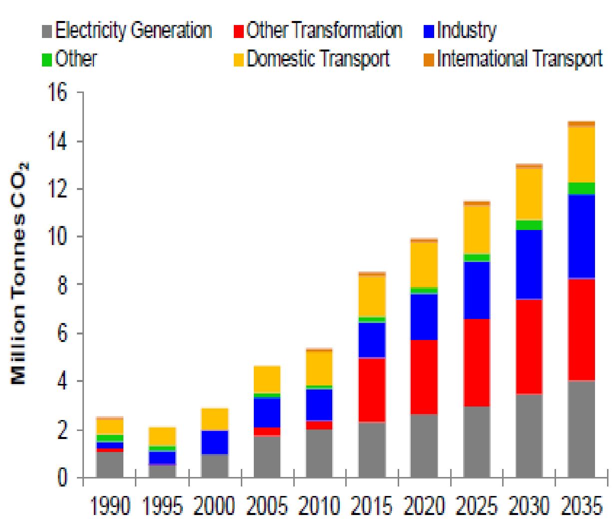


Figure 3.181: Projection of business as usual (BAU) of CO_2 emission for various sector for PNG from 1990 to 2035 (APEC, 2013)

Impact

PNG's economic development requires considerable growth in the coverage and quality of its state of transport network. Although, PNG has one of the lowest road densities, including uses of plane air and sea transport in the world, the transport requirements in rural areas is very high due poor road conditions and accessibility while urban centres experience an increase number in transport usage in urban centres.

PNG need to improve its monitoring of imports of used vehicles into the country in concern to the safety of the people and have regulations in place in monitoring and controlling of road worthy and fuel efficient vehicles. Almost 83.2% of all import into the country are related to transport (PRIF, 2018).

Despite transport having the main infrastructure and development focus of the country development plans, effective measures should be taken in considering the increase net output of CO_2 emissions and effects when addressing climate change issues. This means effective GHG inventory must be conducted to verify the underlining importance of the trasnport sector in economic development. When such data are available, the governmentcan be able to make inform decisions to give priority attention on reducing GHGs emission to achieve economic and environment sustainability.

Energy consupmtion is also third highest in the transport sector. Uses of clean fuel and improvement in technology can reduce GHG emissions from cars.

Response and Recommendations

PNG is still behind venturing into efficient and clean energy trasport systems. Howvere it is not too late but more appropriate that a major reveiew of transport uses, fuel effciency and demand need to be address by the Department of Transport and other government authorities.

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8.8.9 SOLID AND LIQUID WASTE MANAGEMENT

Indicator Definition: Percentage (%) of solid and liquid waste generated and managed

Status and Trend

Baruni landfill, Port Moresby (Photo by J-Prism)

SDG/CBD Targets

SDG: 12.1.1, 12.2.2.1, 12.2.2, 12.4.1, 12.4.2, 12.5.1

Aichi target: 1, 2, , 45, 7, 8

Status and Trend Discussion

Waste management is widely recognised as a major concern for Pacific Island Countries (PICs) as the generation and disposal of waste has direct and indirect linkages to economic development. Nonetheless, reliable data on waste generation and composition is scattered or not available, especially on the amount and composition of municipal solid and liquid waste for all provincial centers in PNG.

However, going by the average for all Pacific island countries, it may be inferred that PNG's per capita waste generation rate could be about 0.45 kilograms (kg) per person per day. There has been alternative integrated solid waste management systems been developed slowly in certain provincial centers in PNG that emphasizing source segregation, collection, composting, reuse, recycling and resource recovery as well as collection, transfer and disposal to landfill. However, PNG is still far way behind in this development compared to the rest of the world.

A survey estimated that the average daily waste generated by the domestic, commercial and industrial sector varied between 0.21 to 0.39kg/person/day, of which over 53% is biodegradable (NCDC, 2011). Discussions with the National Capital District Commission (NCDC) and Department of Environment and Conservation (CEPA), highlighted that PNG does not have detailed up-to-date data on solid waste nor liquid waste. Data on solid and liquid wastes in the mining and oil and gas sector, plus other industrial sectors such as forestry, agriculture, manufacturing and others are lacking or not readily available. Hence, appropriate statistics or information cannot be provided herein this report.

PNG produces almost 31% of all organic wastes in the Pacific. In the Pacific, PNG produces 31% of organic food waste, PNG has no data for glass and metal but could be less than 6 and 14% respectively for pacific average, cardboard at 16% and plastic waste at 10% and for rubber at 4% of all waste (World Bank, 2019). Assuming this average Municipality Solid Waste (MSW) generation rate and the current population, the national household generation is over 3,000 tonness per day, or over one million tons per year (ADB, 2018).

From 2012 until 2030, assuming nominal per capita generation and population growth, PNG is expected to generate in excess of 20 million tonnes of household MSW. On the composition of PNG's MSW, although national data is not available, information from other Pacific island countries indicates that it is likely to contain significant proportions of organic material (possibly up to 60%). Port Moresby likely generates about 135 tons per day of household MSW, equivalent to over 50,000 tons per year (ADB, 2018).

PNG is most likely to have the highest per capita waste generation, at 0.9 kg/person/day. While the generation of waste is growing, the percentage of waste disposed of properly, or recycled, remains much lower. The number of unauthorised dumpsites in PNG is not known.

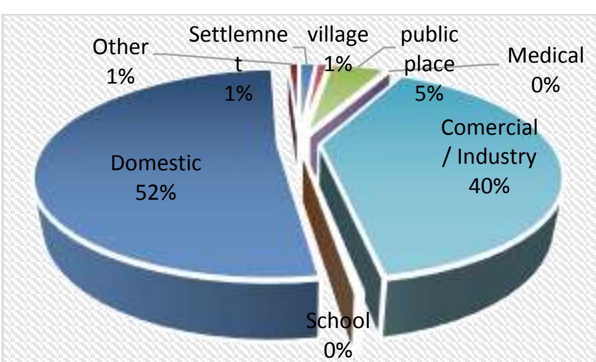

Figure 3.182: Solid Waste in Port Moresby (NCDC, 2011)

Figure 3.182 shows all waste sources in Port Moresby with solid waste comprising of 52% which is the highest of all solid waste followed by commercial and industrial waste making up the next highest percentage of 42%. Littering in public places comprised of a significant source with 5%, with settlement, village and other sources with 1% each. Schools and medical wastes minute and are lower than 1%.

The NCDC in Port Moresby, in 2012, allocated an annual budget of over K10 million (US$3.15m) earmarked for solid waste operations and services. The funds originated from revenue sources, such as land taxes, license fees, and solid waste service fees levied to residents of titled properties at K33.00 (US$10.38) per month and paid quarterly for an 80 litre waste bin. Only around 50% of the levies are collected, however, and the large population living in settlements in the city that does not have access to collection services pays no levy (PRIF, 2018).

Moreover, Tipping fees are applied at the Baruni Dump, at approximately K52.00 (US$18) per truckload. In PNG's second largest city, the Lae City Council waste management budget for 2012 was K$0.5 million (US$157,000). Similar to the NCDC, the revenue derives from license fees, land tax, and waste management charges of K36.00 per month to high-income residential areas. The council recovers approximately 80%. At the national level, import duties are applied, under customs legislation, to second-hand vehicles, ranging between 60% and 110% of value. It appears, however, that this revenue is not allocated as an advance disposal fee.

Liquid waste management

Water is essential for life and every living and non -living things. Water sustains life and is essential for climatic equilibrium, the maintenance of ecosystems, for human consumption and use, agriculture, industrial processing and hydropower. In recent times, water has become a strong issue, even tensions result from it, especially in those countries in the

Middle East. Currently, negative effects of unwise use of water is becoming common due to increasing population, natural resource extraction, food production, industrial activity and other land uses (SPREP, 2007). Increase human activities are becoming main sources of discharges which release contaminants into water bodies which then affect the quality of water for other uses, including the environment and ecosystem.

The type of water resources available at any given point in time depends on the local rainfall pattern and the availability of collection capability of the geology in forming surface water bodies and groundwater aquifers within a catchment. PNG has abundant water resources that has immense potential for development. These water source can be harvested for the benefit of the country whether it is for economic or domestic use.

The following are the likely sources PNG can tap into are: 1) Surface fresh water from streams, rivers, lakes, ponds, reservoirs, estuaries and swamps; 2) Subsurface freshwater from confined and unconfined aquifers; i3) Surface and subsurface brackish water showing varying degrees of salinity; and 4) Effluent water, which can be treated and recycled. (SPREP, 2007).

The Water PNG (formerly PNG Waterboard) is the main government SOE that provides treated reticulated water supply to provincial towns, and some districts in PNG. In urban settlements, Water has been providing public standpipes for community consumption rather than individual households. Most of these systems are subsidised by the operating agency like the Water PNG or the Eda Ranu in Port Moresby (SPREP, 2007). In most rural communities, water for domestic use is obtained directly from surface water bodies, wells and rainwater tanks. In some communities, the raw water is pumped from a surface or groundwater source into an elevated storage tank or reservoir from which it is distributed by gravity to standpipes located throughout the community. In other communities, the reticulated system is entirely gravity fed from the intake structure situated upstream in the watershed. There are also community water tanks around the country and especially on small atolls for rainwater collections (SPREP, 2007). The Department of Health in collaboration with development partners such as European Union under the rural water supply and sanitation had provided these services to almost 30% of rural communities. This work is still continuing today.

Apart from supplying and managing water, Water PNG and local municipality government ensure all liquid wastes are manage appropriately. Most waste from sewerage are connected to main sewage pipes which are connected to the major waste ponds outside the city for treatment before released into the environment. On the other hand, some liquid wastes are discharged directly into the storm water drainage system without being treated and this may have a serious health concern from residents. In rural areas, there is no liquid waste management.

The Eda Ranu Limited operates the National Capital District wastewater and sanitation systems. It comprises of biological lagoons and sewerage system where treatment of wastewater is done prior to direct discharge into marine at depths below 125m below surface of water (SPREP, 2007). Water PNG also operates all systems outside of Port Moresby with combinations of biological lagoons and sewerage systems for treatment and direct disposal into marine environment at various levels below surface water. In the ten towns that the Water PNG operates, there are individual treatment systems for wastewater and sanitation.

It is important to note that although the Water PNG, a state owned enterprise (SOE), is operating in most of urban centres, it does not have the full coverage of the towns with sewerage systems. Lae, Kimbe, and Kavieng still have a majority of residents using a septic system, which is of concern since they depend on groundwater for water supply SPREP, 2007). Large residential compounds have small biological waste treatment units constructed to manage the wastewater and sanitation produced. In Daru and Madang, residents in are still using pan toilets that are regularly collected and disposed of at a designated site for treatment and eventual discharge. Major educational institutions all depend on small sewerage treatment system servicing only their set-ups. The exception is for institutions in the National Capital District where all are connected to the town system.

In squatter settlements within and on the fringes of urban areas, most people use standard, poorly constructed pit toilets or direct disposal into the environment. In rural areas pit toilets or direct disposal into the environment (land/marine) is the means of removing human waste. Most rural toilets are pit latrines of the standard variety with minimum allowance for odour and fly control. Most incidences of diarrhoea, dysentery and typhoid are directly linked to the poorly designed and constructed pit toilets and improper personal hygiene.

The following basic process is used in most reticulated systems. The waste is either: (i) channelled to a fabricated package or pond system for treatment before disposal into a surface water body or (ii) screened, macerated and discharged at depth into the sea through a sub-marine outfall. In major mining, logging and agriculture development camps and towns, reticulated water supply and sewage disposal and treatment facilities are provided (SPREP, 2007).

The current situation with regard to sanitation is very serious because 78% of the population or more than four million people do not have access to safe sanitation services. Statistics in the 1996 National Health Plan revealed diarrhoea as the number one cause of mortality and orbidity in the country at the rate of 1610 deaths per 100,000 of the population (SPREP, 2007). Furthermore, 2.9% of all deaths are caused by typhoid and the current low access to potable water and safe sanitation is an ideal recipe for the incidence of cholera and other similar epidemics (PNG Waterboard Strategic and Medium Term Corporate Plan 2006).

Since 2015 to date, outbreak of cholera and typhoid has hit PNG and a number of deaths have been reported. Polio also has become reappear again in 2018 after being eradicated hence, the PNG health Department and WHO are vaccinating and raising awareness throughout the country. Pollution from sewage, wastes dumped into the storm drains and coastal villages disposing their waste into the sea can cause dysentery and typhoid, skin disease, diarrhoea and other disease. In 1998, samples collected from Ela Beach indicate 1,000 bacterial content per 100 milliliters to 1,500 parts per 100 milliliters in comparison of CEPA standard of 200 fecal coliform per 100 milliliter (Kuble and Konia, 1998).

PNG has the lowest water and sanitation access indicators amongst the 15 developing Pacific Island nations. The 2015 update of the UN's Joint Monitoring Program (JMP) estimates access to safe drinking water and improved sanitation in PNG in 2012 at 40% and 19% respectively. Over the period of more than two decades since 1990, the increase in access to safe drinking water has been very small (access in 1990 was 34%), while improved sanitation coverage recorded a drop from 20% in 1990 to 19% in 2012.

PNG has missed its Millennium Development Goal (MDG) targets for water and sanitation, and is not on track to meet its own national development targets of 70% access by 2030, and 100% access by 2050 (Eda Ranu, 2016). The Guardian (2016) stated that according to WaterAid, 60% of PNG's population live without a safe water supply and PNG, has the poorest access to clean water in the world.

Solid waste management

On the contrary, solid wastes are managed by the local city authority or municipality. The waste management in Lae and Port Moresby is managed by local government authorities: Lae City Council (LCC) and National District Capital Commission (NCDC) through their Waste Divisions. Hence waste collection are very port and sometimes can be done once or twice a week or can be sporadic. However, both authorities experience poor management standards, insufficient funding (resources) and no policy or strategy guidelines.

The landfills in Port Moresby (Baruni Dump) and Lae (Second Seven) for instance practice open burning of waste, causing huge pollution to surrounding environment. This practice has become a serious health and environmental concern to the public. More recently, a landfill system was built for Port Moresby. By JICA where wastes are buried. However, most parts of the country still practice burning at landfills.

Most contractors use small, open topped vehicles for the collection of wastes. Some contractors also collect commercial municipality solid waste (MSW), although many commercial generators either contract alternative private haulers or haul their MSW to the disposal facility themselves (ADB, 2018). The geographic area served by the system is large, but there are no transfer stations and records of collection coverage and collection efficiencies are currently unavailable during the write-up of this Report.

The government does not implement formal waste reduction or recycling programs. In Port Moresby, there are two commercial recycling operators that collect, process, store, and containerize and ship nonferrous metals to foreign ports. Recyclable nonferrous metals and used batteries are exported to Australia, the Republic of Korea, and Singapore (ADB, 2014). Informal, household, and community recycling is also practiced, including the use of food waste as animal feed; and reuse of materials of perceived value, such as plastics. Scavengers work in dangerous and unhealthy conditions such as Port Moresby's Baruni and Lae's Second Seven Municipal dumpsite and other dumping grounds by sifting through piles of garbage to segregate and recover recyclables from the wastes.

Hazardous waste management

Poor waste management is a major threat to sustainable development in Pacific Island countries and territories as it has negative impacts on the region's environment, as well as on human health, water quality, fisheries, agriculture, tourism and quality of life in general (SPREP, 2019). SPREP argued that significant progress is underway, but there is opportunity for improvement in the management of hazardous waste such as asbestos, healthcare waste and E-waste across the Pacific.

Healthcare waste (also called hospital, clinical or medical waste) is the range of waste generated by hospitals and health clinics. E-waste is end of life of electrical and electronic equipment such as televisions, computers and mobile phones, including certain batteries and toner cartridges. Asbestos is naturally occurring material that was widely used in the past in the building and manufacturing industries due to its affordability and resistance to fire, heat, electrical and chemical damage (SPREP, 2019). PNG is still far behind in managing its E-waste and asbestos wastes. Data is also scattered or unavailable but probably manageable in mining and oil and gas field. Public Health Act (Amalgamated) (Amendment) 1974 and the Public Health (Sanitation and General) Regulation are administered by the Department of Health. They relate to practices of scavenging and waste disposal, as well as fines for illegal dumping.

Plastic marine debris

Mismanaged plastic waste eventually enters the marine environment by way of inland rivers and waste water outfalls or is transported by wind and tide. Wastes can also be dumped from fishing boats and ocean liners. Rigid and lightweight, plastic material from products that are consumed or used on a daily basis become marine debris if not managed appropriately. A report by Pacific Regional Infrastructure Facility (2018) indicate an estimated 13% of PNG's waste stream consists of plastic. With a combined coastline of 5,152 km, Jambeck et al. (2015) indicates a daily plastic waste generation of approximately 282 tonnes (t), with an estimated 246t are mismanaged daily, entering the marine environment through release from uncontained disposal sites or by littering.

As a result, an estimated 89,835t of plastic waste became marine debris in the waters around PNG in 2010. PRIF warns that if not addressed, the amount is expected to rise to 242,328t by 2025. Of the 282t of plastic generated each day, approximately 31t may are PET or high-density polyethylene (HDPE) plastic, eligible for recycling under a container deposit scheme (CDS). Based on an average reduction rate of 40% in mismanaged waste with a CDS in place, approximately 10.89t of PET and HDPE plastic would be recycled each day (PRIF, 2018). This could increase to an 80% or above reduction rate, depending on access to recycling collection services and viable markets, among others.

Nonetheless, a 40% reduction in mismanaged PET and HDPE would result in approximately 85,859t of plastic becoming marine debris each year.

CEPA in its campaign 'beat the plastic bags' had done a monthly plastic bag collection between June and December, 2018. Figure 3.183 indicates the volume of plastic bags collected at the coastal villages of Boera and Papa in the month of November was substantial. Total plastic wastes comprised of 89% while Other waste and debris that are not of plastic origin comprised of 11%. For plastic alone, PET bottles comprise of 32.8kg, followed by food packaging with 12.6kg and plastic shopping bags with 10.9kg. Other plastics types combined gives awhopping 33.3kg.

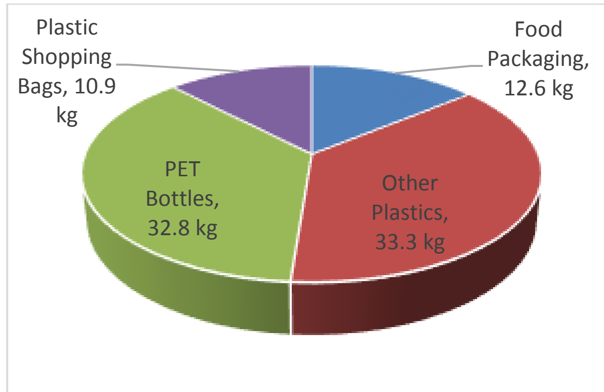

Figure 3.183: Plastic bags collected in the month of November in Port Moresby villages of Boera and Papa (CEPA, 2018)

Comparatively, Figure 3.184 also indicates the volume collected from PET bottles is substantial with 380 litres (L), followed by food packaging with 330L, shopping bags with 150L and other plastics with 200L. Figure 3 also indicates the volume collected from PET bottles is substantial with 380 litres (L), followed by food packaging with 330L, shopping bags with 150L and other plastics with 200L

Figure 3.185 shows the volume and weight of plastics collected in Boera and Papa villages in December. The vollume of Pet bottles was high with 95L, followed by food packaging with82.5%, other plastcis with 50L and plastic shopping bags with 37.5 L. The waeigth corerspond to the volme with 8.2Kg, 3.15kg, 8.33 kg and 2.73kg respectively. The month of November and December shows interesting results with the month of November waste collection being the highest compared to December. The reason was many people participated in the collection in November compared to December. Also December also has low number of plastics because most were collected in November and the local communities were more educated not to dump their rubbish into the sea.

The increae in imports and uses of plastic products has increased substantiallly. With lack of awareness and consideration to litter laws within the city, the trend is most likely to incerase in the future. Illegal dumping of watse and uncharatteristics loitering of waste are contibuting to increase waste within the marine environment and foreshores of coastal villages which is harmful and threatening as well to the marine life and ecosystem.

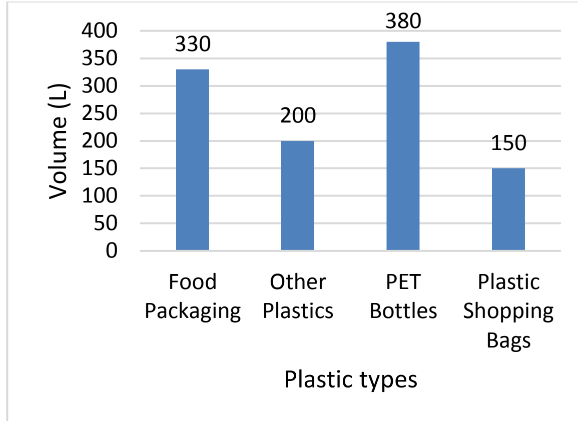

Figure 3.184: Volume of plastic types collected in two coastal vilalges of Boera and Papa (CEPA, 2018)

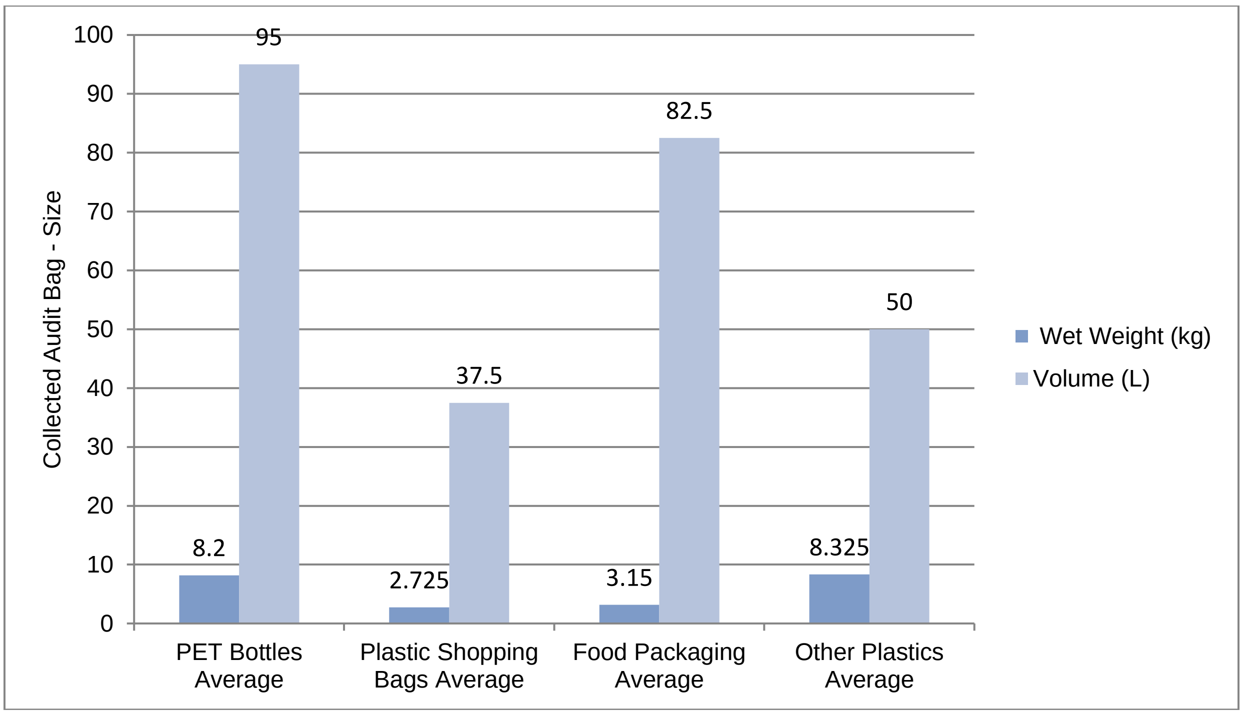

Figure 3.185: Volume and weight of plastic bags collected at Boera and Papa villages in December (CEPA, 2018)

The mismanaged plastic can be split into three primary groups: plastic that remains on the surface of the sea as floating debris, plastic that sinks to the ocean floor and plastic that washes up on beaches (PRIF, 2018). Cleaning marine plastics annually in PNG may recovers 40% of HDPE and PET plastic bottles and also taking appropriate measures may help reduce marine debris each year with 596t in floating plastic, 2,784t in sunken plastic and n 596t in beach plastic (PRIF, 2018).

Impact

The waste generation in both cities is expected to increase in the future given high population growth and the economic boom. Waste generation trends are challenging and becoming a real concern for PNG as negative effects of water uses and management are becoming more pronounced lately in PNG.

Lack of funding to implement better services and facilities would cost millions of kina. Ineffective assessment, planning, utilisation and management of liquid and solid waste by respective authorities for both domestic and industrial activities is a growing concern (SPREP, 2007).

Both the solid waste and sewage disposal service providers and other sectoral users are in dire need for better services. This is because lack of any domestic or industrial wastes management may result in the arbitrary dumping of trash and refuse at any undeveloped sites around the settlement or along the highway roads and city peripheries.

Rarely, if ever, is any consideration given to the selection of sites to manage wastes, and there is inevitably contamination of soils, the water table, surface runoff and downstream catchments. There is also a growing concern in the marine environment where solid wastes such as plastic bags are an eye shore to the coastal areas. These rubbish also are a hazard to the marine habitat and species such as turtles. Moreover, not only does the solid and liquid waste have an adverse impact on downstream habitats and marine environment, but also poses a public health risk when people are using them for washing and bathing purposes. Inadequate awareness on the status and impact of the solid and liquid wastes in the country could be one reason for the low level of access of the population to potable water supply and safe sanitation and cleaner environment.

The availability of data is now important and necessary for the design of a new landfill site for the most urban areas, in the event that this is required. It is also necessary for the setting of targets for waste reduction, reuse, recycling and will allow the measurement of success of any waste minimisation initiatives.

There are significant variations in the water and sanitation access rate, and the status and pace of development, among the rural water supply, rural sanitation, urban water supply and urban sanitation subsectors. Furthermore, until very recently, PNG did not have any agencies designated to be responsible for water sector policy and regulation, nor for overall planning, implementation and management of water and sanitation services in the country (Eda Ranu, 2016). In response, the World Bank has provided funding of US$70mil in implementing the Water Supply and Sanitation Development Project (WSSDP) with the objective to support the development and strengthening of the planning and implementation capacity of water sector institutions, and to increase access to water supply services in selected urban towns and rural districts.

AGO Photo Slide # 8: Shows inhabitants, April, 2010.

The government needs to reorganise the water supply and sanitation sector in order to improve service delivery and eliminate the high incidence of these preventable diseases. The waste dump sites in the main cities and towns are becoming operational for 24 hours a day, open to greenhouse gas emissions from open burning of all categories of waste such as general waste, infectious health care waste, papers, plastics, and other building and commercial or industrial waste materials. The dump sites are available all the time for access by a large number of foragers and scavengers including human beings, domestic birds/chicken and animals.

Natural causes such as droughts, landslides, earthquake, volcanic eruptions, sea level rise, salination, storm surges etc including ma- made disasters from mining pollutions and effluents, oil spill, cyanide spill, and other human induced wastes are affecting the quality of water and the environment. Papua New Guinea is a signatory to several MEA, Conventions and Protocols and has ratified several such as:

- Stockholm Convention on Persistent Organic Pollutants, Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal,;
- 1995 Waigani Convention, Montreal Protocol on Substances that Deplete the Ozone Layer;
- MARPOL 73/78: International Convention for the Prevention of Pollution from Ships;
- 1973 as modified by the Protocol of 1978 (Annexes I, II, III, IV, and V), London Convention on the Prevention of Marine Pollution by the Dumping of Wastes and Other Matter 1972;
- Intervention on the High Seas in Cases of Oil Pollution Casualties (Intervention 1969 Ratified International Convention on Civil Liability for Oil Pollution Damage 1969 (renewed 1992);
- International Convention on the Protocol of 1992 to Amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971;
- Noumea Convention; and
- Protocol on Dumping Ratified Protocol on Combatting Pollution Emergencies.

These conventions and protocols are needed to manage waste and or control waste in the country which CEPA has to report against.

Response and Recommendations

In PNG one of the factors that contributes to the poor management of solid and liquid waste is the lack of consistent data on the composition and quantity of solid waste being produced. Good data are necessary for the design of a new landfill site s and management of waste. Data are also necessary for the setting of targets for waste reduction, reuse, recycling and will allow the measurement of success of any waste minimisation initiatives. With the lack of data on various kinds of waste being generated by municipalities, waste management monitoring activities will be limited.

Also the capacity of the responsible agencies to identify areas for improvement in the performance of solid waste management activities, and also to inform future planning of these activities will be affected. Thus routine data collection must be done by the municipalities. Also regulations are require for household and commercial generators to provide suitable storage containers for their MSW. CEPA needs to enforce and regulate activities as per the Environment Act to prevent pollutions in water catchments, using appropriate protocols and compliance and monitoring tools. Finally, more awareness must be undertaken by all stakeholders and organisations widely using appropriate communication mediums to increase awareness.

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8.8.10 ENERGY CONSUMPTION AND USE

Indicator Definition: Rate of energy consumption

Status and Trend

SDG/CBD Targets

SGS: 7.1.1, 7.1.2, 7.2.17.b.1, 12.c.1

Aichi target: 1, 2, 3,5, 14, 19

Status and Trend Discussion

Transportation, power generation, and cooking dominate energy use in the PNG while industrial use of energy is mostly confined to mining, oil and gas and manufacturing industries. More wide spread are agricultural, forestry, aviation, shipping and fish based industries, and other non-energy users, almost all of which rely directly on electricity. In the theme under climate and atmosphere, transportation is the major user of energy with 47% followed by industries with 39% and residential users with 14%.

The traditional use of biomass for cooking remains the largest component of overall energy use in rural areas throughout PNG, though its use is slowly declining in favour of liquefied petroleum gas (LPG) and kerosene in the more urban areas. With exceptional and notable contributions from hydropower, PNG's energy use is dominated by imported fossil fuel. Even though PNG is a producer of oil and gas, most of its crude oil and natural gas are exported to overseas markets.

Though PNG has refinery for fossil fuel and natural gas, they were not utilised appropriately because of certain business agreement conditions were not included in the initial arrangements and contracts. Until recently, some agreements have been reached to power electricity using natural gas. In terms of fossil fuel, most refined oil products must be imported over large distances from overseas.

Table 3.24 shows the production capacities for electric energy from various sources is equivalent to 8.89 kWh. The major source of energy comes from fossil fuel with 4.97 bil kWh followed by hydropower with 2.37bil kWh and other renewable sources such as geothermal with 552.43 mil kWh. The values are theoretic which could only be attained under ideal conditions but measure the generatable amount of energy that would be reached under permanent and full use of all capacities of all power plants (WorldData, 2019).

Table 3.24: Production capacity per energy source (WorldData, 2019)

Energy source	Total	%	Per capita
Fossil fuels	4.97 bil kWh	63	602.57 kWh
Nuclear power	0.00 kwh	0.00	0.00 kWh
Water Power	2.37 bil kWh	30.00	286.94 kWh
Renewable energy	552.43 mil kWh	7.00	66.95 kWh
Total production capacity	**8.89 bil kWh**	**100**	**956.46 kWh**

In practice this isn't possible because for instance, solar collectors are less efficient under clouds. Also wind- and water-power plants are not always operating under full load. All these values are only useful in relation to other energy sources or countries.

Table 3.25 shows PNG energy balance has a high demand for energy. For instance, PNG is producing 3.48 bil kWh of electricity and consumes 3.24. bil kWh, where consumption is is almost equavalent to the production capacity. (WorldData, 2019). This is because of increasing demand for electricity and rising consumption rate per capita at 392.31 kWh. Although PNG is producing its own crude oil of 50,000barrels, it still import from overseas 22,220 barrels. With a total of 11.18 billion m^{3}of the natural gas produced in country, majority are exported to overseas market with little as 99.11 mil m^3 used in locally.

With 85% of the population living in rural areas and the reminder living in urban areas, only 13% of the population (i.e. 140,000 connections) having access to electricity. Hence, the PNG government envisaged to develop its renewable energy resources to improve living standards and drive higher economic growth (APECR, 2017).

In the Vision 2050 and the PNG Development Strategic Plan 2010-2030, the government sets an ambitious target of achieving 100% of power generation from renewable energy sources by 2050, and increasing electrification rates to 70% by 2030 (GoPNG, 2010). The government's super corridor plan could achieve that in the DSP 2010-2030, supported by low-cost generation resources at various locations.

Table 3.25. PNG's energy balance (World Data, 2019)

Energy Balance Source	Total	Per Capita
Electricity		
Own Consumption	3.24 bil kWh	392.31 kWh
Production	3.48 bil kWh	421.88 kWh
Crude oil		
Production	50,000.00 barrel	0.006 barrel
Import	22,220.00 barrel	0.003 barrel
Export	55,600 barrel	0.007 barrel
Natural Gas		
Own Consumption	99.11 mil m^3	12.01 m^3
Production	11.18 bil m^3	1,354.96 m^3
Export	11.10 bil m^3	1,345.27 m^3

Figure 3.186: PNG Power Limited Operational sites across PNG (PNG Power Limited, 2016)

The PNG Power Limited (PPL), the national state owned utility, manages generation, transmission, and distribution over three main power grids (Port Moresby, Ramu, and Gazelle). These girds serve the main urban centers, and 19 isolated and localised independent power grids servicing provincial centers (Oxford Business Week, 2015).

Figure 3.186 shows the PPL operational sites across PNG. Moreover, PPL installed capacity is approximately 260 MW (66% hydro, 44% thermal) with independent power producers adding 50 MW of thermal capacity. Approximately 280 MW is generated by the mining industry as captive power for their own consumption (ADB, 2018).

PPL also maintained that hydroelectricity accounts for 70% of its electricity while only 14% comes from light fuel. An additional 16% of electricity is provided by other independent power producers.

According to Oxford Business Week, the Port Moresby gird serves the National Capital District which is the largest and derives most of its electricity from the 76-MW Rouna power station. This is supplemented by another 30-MW thermal power plant at Moitaka, as well as through purchases from private power stations. Operated under an independent power project agreement, the 24- MW, diesel-powered Kanudi thermal power station has fed electricity to the Port Moresby grid since it began operations in 1999 (Oxford Business Week, 2015).

PPL's second-largest network is the Ramu Gird that is producing hydro powered generation. It is serving the Momase and Highlands region. This covers towns namely Lae, Madang and Gusap, plus Highlands centres such as Wabag, Mendi, Mt Hagen, Kundiawa, Goroka, Kainantu and Yonki. The largest contributors to the system are the 75-MW Yonki and 12-MW Pauanda hydropower plants (Oxford Business Week, 2015). Oxford Business Week iterates that supplementary power can also be added to the grid as needed from the privately operated 2-MW Baiune hydropower station at Bulolo in Morobe Province, as well as the small-scale PPL diesel standby units located in Madang, Lae, Mendi and Wabag.

Majority of energy produced in PNG is from hydropower provided by PNG Power Limited

The third and smallest Gird system is the Gazelle network, which provides power to Rabaul, Kokopo and Keravat. Power for the grid is generated from the 10-MW Warangoi hydropower station, along with the diesel-powered thermal plants of Ulagunan (8.4 MW) and Kerevat (0.5 MW). PPL operates another 19 independent power systems serving dozens of smaller urban centres across the country (Oxford Business Week, 2015).

Other smaller systems are the Kimbe gird where electricity is supplied by the Ru Creek Mini hydro system and the Bialla system by the Lake Hargy mini hydro scheme, while the other centres are served by diesel generating stations. New proposed projects are the Popondetta and the Bouganville gird in the Autonomous Region of Bougainville (AROB).

Approximately 53% of PNG's population are still living below the national poverty line. Hence, access to electricity is available to roughly over 13% of all households, mainly in urban areas while the majority of the population who live in isolated locations do not have any access to electricity. In those households, almost half use kerosene lamp for light and a quarter relied on open fire (GoPNG, 2014).

In many households, 97% cook food with fuelwood and the remaining 3% use liquid petroleum gas or electricity. In Port Moresby, 70% of household used electricity, 67% had refrigerators and 61% had television. In addition, 75% of Port Moresby residents have electrical lighting, 40% cook food with kerosene while 30% cook with electricity (GoPNG, 2014). This scenario shows electricity or energy is still not efficiently available or affordable by many citizens.

Impact

Energy generation is a major source of GHG emissions. Pacific island countries are also have limited capacity for oil and gas storage and are therefore highly vulnerable to fluctuations in fossil fuel price and availability. The demand for electricity in PNG has grown by an average of 2.2% over the last ten years and this trend is expected to continue in the medium term. As economic growth increases, demand for electricity in PNG is growing. Consumption rate is expected to rise by 2.55% per annum (Oxford Business Week, 2015). With fossil fuel being imported over the years, PNG is vulnerable to fluctuating global fossil fuel and oil prices.

The rapid transformation of PNG and the economic growth experienced in recent years is driving the demand for electricity across the country, thus straining the capability of the country's primary grid networks. The country's premier State Own Enterprise (SOE) and largest single operator, PNG Power Limited (PPL), is now faced with the to ensure reliable and affordable power supply is access by roughly 70-90% of the population ,consistent with the goals of Vision 2050 and DSP 2010-2030. However, the widely scattered population and geographic challenges continue to deter the progress toward increasing electrification, while the small but growing capacity serving the main urban areas is in need of expansion to meet growing power needs (Oxford Business Week, 2015).

There are several economic, social and environmental implications for PNG in energy consumption and efficiency. Expanding into more renewable resources for energy production decreases the vulnerability to world market volatility of fuel prices.

Diversifying energy sources helps to reduce vulnerability during disasters. In addition, the transition to more renewable and or efficient energy sources reduces the emission of greenhouse gases. GHG emissions per capita is relatively high, related to current energy sources.

PPL is embarking on the development of hydro power potentials in a number of provinces. Development and investigation of hydropower and its potential is important as this would replace thermal generation and thus reduce imported fossil fuel. Other sources of energy including oil and gas, solar, wind and bio-energy from sugar cane and oil palm waste will also be investigated to help reduce imported fossil fuels (PPL, 2016).

Response and Recommendations

There is a need for PNG to diversify and invest in the use of energy sources and sell it back into the gird system. This can be achieved through working with development partners to increasing energy efficiency, demand and supply using clear implementation plans and a robust strategy to develop its vast renewable energy sources. There is also options to review the energy policy, prices and improve government subsidy to increase accessibility.

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8.9. THEME 8: CULTURE AND HERITAGE

8.9.1 Overview

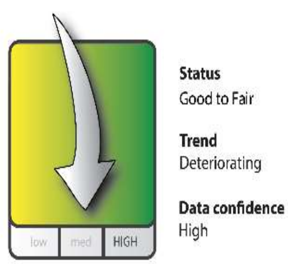
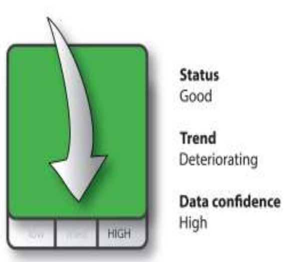
Photo: A traditional Maprik spirit house in Maprik, East Sepik Province

This Chapter is about the cultural and heritage elements PNG as they relate to the environment, and the impact PNG is facing through a changing environment. An important aspect of any SOE report is the link between people, traditions and the environment. For this theme, three main indicators were chosen to highlight the current relationship between culture and the environment: 1. The State of Culture and history, which tie directly to the environment as either a preserved site, such as WWII battle sites, language and trade and or natural sites on which the myths and legends of the Papua New Guineans are based; 2. Traditional diet and medicine and the trend over time; and 3. Customary land tenure, highlighting the ties between humans and their environment, and development occurring in the country,

All indicators show that traditional culture forms the basis for both new and old environmental practices since most over 80% of all land in is customarily owned by people. The changing diet of 'easy to prepare' foods is having significant negative impacts on the ability to cope with the changing social and economic aspects, particularly food security. In addition, there are historic and traditional sites that require better management and care. These sites are essential as they maintain and sustain ties between Papua New Guineans, culture and the environment. Modernisation is rapidly changing the traditional social structure. However, much of PNG's success can be found in embracing both the past and future.

A simbu lass with traiditonal attire (Photo by I.Kolima

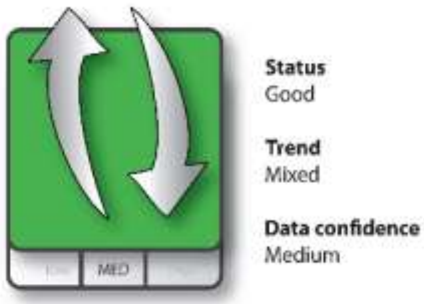
8.9.2 CULTURE AND HERITAGE HIGHLIGHTS

Topic	Status, Trend data confidence	Key Findings	Response and recommendations
Culture and History		PNG's cultures and traditions are deeply entrenched in every Papua New Guineans, families, homes and their way of life. These cultures and traditions are preserved and kept alive through arts, paintings, sculptures, carvings, dances and songs, folklores, architecture and literature, and in all aspects of lives. However, these cultures and traditions are under threat hence slowly eroding. PNG is also a global leader in language diversity with over 1000 tribal groups and 800 plus languages.	The National Museum and Arts gallery can work with the PNG cultural Commission and the Institute of PNG studies, provincial governments, development partners, students and researchers to map, document and archive historical sites, cultures, languages and traditions. Preservation of cultural heritage must be promoted.
Traditional diets and medicine		Diets have improves remarkable from the 1970s, with improvement in preparation and dietary requirement. However, traditional forms of forms have been substituted by processed food resulting in many lie diseases. Modern medicines and medical practices have transformed the health and lifestyle of people thus prolonging their lifespan. PNG also has some of the worse health indicators that need to be addressed.	The population needs to be educated about sanitation, eating proper diets and cutting down on processed food and avoid lifestyle diseases. Medicines, medical facilities and services need to be improved, with increase professionals to deal with diseases, sicknesses and emergencies.
Customary land tenure		More than 80-97% of land in PNG is communally owned by customary land tenure system by traditional who are affiliated to a clan or clan groups (tribe) define by their societal social structures. Only 3% of land are alienated or belong to the State. Over time, land management and acquisition is becoming weak as people loss rights over their land because of weak laws and systems, with some flaws existing. This prompts the government to improve the system.	Land inventories must be done in all provinces documented and archive. The new land-use planning and policy under development must be implemented amicably. Also, continuation of digital work and transparency in any land matters must be upheld within DLPP

8.9.3 TOPIC/SUBTOPIC: CULTURE AND HISTORY

Indicator Definition: Trend in culture, heritage and history of the country

Status and Trend



Landowners and their cultures and traditions are now facing new challenges from development activities such as logging (Photo: Unknown)

SDG/CBD Targets

SDG: 2.4.1, 2.5.1,4.1.2.1, 4.7.1, 5.1.1, 5.5., 8.4.2, 8.9.1, 10.1.1, 14.5.1, , 15.2.1, 15.5.1

Aichi Target: 1, 2, 5, 6, 7, 9, 10, 11, 12, 13, 14, 16

Status and Trend Discussion

Wikipedia documented that the first known Europeans to sight New Guinea were probably the Portuguese and Spanish navigators sailing in the South Pacific in the early part of the 16th century. In 1526–1527 the Portuguese explorer Jorge de Menezes accidentally discovered New Guinea and is credited with naming it "Papua", after a Malay word for the frizzled quality of Melanesian people's hair. The Spaniard Yñigo Ortiz de Retez applied the term "New Guinea" to the island in 1545 because of a perceived resemblance between the islands' inhabitants and those found on the African Guinea coast (Wikipedia, 2019).

Wikipedia iterates that although European navigators visited the islands and explored their coastlines thereafter, European researchers knew little of the inhabitants until the 1870s, when Russian anthropologist Nicholai Miklukho-Maklai made a number of expeditions to New Guinea, spending several years living among native tribes, and described their way of life in a comprehensive treatise (Wikipedia, 2019).

When Europeans first arrived, inhabitants of New Guinea and nearby islands, use technologies such as bone, wood, and stone tools, had a productive agricultural system. They traded along the coast (mainly in pottery, shell ornaments and foodstuffs) and in the interior (exchanging forest products for shells and other sea products).

Dugout canoe made from special trees as a mode of river transport, Suki, Western Province

Many of the cultures and traditions were intact and primitive but advance to their own society during the early contact. PNG is also rich with biodiversity and cultural heritage with little influence of the outside contact but this feat is now deteriorating and under threat. Today Papua New Guineans have a great tasks and responsibility to protect their resources and cultural heritage. Papua New Guineans are also closely linked to their environment through their culture and history. Because both the natural environment and cultural heritage cannot be separated. Specific places, rocks, trees and animals and myths have powerful cultural meaning and connectivity to people's way of living and identity. Many river and sea communities still use special trees (logs) to make dugout canoes as a mode of water transport.

Most land and seascape is customarily owned and controlled by clan or clan groups (sub-clans) in a tribal group. Some of these land or sea are either patrilineal or matrilineal owned or manage, which the Chief or clan leader controls all affairs concerning land rights. Both the land and sea are prized above all else and the conservation and use of the environment is linked to Papua New Guineans culture and traditions. The *Tambu* or *Taboo* sites are traditional conservation sites that continue to influence land management today. There are conditions that apply to these traditional conservation sites which include seasonal harvesting in the marine, coastal and terrestrial environments.

These *Tambu* or *taboo* sites are undocumented cultural sites not fully mapped for PNG. However, there are some documented reports from Environment Impact Studies, government patrols, research and other forms recorded across PNG. However, the availability of standard maps depicting all sites is unavailable. Thus there are some most significant sites of traditional or pre-historic values recorded by anthropologists will be discussed below which link the Papua New Guineans and their land.

Traditionally, societies have their own cultural code of ethics that provides guidance to the members of the community, clans and tribe collectively. Thus, the Constitution of PNG recognizes those Customary Laws of the 1000 tribes of PNG, such as customs, culture and beliefs. The Constitution also gives power to several legislations that governs cultural heritage in PNG including;

- Environment Act 2000 (PNG);
- National Museum and Art Gallery Act 1992 (PNG);
- National Cultural Property (Preservation) Act 1965 (PNG);
- Coroners Act 1953 (PNG); and
- Cemeteries Act 1955 (PNG).

Many international developers and financial institutions also recognized cultural heritage in their business ventures. For instance, the International Finance Corporation (IFC) Performance Standard 8 (2012) recognizes the importance of cultural heritage for current and future generation and aims to protect the irreplaceable cultural heritage. According to IFC, cultural heritage encompasses properties and sites of archaeological, historical, cultural, artistic, and religious significance (IFC, 2012).

This standard also recognizes cultural heritage as unique environmental features and cultural knowledge, as well as intangible forms of culture embodying traditional lifestyles that should be preserved for current and future generations. Moreover, the standard aims to guide proponents in protecting cultural heritage from adverse impacts of project activities and supporting its preservation, and at the same time promoting the equitable sharing of benefits from the use of cultural heritage.

PNG is also a signatory to the international United Nations Convention for the Safeguarding of the Intangible Cultural Heritage (1972) and the World Heritage Convention (1997). These two international conventions are house at the United Nations Educational, Scientific and

Cultural Organisation (UNESCO). PNG has a UNESCO office based at the Department of Education, a Cultural Heritage Secretariat housed at the PNG National Cultural Commission and the World Heritage Secretariat based at CEPA. These institutions ensure the culture and heritage of the country whether traditional or modern are documented, archived, preserved.

The UNESCO recognizes the existing international human rights instruments as well, in particular the Universal Declaration on Human Rights of 1948, the International Covenant on Economic, Social and Cultural Rights of 1966, and the International Covenant on Civil and Political Rights of 1966. In addition, UNESCO see the importance of the intangible cultural heritage as a the backbone of cultural diversity and a guarantee of sustainable development, as underscored in the UNESCO Recommendation on the Safeguarding of Traditional Culture and Folklore of 1989, in the UNESCO Universal Declaration on Cultural Diversity of 2001, and in the Istanbul Declaration of 2002 adopted by the Third Round Table of Ministers of Culture (UNESCO, 2003).

Kuk agriculture World Heritage Area and ancient agriculture (Photo: J. Golson)

Historical sites

There are many historical sites in PNG that relate to human history and captured in individual societies and folklores or development plans. However, only few received prominence such as Huon geological Terrace in Morobe province (up lifting of corals from seabed), the earliest agriculture practices at Kuk swamp dating 50,000 year BP, and the Kosipe early settlement around 46,000BP where food and stone tool implements were found. There are some areas in Manus, Milne Bay, New Britain and New Ireland provinces which the earliest mining of obsidian rocks and trade of Lapita potteries have been recorded.

The only World Heritage Area (WHA) recognized by UNESCO is the 116ha swamp land of Kuk, in the Waghi Valley of Jiwaka Province. Given the stringent criteria and processes, including documentation (e.g. management plan) set by UNESCO for WHA, it took almost 7 years from 2007- 2014 for the site to become a WHA. Nonetheless preliminary work on the site began since 1972, after the Government of PNG ratified the convention on World Heritage. Several challenges such as resources and capacity were hindering the progress.

Currently, there are 7 nominations submitted by the PNG Government in 2006 for WHA status to UNESCO because of their both cultural and biological values. However, only four have been clearly identified with mapped boundaries, namely the Sepik, Trans-Fly, Kikori or the Great Papuan Plateau, and Milne Bay Seascapes. The remainder (Kokoda Track and Owen Stanley Ranges, The Sublime Karst of Papua New Guinea, and the Huon Terrace) were limited to mostly broad geographic descriptions. These World Heritage listings sites were not followed persistently because of issues highlighted above.

The significance of the Kuk WHA is that it is one of the first agriculture sites in the world that developed independently and systematically cultivated over the last 9,000 years. It was developed in tandem with other independent agriculture sites such as the Fertile Crescent in the Middle East, the Indus Valley, Eastern China and Mexico some 7000 to 10,000 years. The cultural significant values of KUK WHA includes archaeological resources that include drainage and ancient tool implements, with a potential for full exploration of archaeological excavations of Kuk still remain buried beneath the surface of the land (GoPNG, 2013). The Kuk is a well-preserved buried archaeological testimony, demonstrating an independent technological leap which transformed plant exploitation to agriculture around 7,000-6,400 years ago, based on vegetative propagation of bananas, taro and yam (GoPNG, 2013). It stores wealth of information regarding the transformation of agricultural practices over time from mounds on wetland margins around 7,000-6,400 years ago to drainage of the wetlands through digging of ditches with wooden tools from 4,000 BP to the present.

The archaeological evidence reveals remarkably persistent but episodic traditional land-use and practices where the genesis of that land-use can be established and changes in practice over time demonstrated from possibly as early as 10,000 BP to the present day (GoPNG, 2013). Figure 3.187 shows PNG is one of the first countries where domestication of plants and animals occurred.

Almost 200,000 years before present the (BP) in Africa, modern humans migrated and colonized the globe, reaching Australia and New Guinea by 40,000 to 50,000 years ago. The first humans had possibly migrated via Sunda through the Papuan Plateau in Western Province to reach Hela, Gulf and other places, including the Sahul (Australia). Figure 3.188 shows the land bridge connecting Asia, New Guinea and Australia and the possible migratory route through Western Province in the Aramia River region, to Australia.

Some work are currently under progress in Western, Hela, Southern and Gulf provinces where evidences of human settlement in rock shelters have been found, with a possibility of carbon dating their existence back to the early migration of early humans from Sunda or Asia (*pers com, B. Baker*).

Understanding how humans lived and adapted to the range of environments in these areas has been difficult because well-preserved settlements are scarce. Data from the New Guinea Highlands (at an elevation of ~2 000 meters) demonstrate the exploitation of the endemic nut Pandanus and yams in archaeological sites dated to 49,000 to 36,000 years ago, which are among the oldest human sites in this region (Summerhayes et al., 2010). The site also contained stone tools implements (e.g. axes and adzes) believed were used to remove trees, which suggests that the early inhabitants cleared forest patches to promote the growth of useful plants (e.g. *Karuka* or *Pandanus* sp. and yams or *Dioscorea* spp.). The earliest archaeological evidence of human occupation in the Papua Region was at Ivane valley, Koisipe, Goilala District, north of Sogeri. By year 46,000 BP, hunter-gatherers have occupied rainforests to at least 2000 m *asl* (Summerhayes et al. 2010).

After 8,000 BP, evidence of the beginning of sedentary subsistence activities and shifting agricultural practices were recorded for the Koiari hinterland. The occupation of Mountain and Central Koairi appears to have been fairly stable from this time forth. Archaeological records indicate human settlement in the Koairi area dating back to 2900 BP (Leavesley and Prebble, 2012), with the ancestors believed to have come from the east in Oro province.

A recent finding by Exxon Mobil in Lealea village outside Port Moresby, Central Province found evidence of Lapita pottery dating 4000 years BC (*pers. com J. Mogina*). The early Motuans were thought to traverse the southern coast in the last 200-300 years but this finding resolves some of the earlier trade doubts in PNG and human settlement in the Motuan coastline. Evidence of early trade of obsidian rocks and Lapita pottery are found in in many coastal areas, mainly Central, Milne Bay, New Britain and Manus, including the Solomon Islands and Vanuatu (Leavesley and Prebble, 2012). These finds shows that early PNG ancestors were great seafarers and traders

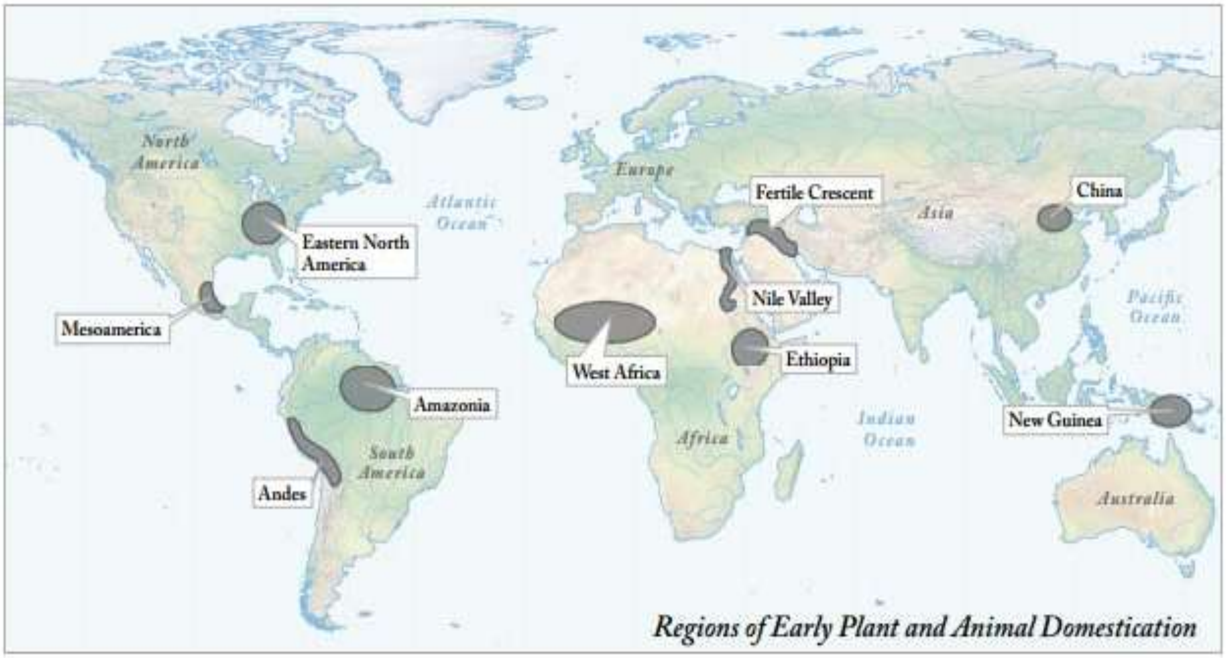


Figure 3.187: The early plant and animal domestication regions of the world https://whfua.history.ucla.edu/eras/era4.php)

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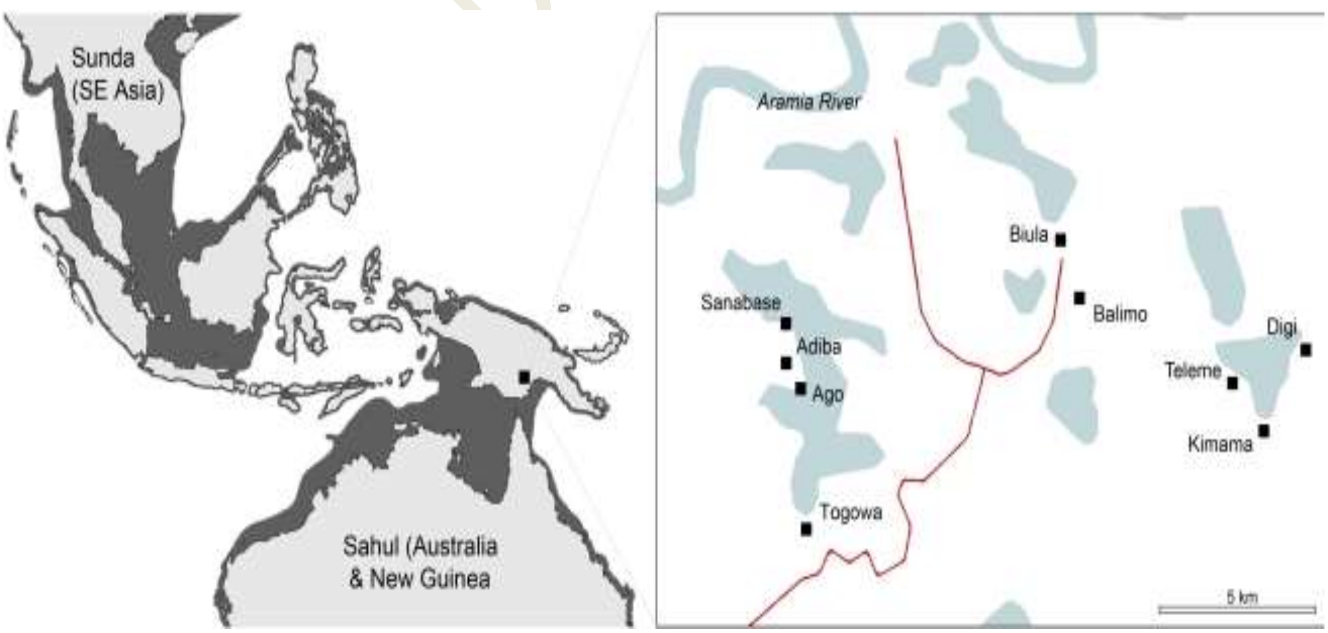

Figure 3.188: Migration of ealry humans to Australia New Guinea from South-East Asia (Baker A, Pearson T, Price E.P and Dale J 2018)

World Wars

In the modern history of PNG, during World War 1, less than 10 people were killed when the Australian Forces fought with the Germans in Rabaul, East New Britain province. During World War 2 from 1942 to 1945, a great impact was expereinced by the country and many lives were lost. It was estimated that about 202,100 Japanese and 127,000 and Australian soldiers died during that conflict, plus countless people from PNG and other nations. The world wars shas caused significant destructure to the world.

Mural painting of war taken in the Australian War Museum, Canber*ra*

The invasion of the Japanese forces in the Pacific was resisted by the Allied Forces led by the US, Australia and the New Zealand. Small groups of Commonwealth armies such as India and Fiji, including local Papua New Guineans fought with the Japanese invaders. Photo 3 shows a war scene in a mural painting at the Australian War Museum, Canberra, Australia.

Many war relics, bombs and bullet shells are scattered right across the country which are evidence of this arm conflict. Roughly 5 major war memorial cemeteries are located in Wom Beach in Wewak (East Sepik province), Bitapaka (East New Britain province), Lae Botanical Garden (Morobe Province), Alotau (Milne Bay province) and Bomana outside Port Moresby (National Capital District).

Bitapaka War Memorial Cemetery, East New Britain Province

Many war cemetaries reminds the world of the sinister damages the war has caused on humanity. Annually, a Remembrance Day is celebrated to commemorate those who lost their lives through that evil conflict.

One of the famous historical sites that received thousands of visitors and pilgrims annually is the Kokoda Track, situated in both the Central and Oro provinces. Tourists walk the track annually, thus it generates a huge income for the country and local landowners. Visits to other parts of the country by tourist are made every year as well.

Colonial Era

Prior to PNG became an independent nation in 1975, there were two separate admirations of Papua and New Guinea. Papua was colonised by the British until Australia became independent, hence Papua became a protectorate territory of Australia after Australia gained its political independence from Britain in 1908. New Guinea was then colonised by Germany but during World War 1, the Australian forces invaded the Germany headquarter in Rabaul and took over New Guinea. In 1975, the country united and became the independent state of Papua New Guinea.

Prior to the two World Wars, PNG experienced a gold rush and many miners from Australia came to New Guinea. The first mining operation was a gold and copper mine which first started in the 1900s outside Port Moresby, at Sapphire creek, 17 mile. Right after World War 1, in the years leading up to 1930, Gold Rush began in Wau and Bulolo and many foreigners and miners came to PNG in search of fortunate. Gold dredging occurred in the Bulolo valley in the 1930s and after World War 2. The mine ceased operation during World War 2 but resumed thereafter until the 1950s. During those period, the Wau and Bulolo airstrips became some of the world's busiest airports because of the Gold mine activities.

Until recently, during that Gold rush period, the Hinterland highlands of the mainland New Guinea and its people were discovered by explorers, Michael Leahy, his brother Dan, and the patrol officer Jim Taylor, looking for Gold..

No. 2 Ship gold dredge ship being assembled in Bulolo in the *circa* 1920s (Photo by: Unknown)

Culture and tradition

PNG's cultures and traditions are deeply entrenched in every Papua New Guinean, in families, homes and their way of life. These cultures and traditions are also preserved and kept alive through arts, paintings, sculptures, carvings, folklores, dances and songs, architecture and literature, and in all aspects of lives. Papua New Guineans are now doing paintings, carvings and handcrafts and sells them to tourists and the public to earn few moneies to sustain their families.

PNG's tradition and culture is the very essence of its existence reflecting its history, language, tradition and beliefs. However, globalization has influenced those cultures and tradition, hence the traditions do not remain static but evolves overtime.

Cultural heritage in PNG is passed on either orally or through observation and participation from one generation to the next. Western influence is now a concern as it erodes some customs and cultures and communities lose their set cultural values which once guides the actions of their members. Christianity also brought with it its own Christian morality and nowadays communities are developing their own moral systems based on Christian ethics and not necessarily basing on cultural moral systems in their societies.

Women and men selling their handicrafts, *bliums* and paintings outside Holiday Inn, Port Moresby

Cultural heritage in PNG is expressed in the environmental features such as large trees, limestone caves, limestone outcrops, swamps, waterways, etc. that are intertwined with biodiversity. This fact is recognized and acknowledged because there is a strong connection between the people and their cultural heritage. Hence in order to manage cultural heritage one must work with the people at community level to manage the cultural resources accordingly.

PNG is a land of a thousand tribes and is recognized as one of the few nations in the world with more than 800 languages. There are 843 to 1020 languages are known (*pers com. J. Himugu*), and this is three times the combined languages spoken in Europe. This means multiple cultural systems and values exists. About 843 languages have been recorded and in recently memory, about 43 languages are dying out, or only 1 or two speakers are alive. Another report shows has a high level of linguistic and cultural diversity with 852 distinct indigenous languages of which 12 are now extinct (Ethnologue, 2018) plus an unknown number of associated dialects. Figure 3.189 shows the language map of PNG from coastal to the highlands region.

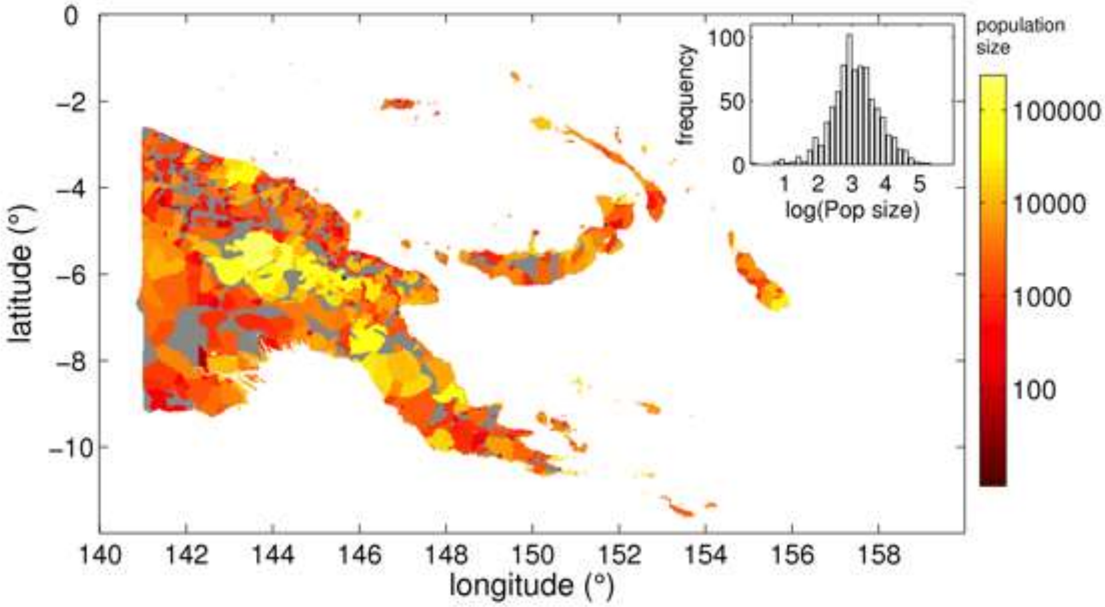

Figure 1.189. Index of Linguistic Diversity of Papua New Guinea & log population size histogram (Ethnologue Database v15)

Figure 3.190: Linguistic Diversity of the World (i.imgur.com, 2013)

Figure 3.190 shows PNG is one of the World's most diverse linguistic countries together with few places such as India and Africa with a value Indices of 0.9. English, *Tok Pisin* and *Motu* are the official languages of PNG. The world has over 7000 languages and PNG has about 12% of the global language diversity.

Kairiku students of Tokara Secondary School Strutting their staff during a school cultural dayt (Photo by Yuda Pictures)

It seems most of the languages are slowly dying or not many people can be able to speak. For instance, when you go to a village nowadays, the children are speaking *Tok-Pisin,* a creole which is one of the 800 languages. The reality is that *Tok Pisin* has become so popular that it affects speaking of local vernacular, hence the local vernacular is slowly dying out. If one speak his or her mother tongue to a group of 10 children, 7 may fluently reply back, 2 may reply in Tok-Pisin and 1 may not even understand a word at all. Ten years down the line, from that 7, the number may decrease further. This picture paints a sad picture of how PNG's local vernacular is disappearing in modern time.

The extinction of a language occur because of extinction of a tribe as population decline, people choose not to speak their mother tongue but other languages, loss of tribal land and people disperse or migrate elsewhere, hence speaks another language. Prior to the arrival of western civilization and foreigners, knowledge and history were passed down through oral history or myth of origin using local languages. The Summer Institute of Linguist (SIL) in Kainantu has recorded most languages.

In this generation the majority of people are orally literate in their own language although there are signs that this will decrease in the next generation. As language is integrally linked to culture and customs these are also being lost. Despite this the linguistic and cultural ties between communities and their surrounding environment upon which they depend remains functionally strong, it is however different in the major cities where young people growing up in this urban environment are disconnected from their ancestral lands and this is a growing concern. Figure 1.191 shows the threat percentage of language of PNG with more than 6% is Critically endangered, Endanagered has 16%, Vulnerable has 29% and least Concern has 48%. Figure 1.192 shows PNG languages in cluding West Papua languages are declining between 1970 and 1990 on the language index compared against Australian indigeneous languages. A recent study by Leverington et al. (2018) shows landguages within PAs are under threat as well and some local names for species have now been lost or known by elderly and older men and women folks (Fig 3.193).

Figure 1.191. Threatened Languages in Papua New Guinea (Ethnologue, 2018)

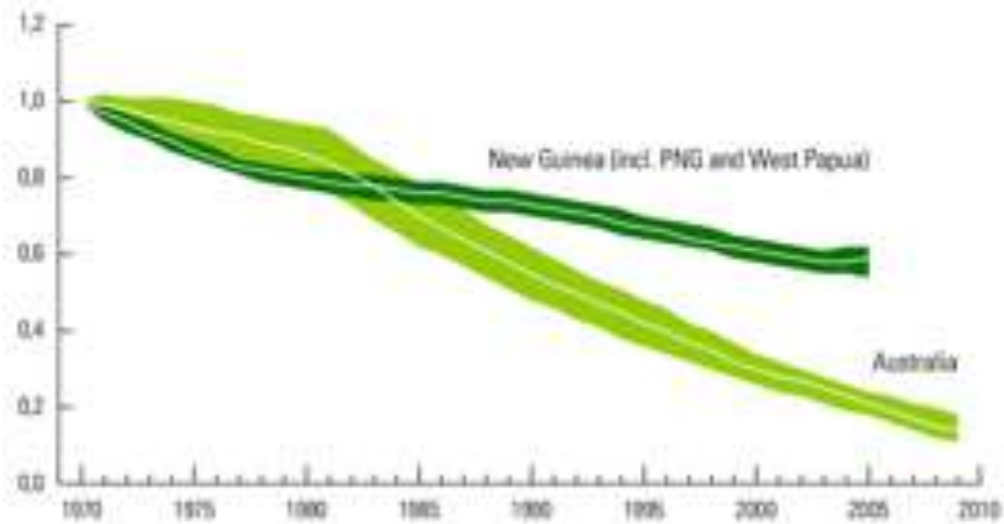

Figure 1.192 Index of Linguistic Diversity 1970-2010 (Ethnologue, 2018)

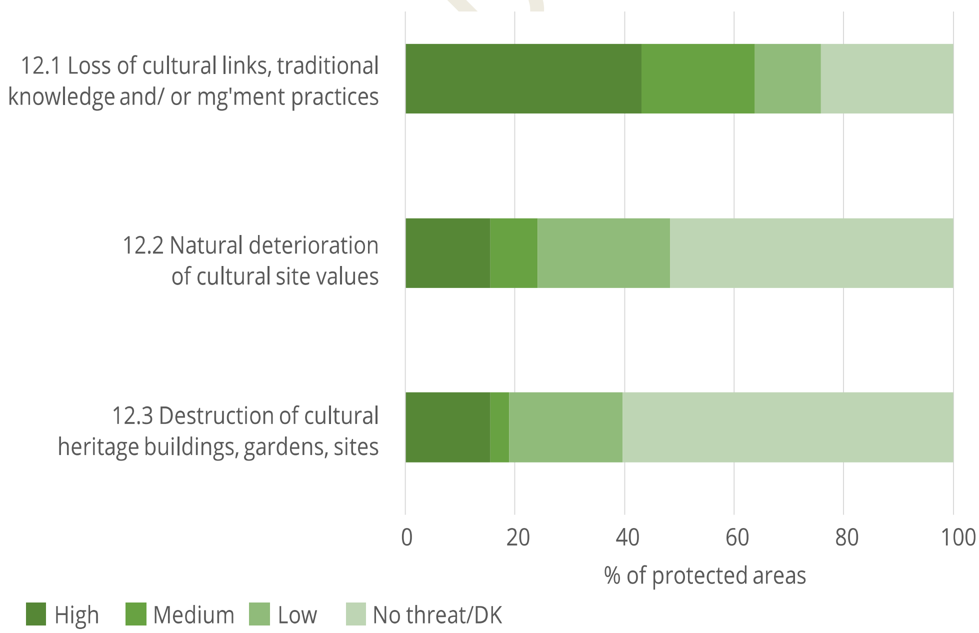

Figure 193. Level of threat within PAs relating to loss of culture (Leverington et al., 2018)

The importance of language and culture in the process of development of our country is enshrined within the 5th goal of the PNG Constitution on Papua New Guinean Ways which in part calls for the recognition that the cultural, commercial and ethnic diversity of the people of PNG is a positive strength, and for the fostering of a respect for, and appreciation of, traditional ways of life and culture, including language, in all their richness and variety, as well as for a willingness to apply these ways dynamically and creatively for the tasks of development.

Nowadays, Papua New Guineans tend to identify with larger territorial groupings of traditional political communities, such as those united by a common language or culture, and hence by a shared understanding of their natural environment (Filer, 2015). Essentially these language/cultural groups though not currently recognized as such, could represent 'nations' across Papua New Guinea. Efforts of recognising leadership, values, Traditional Ecological Knowledge (TEK) in sustainable development could occur at a nation level.

Traditional Environmental/Ecological Knowledge gained through experiential learning over many generation has led to various management practices of terrestrial and marine areas some of which a 'tambu' sacred/forbidden areas. These have been incorporated into the *Protected Areas Bill* 2018 as they often have high conservation value. This however is under threat as languages are becoming threatened as seen in Protected Areas right across the country as seen in Figure 1.192 (Leverington et al., 2017)

PNG can be classified into various cultural heritage regions either through the languages the community speak or through a common cultural practice. There were trade links between these communities with which plants or animal species from the lowlands were transferred or traded to high altitude during those trade exhibitions. For instance, pig and dogs were believed to have been domesticated and brought to the Pacific by the Lapita people from the South East Asia of Taiwan.

During their voyages they stopped along the way at different locations and spend time before moving on for various reasons, either it be the weather or restock of food supply, hence they can continue their journey. With trade links and networks between the coastal and highlands communities, the pig moved to the highlands and is now a form or wealth for a highlanders when it comes to bride pride payment and mortuary compensation. The more pigs, land and wives a highlander has, the higher his social status is within his clan and community.

Take for instance, the PNG LNG Project which crosses 4 different provinces and different cultural heritage regions with diverse ecosystems, language groups and cultural systems. We will look at them and try to depict the picture of PNG as a whole. These regions are in the Highlands, Lake Kutubu, Kikori and PNG LNG Facilities at the Coast which are discussed briefly of their past history below:

Huli Wigman traditional dancers of Tari, Hela province

- Highlands region in the Hela Province is occupied by the Huli speaking communities of Hides, Komo and Homa/Paua people. They traditionally have an ethnic trade network where information, knowledge and materials flowed amongst the tribes. They also trade with the Enga and Obena people for stone tools, exchanging pigs and oil in return. To the south they trade with the Foi and Fasu people from Lake Kutubu for *digaso* oil (*Campnosperman brevipeiolata*) in exchange for pigs. Pig is a high value commodity for the Hulis. Photo 7 shows Huli Wigmen ready for a *singsing (*traditional dancing and singing*)*;

- Lake Kutubu in the Southern Highlands Province is occupied by the Foi and Fasu language speaking communities. They live in limestone caves and rock shelters which have cultural significance to them. Traditionally the deceased corpses are laid to rest inside the limestone caves as there were no cemeteries as seen nowadays. The practice is no longer active but those limestone rock shelters and caves are still considered sacred and preserved by the communities;
- Kikori in the Gulf Province is occupied by the Ikopi/ Kasere, Kerewo, Porome and Omati language speaking communities. These tribes have an indirect partner in the ancient *Hiri* trade between the people of Central and Gulf Provinces of PNG. The underground water and limestone caves are considered sacred and are of cultural heritage significance; and
- The LNG Facilities in the Central Province is located in an area where the communities speak the Motu and the Koita languages. Traditionally, they are famous for their clay pot manufacturing and it was in the Boera village just outside Port Moresby at the LNG Plant site, the first *Lagatoi* (traditional yacht or shipping vessel) set sailed into Gulf Province for the historical *Hiri* trade to exchange clay pot for sago and bettlenut and other goods.

It would be good to see Papua New Guineans reviving back some of the old traditions the skills and knowledge, especially good things and preserve them from extinction. For instance, in the part of East Sepik Province, in Kubalia and Biwat LLG, the old-fashioned mode of communication was the beating of the *garamut* and sounding of the cone shell. The sounds played have certain pitch and depicts different meanings. Some could mean there is death in the village, fighting between clans, community gathering for general discussions and so on. Selected people within a clan, tribe or community were trained and skilled with interpreting these sounds and would be relating whatever sound to the entire community.

Today with the advancement of technology such as mobile phones, the frequency of using the *garamut* and the cone shell is diminishing. People no longer take interest in carving a new *garamut* and learning the skills of interpreting the sounds it depicts. In the past, in almost every hamlet one visits, there is a newly carved *garamut* but in recent times, the old *garamut* that was carved and used in recent past, some as late 1970 or 1980s are slowly rotting away. In contrast, in the Highlands of PNG, before the birth of telecommunication, messages are sent through sounding of loud shout from mountain tops to mountain tops, valleys to valleys or from village to villages. The sounds have specific meanings relating to tribal wars, death, visitors, feast and so forth.

This mode of communication is not used today because of accessibility to modern forms of transport and communication. The tradition and cultures of PNg is rapidly changing and evolving but some are still being preserved such as the famous Asaro Mudmen. Many toursits visits provincial shows to take a glimpse of the rich culture PNG has and for tourism. Annual cultural shows provide an avenue for PNG and tribal groups to showcase traditions and cultures.

Asaro Mudmen in one of their acts

Given the above scenarios we can conclude that PNG is losing many of its traditions, belief systems, customs and cultural identity through the influence of Christianity, modernization, migration, and intermarriage. The onus is now on the government to document and achieve the histories, culture and languages of the people. As PNG become more modernize, most of the unique cultural assets and histories will be lost forever in the annals of history.

Impact

Most languages, beliefs, customs and cultures are facing threats because of intermarriages between different tribal group, migration to towns and influence of western world and modernisations. Unless these assets are not preserved, documented or passed onto the next generation, many of these cultures and traditions will be lost into eternity. The Tourism Promotion authority (TPA) is very rigorous in promoting tourism in the country and has been supporting various cultural shows annually over the year.

Oral knowledge is rarely in other mediums of communication being held by custodians. There is also mo monitoring system in place to detect extinction of language. With so many languages this is extremely complex and overwhelming challenge to record all aspects of traditional knowledge across the entire country.

The government's priority also is to embark on teaching the children in the elementary schools before formal education begins so the rich cultures and traditions can be preserved. Constant contact with village, family ties and speaking local dialect or participate in cultural practices and traditions may protect or preserve the identity of individuals to their culture, clan and tribe affiliations. However, this trend is becoming less prominent as the gap between villages or rural areas and urban areas become widen.

Currently, almost 70% of the population are thinking differently to those living back of 1960s who believe in legends told by their ancestors. The current generation are different simply because of the influence of western cultures, education, Christianity and technology.

Over the years, the provincial and national government have failed to conduct inventories in all provinces, or hire students or professionals to document languages and archive cultural or historical sites. They also failed to document languages, cultures and traditions and giving copy rights to the different language groups or the author. This is because most historical events or folklores and traditions are verbally passed by oral history.

Over the years, lack of government funding has fallen drastically but hopeful it is not too late to intervene to support those key government agencies in protecting and preserving both culture and history of PNG. This can be done by way of conservation and tourism, which can generate income for the country as well.

Although Customary law is recognized, there is also a need for law on customary intellectual property rights and in maintaining ethical standards of prior informed consent to protect the rights of the custodians of this information.

In the meantime indigenous languages, culture and oral traditional environmental/ecological knowledge are threatened now under threat from being lost. There is knowledge that is held by one clan or tribe or even by an individual; rituals, rites of passage, sensitive sacred and tambu or taboo intellectual property and it is for the owners of this information to decide if and how they pass it on. The information that is hidden in the forest and in the minds of people is depicted in Majanep (1982). Although Environmental Anthropology is a potential major in studies at UPNG or other PNG universities, there is little emphasis or available support to enable the systematic recording of applied customary knowledge, apart from individual dissertations or ethno-botanical publications.

Response and Recommendations

The National Museum and Arts gallery can work with the PNG cultural Commission and the Institute of PNG studies, provincial governments, development partners, NGOS, students and researchers to map, document, record and archive historical sites, languages, spiritual sites, historical sites and so forth. This mean appropriate documentations need to be done Also more promotion must be done by the Tourism Promotion Authority (TPA) and more awareness and education must be promoted in schools by way of cultural shows. Educational institutions must be given tasks to revive dying cultures and traditions.

There is an urgent need to record Traditional-Customary Environmental/Ecological Knowledge especially in its application, in both local language and a *lingua franca* in a medium that is reliable. Although not formally recognized the language/customary groups form nations across Papua New Guinea which offer a strong customary management structure under which information collection can inform localized development.

There is an urgent need to value this Traditional-Customary Environmental or Ecological Knowledge and invest in *in situ* community-led programs that utilize these records to educate and advocate in its ongoing application in the changing social contexts of village societies across the mosaic of cultures within the Nation State of PNG.

There is an urgent need to invest in the registration of aspects of this knowledge in tangible (sacred sites) and intangible heritage (cultural practice) so that the social landscape that links people to their land and environment is recognized, strengthened and promoted.

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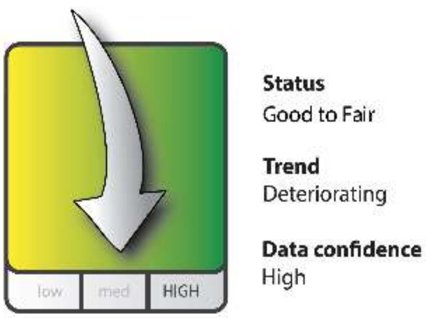
Mural paintings are major attractions in places like the Jackson's airport.

8.9.4. TOPIC/SUBTOPIC: TRADITIONAL DIETS AND MEDICINES

Indicator Definition: Trend in diets and medicines

Status and Trend



A healthy population is a prosperous nation

SDG/CBD Targets

SDG: 2.1.1, 2.1.2, 2.2.1, 2.2.2, 2.3.1, 2.3.2, 2.4.1, 3.1.1, 3.1.2, 3.2.1, 3.2.2, 3.3.1, 3.3.2, 3.3.3, 3.3.4, 3.3.5, 3.4.1, 3.7.1, 3.7.2, 3. 8.1, 3.8.2, 3.9.1, 3.9.2, 3.c.1

Aichi target: 1 ,4, 5, 6, 12, 13, 14

Status and Trend Discussion

Diet

The way the people live, the location, conditions (economic, social and spiritual) and cultures have greatly influence the living standards of Papua New Guineans: Where the people live and the prevalent conditions of the environment they live in have a considerable impact on their diets, nutrition and food preparation techniques. For instance, the people rural communities of Morehead District in the South Fly of Western province way of doing things, preparing food, and choice of diet is totally different in different regions, in the highlands, coastal, islands, river or marine environments.

Saraga betelnut and food market, 6 Mile, Port Moresby

A large proportion of those living in rural areas and remote villages continue to live a very traditional lifestyle living in huts, practicing subsistence farming, hunting for game, fishing and gathering wild fruits and vegetables. It is also usual for them to cook food directly over hot coals, in pots over open fires, or in ground ovens (*mumu*). When cash is available, food such as rice, canned fish and canned meat may also be purchased to supplement the diet.

Eighty-seven percent of rural population are engaged in subsistence agriculture On the contrary, the urban Papua New Guineans may have access to electricity, gas and other modern conveniences and many processed or manufactured food. They also have access to food from both marine and garden supplied to major town markets by the rural population living nearby who have access to the cities and towns.

PNG has had continuous agricultural cultivation over 8000 years at Kuk in the highlands which is the only UNESCO World Heritage listed site within the country. There are high levels of agricultural biodiversity, and PNG is the centre of origin for banana and sugar cane and the centre of diversity for yam, taro and sweet potato.

There are over 250 defined agriculture systems which have varying staple crop diversity and cultural agronomic practices. Numerous plant species have traditionally been cultivated, including more than 30 root crops, 21 legume species, 40 leafy green vegetables, 60 other vegetables and roots, 43 varieties of nuts, 102 fruits, and 89 other plants used for food or seasonings (GoPNG, in press).

Agriculture diversity and traditional agronomic knowledge lies predominantly *in situ* with subsistence farmers. This is tenuous with loss of cultivars through influence or natural selection from climate change and a corresponding loss of customary knowledge. There are *ex situ* collections held by the National Agricultural Research Institute (NARI) and overseas which despite preserving genetic material represents a loss of customary property rights.

Hunted and traded wildlife plays an important part in custom for exchange in celebration and within traditional diets, supplying the primary intake of proteins and fats in many highland areas and other isolated areas of the country. In coastal areas, a wide variety of seafood, including fish and molluscs are fished and gleaned.

Domesticated and to a lesser extent wild pigs, inlcuding chicken are an important animal for exchange and feasting. Wildlife is an important part of all communities with value in customary practice and as a protein source.

In coastal areas there is a reliance on seafood as a protein source, and importantly coconut.

Their lifestyle is influence by the environment, the prolonged dry and wet seasons, the abundance of wildlife, and the suitability of crop that grows there. The prevailing condition, living location and its accessibility, topography, altitude, soil, climate, economic status, access to government services and degree of adoption of western versus traditional lifestyle have influence how people behave and eat and the yield produced crops or population of wildlife people hunted or fished (Bourke et al., 2009; Sam, 2015).

Hence, various ways of cooking and dishes have evolved. Various local and introduced vegetables are sold at local market around the country. Most of the cabbages, onions, carrots comes from high altitude regions while lowland crops are supplied from neighbouring villages in Central province. Figure 3.193 shows different regions and places, have different food preferences, including Solomon Island.

The staples traditional PNG diet include fish, seafood, sago, sweet potato (*kaukau*), taro, taro leaf, cassava, cassava leaf, breadfruit, edible leafy greens (*kumu*), coconut and fruits. The traditional meat is pork, which is often eaten on special occasions. It is also a form of currency, with a number of pigs an individual, family or clan owns determining their wealth and status in the community. Coconut milk is the predominant liquid cooking medium but was traditionally used only in coastal regions.

Snacks usually comprise fresh fruits, nuts and berries. In most villages, the main foods eaten today are still those noted by Europeans at first contact: root vegetables (taro, yam and sweet potato), bananas and plantains, sago, green leafy vegetable, fruits, marsupials, birds, fish and shellfish (Sam, 2015). These are frequently supplemented by imported canned fish and rice.

City residents buying vegetables and fruits at the Pacific Adventist University in Port

Many new fruits and vegetables have been introduced in the last 100 years and are widely grown and liked, but cassava is the only important addition to the list of starchy staples. In many regions most protein is supplied by green leafy vegetables. Pork is mainly reserved for feasts. In towns and adjacent villages bread, chicken and pork are added to the basic diet of canned fish, rice and vegetables in the better-off households. Beer and soft drinks are popular and produced locally. PNG is not self-sufficient in food. In 1988 an estimated 20 percent of food consumed was imported. Poor transport and marketing facilities make it difficult for highland producers to supply coastal towns. In 1989 food imports accounted for 15 percent of the value of total imports (Sam, 2015).

Until after World War II an estimated 95 percent of the population was entirely dependent for food upon subsistence agriculture, hunting and gathering and, where possible, fishing. In 1992 an estimated 85 percent of the population were wholly, or partly, dependent upon subsistence activities. Seasonal crops such as yams and taro are cultivated in gardens, tree crops such as sago and coconuts either grow wild or are planted near villages where they are tended. Men usually clear and prepare the ground, build fences (to keep out pigs) and, in some areas, help in planting and harvesting. Women and girls plant, harvest and tend the gardens during the growing period (Sam, 2015).

Until the introduction of metal, the main tools were stone axes and wooden digging sticks. Today, digging sticks are often tipped with metal, such as pieces of piping; stone axes have been replaced by imported steel axes; and bush knives (machetes) and other imported metal tools are used occasionally. Land use depends on the terrain, soil, climate and population density of the area. In the lowlands, a system of shifting agriculture and bush fallow is mostly used. In the highlands, where the density of population puts greater pressure on usable land, more intensive systems are needed and in some places imported artificial fertilizers are used. Traditional rituals still accompany planting and harvesting in most parts of PNG (Sam, 2015).

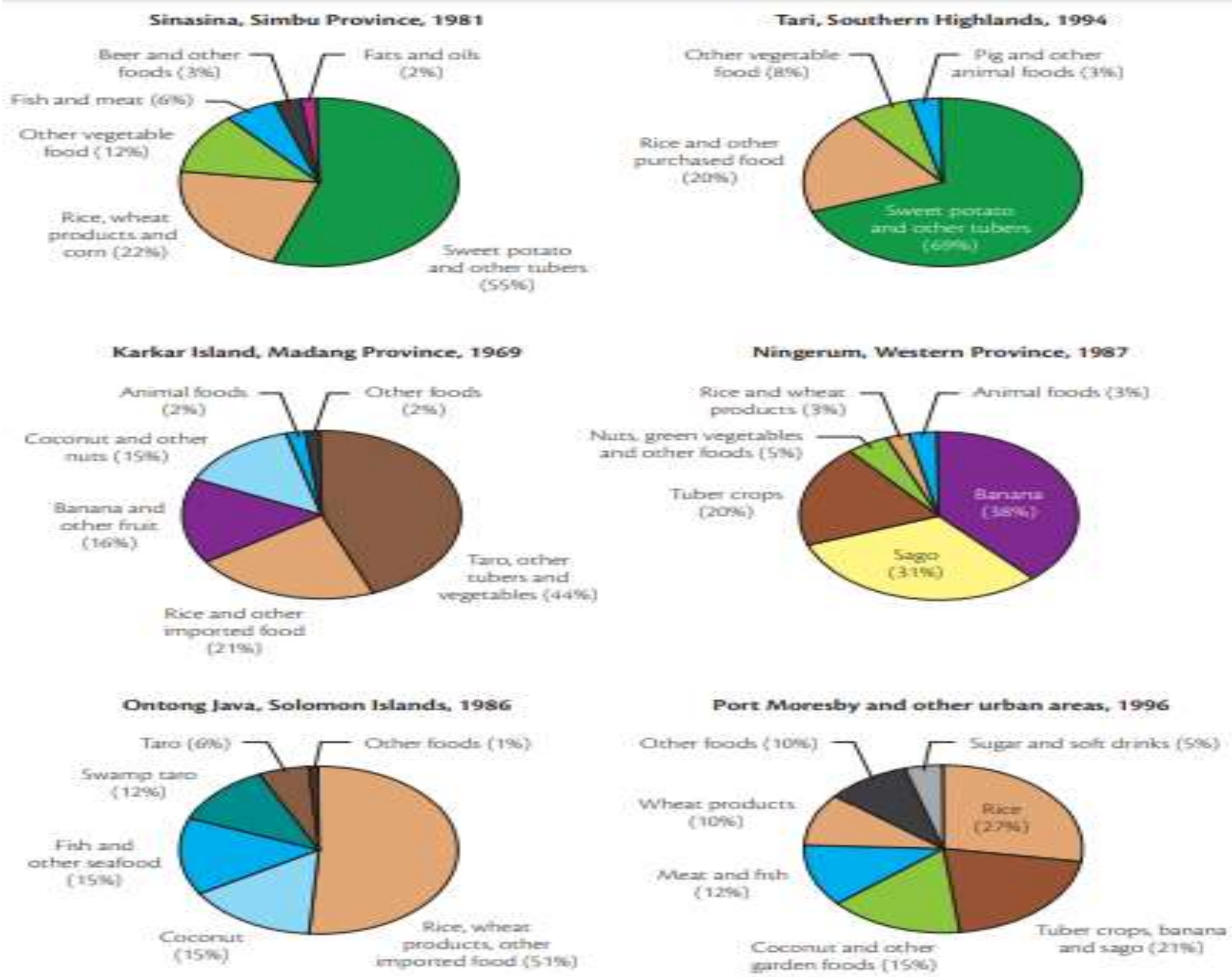


Figure 3.194: Proportion of total energy from different foods in selected locations. Note: Ontong Java is an atoll group in Solomon Islands near the international border with PNG. This data was used because it is of higher quality than that available for atolls in PNG and is likely to be representative of PNG atolls (Bourke et al., 2009).

There is a big variation between westernised or modern and urban lifestyle compared to traditional or village and rural lifestyles. In urban areas, Papua New Guineans who are more affluent or employed may have adequate income to purchase food rather than relying on subsistence agriculture. They depend much on available imported food products, especially those with money to purchase and fresh local produce may be purchased daily from the markets supplied by the rural population or supplied from other provincial centers such as Port Moresby and Lae.

Figure 3.195 shows most of the food used in PNG comes from local sources while less than 20 percent comes from imports. Food energy derived from local food constitute about 83% while imported food is 17% compared to food protein where 76% is local while 24% are imported (Bourke et al. 2009). Some of the protein such as pork, chicken and beef are produced locally in PNG. Cattle herd farming in

PNG is done by some established agriculture companies to discourage import of red meat.

A cattle herd raise amongst a coconut plantation in East New Britain province

According to the World Bank, food imports (% of merchandise imports) in PNG was reported at 11.03 % in 2012 (Trading Economics, 2019). These amount or percentage may have increased over the years because of the rising population the country is facing. PNG is yet to go into downstream processing to produce its own food to meet the increasing demand of its population. The more food stuff brought in from overseas would become dearer as PNG currency has plummeted to less than US 0.29 for a *Kina*.

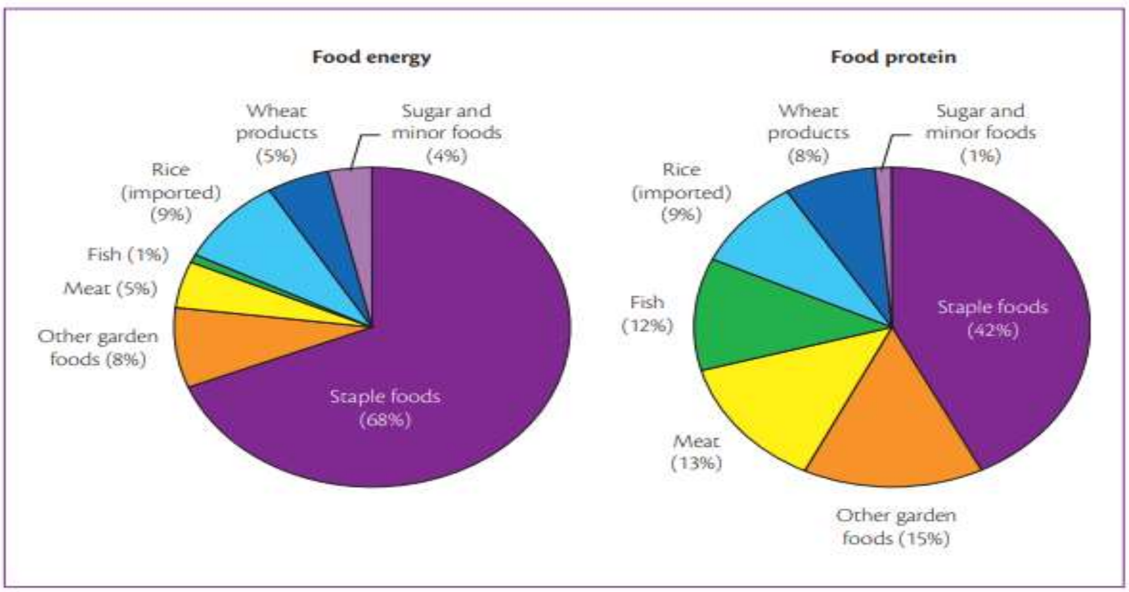


Figure 3.195: Source of energy and protein by main food groups, 2006 (Bourke et al., 2009).

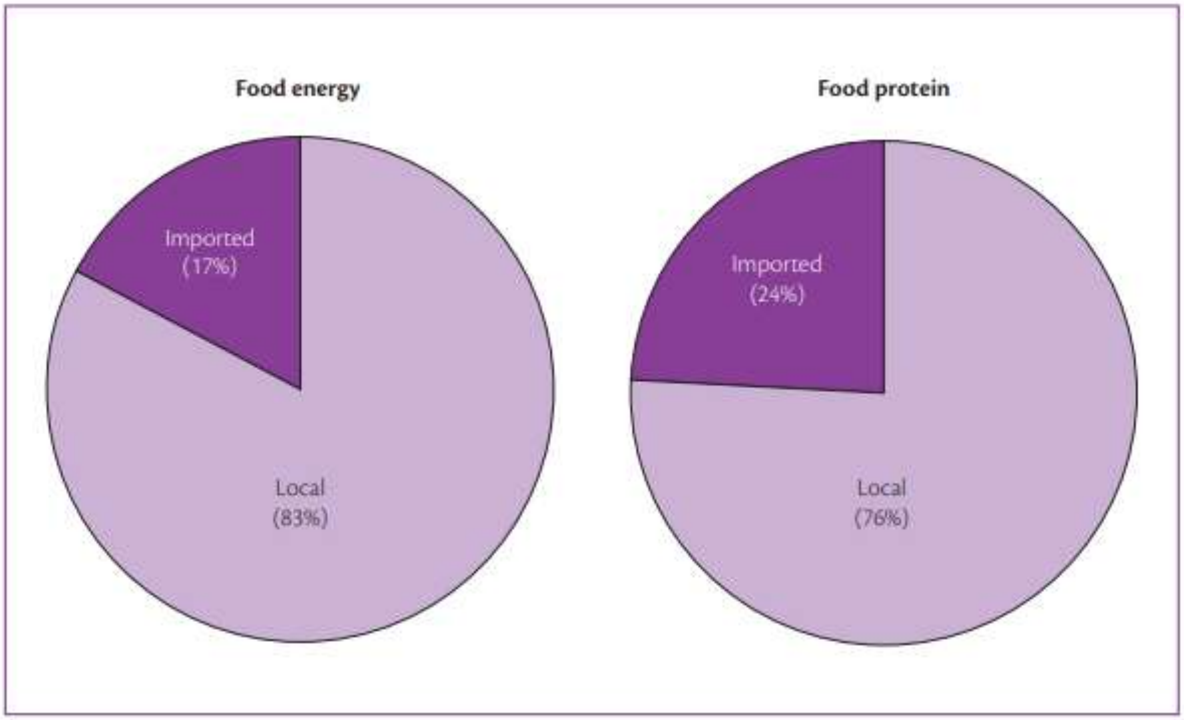


Figure 3.196: Proportion of energy and protein derived from locally produced and imported foods in 2006 (Bourke et al., 2009).

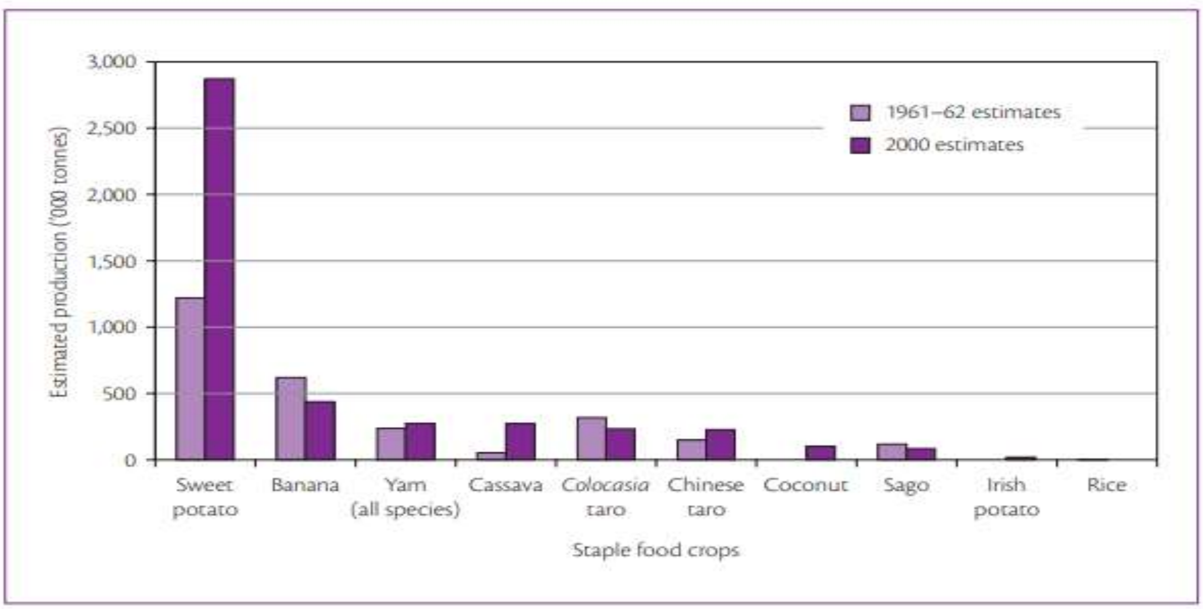


Figure 3.197: Comparison of the 1961–1962 and 2000 estimates of production by weight of ten staple food crops. Note: Coconut production was not estimated in 1961–62. Estimated Irish potato production in 1961–62 was negligible. Rice production was estimated as 3000 tonnes in 1961–62, and 407 tonnes in 2000. The 1961–62 figure for rice is unlikely to be accurate (Bourke et al., 2009)

Figure 3.196 shows that majority or 68% of the food energy comes from the PNG staple garden foods while the others comes from imported rice (5%), other garden foods (8%), meat and wheat products (5% each), sugar and minor food (45) and fish (1%). For protein, PNG staples food meat provides 42% followed by other garden foods (15%), meat (13%), fish (12%), Rice (9%), Wheat prodiucts (8%) and sugar and minor foods (1%).

Figure 3.197 shows a generally cultivation of sweet potation increased in 2000 from the 1960s, including cassava, Chinese taro, Irish potatoes, and yams because they are now becoming commercialised. All other staple food crops decline while new entery sees rice and coconut entering the markets because of their demand. In recent times, more bananas are now being grown and sold at the market but the figure is lacking to justify this claim.

People living in the village or rural areas tend to eat traditional foods. Often men hunt for meat and fish, gather firewood and women are responsible for gathering the edible greens, fruit, seafood and starchy components of the meal, such as yams and taro from their gardens and sago from their family plots. In remote areas where there is minimal outside influence and no commerce or job prospects, bartering food is a common practice. Until recently, some imported foods like biscuits, rice and canned fish or meat are sold in the villagers. The PNG government through the MTDP3 2018-2022 plans to revolutionise the economy through green revolution by increase productivity and the economics of scale in the renewable sector, including agriculture.

In most homes, eating utensils are used but people sometimes resort to other natural things such as leaves, coconut shells, bamboos and general using their hands when situation does not allow. For those who can afford three meals are day, it becomes a norm but often many people do not eat well. Consequently, this result in PNG being one of the most stunted countries in the world. Connection to better water quality is still a challenge for many households in PNG (Section 8.3).

Medicine

According to oral history, before the arrival of Europeans, the life expectancy of the people were high where 'men and women live up to very old age'. During those period, population density was low because of tribal fights, death of children at early age from diseases and other causes. However diet was not balanced and life was less sedentary but more nomadic. However, the trend has change in life expectancy of Papua New Guineans. In the 1980s, the average life expectancy of people was 42 years old but that increased to 65 years of in 2011 because of improved standard of living and medical services and medicine. The World Bank recorded the average life expectancy for women is 68.08 years whereas for male is 63.14 years (Trading Economics, 2019).

Every year almost K1.2 billion has been spent on health but nothing much has been achieved because not all Papua New Guineans have access to better health services. According to the World Bank, in 2010 the number of physician seeing a patient is equivalent to 0.055:1000 (Trading Economics, 2019). About 2.7% doctors are employed in the health and social services while 4.1% work in formal wage jobs (NSO, 2010). Still medicine supplies are not for coming to clinics in many rural areas and is quite expensive and unaffordable for many Papua New Guineans.

There are also lack of facilities and specialist doctors in PNG that can attend to patients. Human resource is critical and central to the delivery of government priorities and services. Papua New Guinea has an ongoing issue with lack of educated professional and technical staff to contribute to national development.

The Health Sector Work Force Crisis Review Report 2011, by the World Bank, highlighted shortfalls in human resources for health, and recommended for accelerated efforts to address this problem. The National Department of Health (NDoH) is formulating several response plans, including the Health Human Resource Enhancement Plan 2014-2016 and the Health Human Resource Policy 2012. In line with the NDoH response, this policy aims to ensure the Department of Health in collaboration with key stakeholders, develop and deploy adequately trained human resources for health, in particular for the pharmaceutical sector (GoPNG, 2014). The government and development partners such as European Union and the Australian government have invested a lot in development of human resources in the recent years.

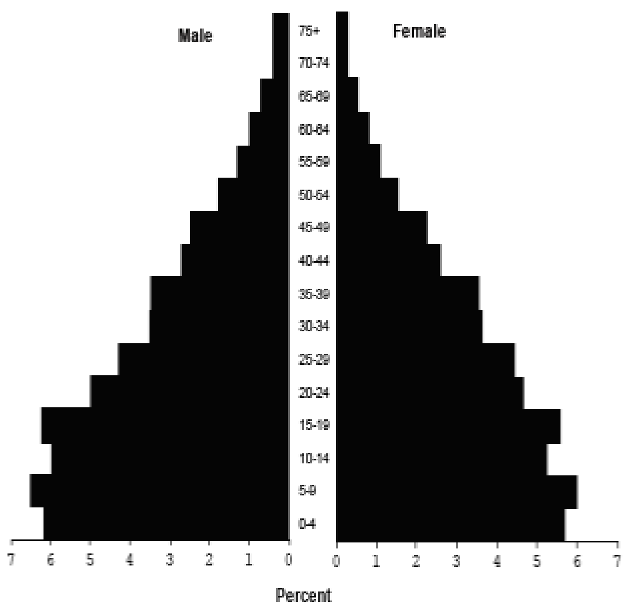
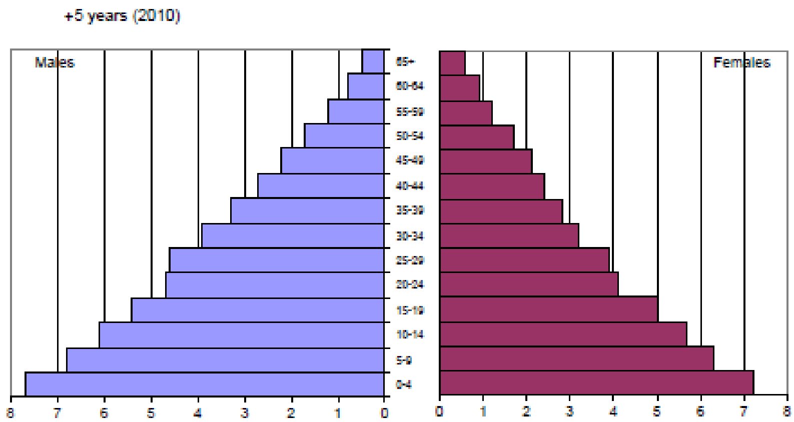
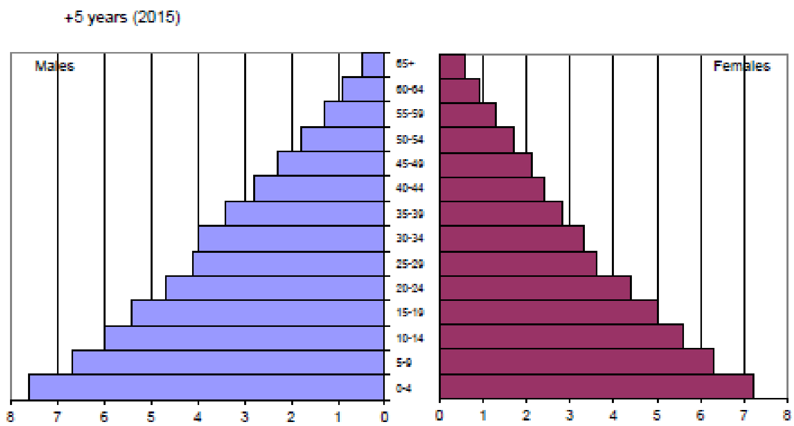


Figure 3.198: Population pyramid of citizens by age and sex in 2011 (NSO, 2011)



	Male	Female
0-4	7.7	7.2
5-9	6.8	6.3
10-14	6.1	5.7
15-19	5.4	5
20-24	4.7	4.1
25-29	4.6	3.9
30-34	3.9	3.2
35-39	3.3	2.8
40-44	2.7	2.4
45-49	2.2	2.1
50-54	1.7	1.7
55-59	1.2	1.2
60-64	0.8	0.9
65+	0.5	0.6



	Male	Female
0-4	7.6	7.2
5-9	6.7	6.3
10-14	6	5.6
15-19	5.4	5
20-24	4.7	4.4
25-29	4.1	3.6
30-34	4	3.3
35-39	3.4	2.8
40-44	2.8	2.4
45-49	2.3	2.1
50-54	1.8	1.7
55-59	1.3	1.3
60-64	0.9	0.9
65+	0.5	0.6

Figure 3.199: Population pyramid for PNG in year 2010 and 2015 (NSO, 2000)

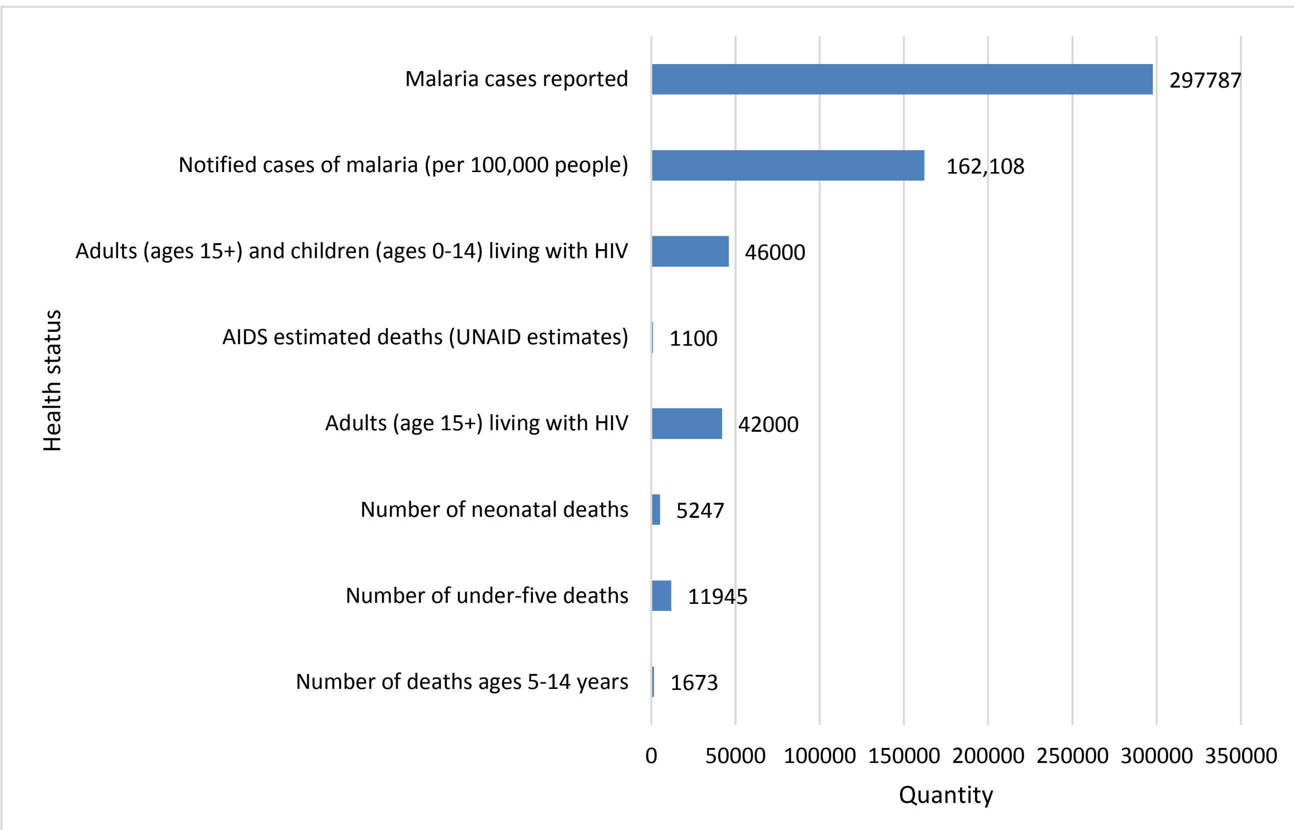
Figure 3.199 shows of the 7.2 million citizen population enumerated in PNG in 2011, 36% were below the age of 15 years and 62% were aged 15 to 64 years. The proportion for the younger age group (less than 15 years) has decreased with a possible shift to the working age group (15-64 years) while the proportion for older persons (65 years and over) has remained consistent (NSO, 2011). Figure 1.99 also shows the population pyramid of PNG in 2010 and 2015, with the number of females and males almost equivalent at 50%.

This depicts not many children are being born or may have succumbed to preventable diseases and death in ages below 15 years. On the contrary, not many people live up to beyond 65 years and many die early because of lifestyle or preventable diseases due to lack of medicines medical facilities and practitioners.

PNG has some of the worse health indicators status in the Asia-Pacific region and the world (Figure 3.199, Figure 3.200 and Appendix 11). Generally Figure 3.199 and 3.200a,b indicate the health status of PNG is still low or poor and much improvement is needed. All these health statistics are relating to many factors including poverty, changing lifestyle, personal hygiene and economic status.

Figure 3.200a shows Malaria is still a killer diseases with 297, 787 cases reported annually, with 162,108 people out of 100,000 are affected. There are also 46,000 people including children (42,000 adults) living with HIV with an estimated 1100 deaths. It is also appalling the number of neonatal deaths recorded is 5,247 and that could be prevented as a result of lack of proper health services, resources. This is mainly occurring in rural areas. Many children under five years and children between 5 to 14 years old still succumbed to death to preventable disease is 11,945 and 1,673 respectively.

Figure 3.200a also shows PNG's quantity of PNG's health status whereas Figure 3200b depicts rate of PNG's health status. The health expenditure capita PPP and Health expenditure per capita is 1752 and 1478 respectively. Accessing better services is still low. For instance, the maternal mortality rate is one of the highest in the world with modelled and national estimates per 100,000 live birth is 215 and 730 deaths. Incidence of TB is also very high with some patients developing residence to drugs because of not completing their doses. The infant mortality rate is very high per 1,000 live births at 42.4 babies that could have been prevented. This prompt the government to increase Immunisation programs which averaged around above 70% of the population because some mothers fail to bring their children for immunisation of simply visitation by medical people were not done. In addition, PNG is an overweight country with a prevalence rate of over 52.9%.



a.

Figure 3.200a: Quantity of health status for PNG (World Bank, Trading Economics.com)

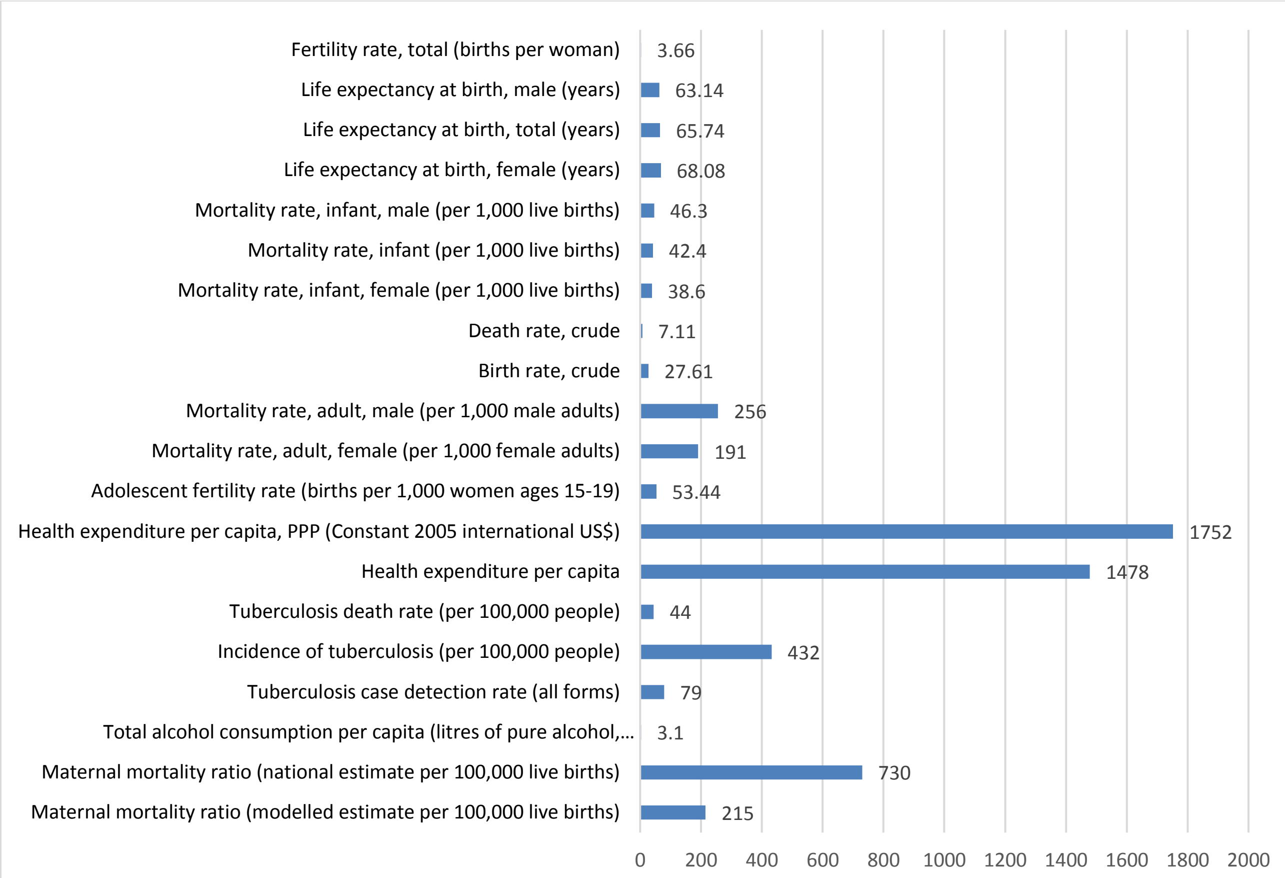


Figure3.200b: Rate of health status for PNG (World Bank, Trading Economics.com)

Since PNG has one of the poorest human health indicators in the world, medicines are critical building blocks for a health system. The negative consequences are undeniable if the right medicines are not available at the right time, at the right place and in the right quantities (WHO, 2018). However, ensuring access to medicines must also guarantee quality and safety of medical products, coupled with right facilities and personal in terms of doctors, nurses and aid post orderlies to attend to patience.

Only approved and prescribed medicines are sold at recognised pharmacies or distributed in hospitals and clinics.

Only prescribed medicines of quality are allowed in recognised pharmacies. The National Medicines Policy 2014 which was update from the first National Drug Policy has a goal *to ensure that high quality medicines are accessible and affordable to the entire population at all times and that they are used rationally*. Its vision is to ensure PNG becomes a *healthy and prosperous nation, that is able to enjoy equity of access to quality pharmaceutical products and services.* The Mission of the policy is to *Improve, transform and provide quality pharmaceutical products and services to the people of Papua New Guinea*. This policy is governed by the following objectives below:

- To ensure adequate and continuous availability of safe, effective and good quality medicines to the entire population at all times;
- To ensure that essential medicines are affordable to all those who need them;
- To ensure available medicines are safe, efficacious and of high quality;
- To promote rational prescribing and dispensing of medicines by health professionals and the appropriate use of medicines by the patients;
- To develop and deploy human resources to support the successful and effective implementation of this policy and related legislation and regulations;
- To improve and strengthen management and delivery of Pharmaceutical Services through reforms, restructuring, streamlining, better role delineation, and partnership; and
- To monitor and evaluate regularly the performance and achievements of the National Medicine Policy 2014.

In order for this policy to work, it must be implemented in tandem with policies such as Vision 2050, the DSP 2010-2030, the National Health Plan 2011-2020, the Traditional Medicines Policy 2007, the Health Sector Research Policy 2010, National Health Service Standards 2011, MTDP 3 2018-2022, Health Human Resource Policy 2012, Free Primary Health Care and Subsidized Specialized Services Policy 2013, Community Health Post Policy 2013, and the Health Sector Partnership Policy 2014. Currently, drug shortage and distribution or availability of quality and affordable drugs is a huge problem right across the country. This is because of poor handling by distributors of medicines and other resources and services.

In order to resolve some of the issues, the Policy wants to ensure medicines availability to the population, must be improved by way of:

i) evidence based selection;
ii) effective and transparent procurement processes;
iii) reliable inventory systems iv) and an effective storage and distribution system; and
iv) A sound functioning system that performs well will be able to ensure adequate and continuous availability of safe, effective and good quality medicines to the entire population at all times.

In order to achieve a functioning system and services, medicines shall be rationally selected for use in the country in accordance with the "essential medicines" concept and prioritized by generic names. Also medicines procurement for the public health system shall remain a centralized function of Government, however this must be done transparently to avoid the citizens of the country to suffer. The National Department of Health (NDoH) as the steward of the Health System shall take carriage of this function and ensure Vital, Essential and Non-Essential medicines are available in adequate quantities at all times (GoPNG, 2014). Storage of medicines are important hence, all medicines should be appropriately stored and secured in accordance with good storage practices.

To avoid shortage of medicines, the policy calls for a centralized Stock Inventory Management information system to be used to support management decision making. This will allow for vital, essential and non-Essential medicines to be made available and accessible to all health facilities including the remotest ones at all times.

Often the drugs are expensive and the policy calls for local production of generic medicines and natural health products will be promoted and encouraged and will be subjected to product registration. Any drugs that are expired and unwanted shall be disposed safely to minimize hazard to the community and environment (GoPNG, 2014).

In recent times, private recognised pharmacies that are subjected to PNG laws are selling medicines to people but only when prescriptions are provided by a certified doctor.

Pharmacies are now selling prescribed medicines

Many citizens still have no accessibility to better and quality medical services. Hence the ability to afford medicines can have an impact on whether a patient receives a full course of treatment or no treatment at all. The Government’s “Free Primary Health Care and Subsidized Specialist Care Policy” intends to ensure minimal costs for those accessing primary and specialist health services in the public sector. This attempt should be complemented by exploring other options for financing, including insurance and endowment schemes (GoPNG, 2014). However, most appropriate medical services are not available in country in major provincial hospitals but offshore, hence very expensive for an average Papua New Guinean to afford. Often times, many Papua New Guineans resort to traditional medicines sold in open markets which are sometimes not sanctioned by authorized bodies.

The Government also has a policy incentive in force on tax exemption for all medicines and health goods imported into the country for all sectors. The impact of this policy on pricing structures, especially in the private sector is still unclear. With a free passage into the market, it is necessary that the Government introduce price control measures to allow for fair pricing structures across the private sector for the sale of medicines (GoPNG, 2014). Government interventions in financing schemes as well as pricing control for medicines are necessary to limit out of pocket spending on medicines and improve access to medicines for all. This is because at the moment, the user-pay policy is common throughout the country, and most people pay for their own supplies from private clinics or pharmacies. In the past, it’s a one stop shop where medicines are provided at the clinics or hospitals right across the country.

Impact

Staff of the Conservation and Environment Protection Authority (CEPA) having a closing Christmas party

Since the arrival of the Europeans, the citizens of PNG are enjoying much improved or better diets, better health services and medicines which improved drastically resulting in improved living standards compared to the past. Many citizens living in rural communities still get their food and protein from their land or sea using improvised means while those in towns use money to buy processed foods sold at supermarkets or stores or get their garden food from local markets. However, many citizens still lack access to proper diets, medicines, and health facilities. Photo 6 shows food preparation and diet has improved drastically in modern PNG.

Eating of processed food and red meat, fatty foods, and processed food, and less balanced diet also has side effects. Escalating lifestyle diseases which are killing many caused by processed food and drinks, red meat, stress, lack of exercise poor personal hygiene and standard of living have influence the health of citizens thus contributing to those worsening health indicators. Though some traditional ways of cooking, including, fishing, hunting and gathering have been replaced by modern ways practices, more needs to be done.

For instance, lack of knowledge to prepare a balance meal may impact growth of children and this has resulted in PNG having one of the high rate of stunting in the world. This indicates that Papua New Guineans need more training and educational programs to be able to prepare better food for their children. Physical exercise and work avoiding bad eating habits are also important as well to curb lifestyle diseases as the number of fast food and imported manufactured goods are on the rise.

In hindsight, the National Department of Health must also ensure that public health is secured through the establishment of a comprehensive quality assurance system for medicines that are imported into the country for public use. This calls for improved regulatory and quality assurance frameworks to counter any threat of exposure to low quality medicines by the population. The procedures and interventions must target both pre-marketing and post marketing surveillance including; product registrations, personnel and establishment licensing, improved inspection services, routine testing, enforcement of good storage and distribution practices, rational use and reporting or recall programs. A robust functioning regulatory and quality assurance system supported by competent legislation, will ensure available medicines are safe, efficacious and of high quality (GoPNG, 2014).

Response and Recommendations

The population have to be educated about sanitation, eating proper diets and cutting down on processed food. New ways of food preparation and cooking need to be taught to all.

Most people cannot afford high medicinal costs and are not going to hospitals or clinics. They tend to revert to using traditional herbal medicines or practices. This mind-set need to be changed and proper medical checks done. Also the government should ensure medicines are affordable and available to the public or services are improved to reduce the high number of health issues faced by the country.

Improving the organizational structure and optimizing the performance in the delivery of pharmaceutical services in the country is needed. Also operational researches must be financed and conducted to measure key policy areas in the National Medicines Policy 2014 that can be used to review approaches and redesign policies for way forward.

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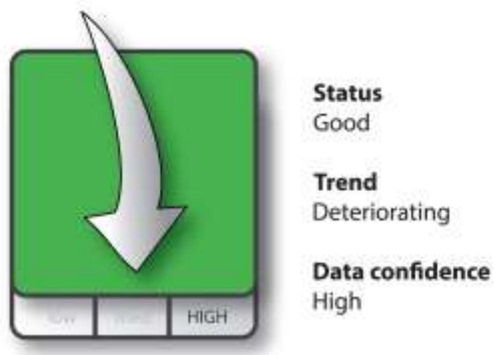
8.9.5. TOPIC/SUBTOPIC: CUSTOMARY LAND TENURE

Indicator Definition: Trend of landownership in Papua New Guinea

Status and Trend



A scenic view of Wau valley, Wau, Morobe Province, Wau is known for goldrush in the 1930w (Photo by A. Homba)

SDG/CBD Targets

SDG: 15.1.1, 15.1.2, 15.2.1, 15.3.1, 15.4.1, 15.4.2

Aichi Target: 2, 4, 7, 11, 15

Status and trend Discussion

Life in Papua New Guinea revolves around land (including rivers and sea) which is essential for life of people, including plants, animals and may biological and ecological functions. For the rural people of PNG, their relationship with land extends beyond cultivation and producing food. It anchors the community and their culture and identity, and from which many people are now facing justice for various reasons.

Customary Law derived from the traditions of the various peoples of Papua New Guinea is recognized within the Constitution and given statutory recognition in the *Underlying Law Act* 2000.

Today the world is faced with worsening global hunger, intensifying famines, and escalating land-related conflicts at the backdrop of continuing massive land and resource grabbing. It is estimated that 124 million people were under crisis-level of hunger, almost 11% higher than the 2017, which had a 35% jump from 2016 (Mariano, 2018). Mariano iterates that rural peoples constitute more than 90% of those in acute hunger, and 80% of 815 million in chronic hunger and 2 billion malnourished.

Most landownership in the world are held under freehold or lease hold. These two landholdings are also practiced in PNG but the third and most common landholding is customary landownership. Freehold titles indicate that the name of the person or business group on the Certificate of Title (COT) that owns both the property *and* the land upon which they stationed. Land which can be converted to freehold is originally customary land and cannot be State Land (Hausples, 2018). Hausples iterates that leasehold titles involve a person who owns the land, but gives it to another whom will have ownership over the property on the land for a period of time.

In PNG, the most common form of leasehold dealing is through a State Lease lasting a maximum of 99 years (e.g. agriculture lease). Much of the 'alienated' land belongs to the

State. In addition, freehold land registration is not commonly advocated for as the Incorporated Land Groups (ILG's).

ILGs in comparison to freehold, involve a large number of groups or clans that have come together to register their members and respective customary land under one group (Hausples, 2018). An ILG can then lease the registered land to a businesses (most common mining companies) and other private entities or person who operate on their land, and in return paying royalties to the members of the ILG.

Land has value in PNG and it can be utilised for sustenance of livelihood such as subsistence agriculture or for business. More than 80-97% of land is communally owned by traditional or customary owners, who are affiliated to a clan or clan groups (tribe) define by their societal social structures. The tribal land is owned by the major clans, clans, sub-clans, families and individuals that determines one's land tenure system, through the patrilineal or matrilineal systems (*pers comm. John Himugu*). Only 3% of land are alienated or belong to the State Most alienated land in PNG belongs to the state but more recently, private individuals and companies through lease-lease back arrangements.

Mountains, Rivers and valleys are natural features that determines a clan boundary (Photo: Matilda Koma)

Most tribal groups are recognised by their myth of origin, tribal genealogy and tribal land. There is no recognised government title unless it is registered officially with the Department of Lands and Physical Planning (DLPP). These lands have their boundaries determined by rivers and other natural features such as valleys, mountains and ridges.

Customary land in PNG are passed onto the next of kin either through the matrilineal or patrilineal parents line of family who have title over the land either through the father's or the mother's side of the family. Only few provinces are matrilineal societies where women owns the land, namely Milne Bay, Autonomus Region of Bouganville (AROB), East New Britain and New Island provinces. The majority of the country have their land passed to the next of kin through the patrilineal bloodline. In essence, the land is managed by clans which is formed by family members.

Clan ownership of land can be complex too because people who become residenst in a settlement, in a place over a long time, may claim to be landowners and this argument becomes stronger than claims of ancestry regarding ownership of land. However, in local land courts and mediation, the membership of a clan is determined ultimately by continuous uses and cultivation of the land by a clan member. Non-usage means the bond between land and clansmen becomes weaker, thus clanship membership is either dissolved or a member is absorbed into another clan. Often settlers are given user rights to a land where they settled on but over generations, their ancestors sometimes claim rights over that land.

In a patrilineal society, for instance in Koiari, outside Port Moresby, a person losses permanently his claims as a clansman and his land when he settles with another clan at a distant place. Close contact with the land and clan members enables one to maintain his "land rights". Generally resource rights are vested in the patrilineal line of the clan that owns that land. If another clan member wants to use a particular resource on another clan's land, permission has to be sought first. A user rights and not the ownership rights will be given through a verbal agreement to comply to its terms and conditions.

Communal land ownership is recognised by the existing land legislation in PNG, which denies individual ownership, recognising the bond and relationship between man and his land over time. Though distribution of land resources has worked for many indigenous nations for thousands of years, it is the tribal groups or clans that managed the land collectively (Karigawa, 2018). They have certain rules that promotes the rights of tribal sub-groups (clans) for access to land and resources to enhance their livelihood.

The land is held not only for gathering food and resources, but tribal members have an obligation to maintain the land in good use for future generations. Since the families, clans or villagers that uses the land expect to live in the same area for generations to come, the clan members have a vested interest to maintaining the ecological and cultural soundness of their allocations. However, during the course of maintaining the land for future generations by individuals, their fathers or mothers transfer ownership from the main clan to individuals and families, hence the rise of a mixed communal ownership in PNG.

Consequently, communal ownership of land was slowly transformed to ownership, control, use and disposition by specific groups within the main community, together with land obligations that are vested in those specific groups (sub-clans) and individuals (Karigawa, 2018). That is, different clans and sub-clans own the land in tribal groupings in PNG.

History

Prior to colonisation, the traditional land owners in PNG had their own mechanisms in place to deal with the issue of land ownership. These processes were aimed at mediating peace and finding a compromise between warring tribes – this same spirit we see now entrenched in PNG's land mediation processes. In the past, land boundaries are demarcated using natural features such as rivers, creeks, mountains, including islands, bends or mainland, and reefs for maritime people concerning seas.

Over 80% of land is own by tribal groups and clans. PNG is united through events such as 2018 Rugby League World Cup in Port Moresby. A cultural parade of different tribal groups at the 2017 Rugby League world Cup in Port Moresby which PNG was one of the co-host with New Zealand and Australia.

After the arrival of the British and German colonisers, they brought along their system of land ownership used today – freehold and leaseholds, whilst recognizing traditional forms of ownership in the land by the native population. The British, colonisers after settled in New Guinea, especially in Papua, declared the land as wasteland and claimed the land for the British Monarch as 'crown land', hence the land becomes State land under the British Law.

The land acquired by the colonizers were used for a variety of purposes, mostly large plantations. These plantations are apparently seen in the New Guinea Islands after World War 1 when the British took over the German rule. The Crown Land Law states that anything below 6 feet is also the property of the state. This law still stands todate for mining and gas and oil despite many calls to change the law.

The years leading up to Independence saw the first real indication of how Papua New Guineans wanted their land to be regulated when the

Commission of Inquiry into Land Matters Report 1973 suggested that upon independence, all land acquired by foreigners be revert back to the traditional land owners, in particular those heavily affected by the issue of land shortages at the time (Hausples, 2018). Those who kept their land at the time of Independence were required by law to have significant development made within 5 years or bear the risk of losing the land. In 1996 the new *Land Act 1996* was passed together with other accompanying legislations saw the recognition of processes to deal with land ownership, through the adopted leasehold and freeholds as well as customary land ownership. In 2009 the Lands Act was amended again to allow for voluntary registration of customary land or Incorporated Land Group (ILG).

Current issues and challenges

Given the global demand of energy and natural resources, coupled with increasing global trade, exploitation of these natural resources is wanton. Despite hypocritical calls and posturing by many global organisations like the World Bank to bring an end to global hunger and inequality between the developed and developing nations, many international orgnaisations, governments, financial institutions and private entities have facilitated, enabled, and led the global rush for land grabs –taking away large swathes of lands and water resources from the calloused hands of hungry farmers, peasant women, pastoralists, fishers, and rural peoples to large agribusiness corporations, feudal landlords, and vulture financial capitalists (Mariano, 2018).

In recent times, the government of PNG and many outsiders see development progress is often hindered by the PNG's customary land tenure system. Since then some reforms have been done to ensure land is free to enable landowners to participate equally in any resource and land development activities. At one stages in 2007, students from the University of PNG have been killed by police because of the issue of land registration and the Structural Adjustment Program of the World Bank. Hence, the government has amended the Customary Land Registration Act of 1975 in 2009.

However, land held under customary tenure has proven difficult to register and release for private enterprise globally. This is because the costs of developing secure rights to land held under communal ownership is high given the fact that such ownership rules out a 'pay-to-use-the-property' system while punitive negotiation and policing costs make a 'pay-him-not-to-use-the-property' system ineffective (Demsetz, 1967; cited in Chand, 2016).

Reforms put in place over the past decade have allowed for voluntary incorporation of landowning clans, the registration of land by local landowners, and the leasing of this land for up to 99 years. Chand (2016) iterates that the ongoing reforms provide lessons both for PNG and for others wrestling with the challenges of making available land held by customary groups for individual enterprise.

While titling programs for land held under customary tenure has proven to be difficult, the benefits of providing secure and long-term access to such land is well recognised as highlighted, where benefits arise from four distinct channels, namely:

1) enhanced incentives for private enterprise;
2) gains from trade between the owners of plots of land;
3) improved access to credit; and
4) better allocation of household labour across space including the reduced need for 'guard labour' to protect the home and the gardens.

Inextinguishable allodial title, as is the case for land held by clans in PNG, shows the costs of providing individual tenure are large, but its success in doing so over the recent past has lessons for others in a similar predicament. This provides a good test case for reform to customary tenure given that some more than 80 percent of all land is held by traditional clans that provide the basis for 'social protection' for the majority of the population (Filer, 2014; cited in Chand, 2016).

Most appallingly, the current practices on customary land registration processes can easily be captured by local 'big men' and companies with disastrous consequences for local people. This is the conclusion drawn in a study on recent oil palm expansion through the Sustainable Agriculture Business Lease (SABL) in PNG where almost 5 million ha were taken away from the customary landowners by private logging companies in the name of agroforestry projects, facilitated by the Department of Agriculture and livestock (DAL).

Land is a sensitive asset and any lease or development must be properly understood by all clan members

Companies were acquiring Forest Clearance Authority (FCA) from PNG Forest Authority (PNGFA) to log the forest. It seems this allows companies to avoid the lengthy process of acquiring a forestry permit via PNGFA. Any land acquisition, lease or development in PNG must reach a consensus by all clan members and adjacent clans through a public hearing and awareness.

A significant challenge for policy makers in PNG is to deal with the proliferation of informal (and sometimes illegal) land transfers taking place, as landowners develop their own arrangements for land mobilisation outside government structures, such as with the SABL projects and as they seek to capitalise on the demand for urban and rural land development (Karigawa, 2018).

A study by Hambloch details how PNG's weak or non-existent state capacity for regulation and enforcement of laws have been exploited by logging and or oil palm companies who have surpassed various government agencies. The results have been disastrous for local communities. Some are experiencing worsening poverty, increasing wealth inequality, increased conflict and a lack of basic service provision such as roads, schools and health centres. The study is very important for PNG as it exposes and debunks the myth that land registration or 'formalisation' is necessary to generate income, improve productivity and drive development (Chand, 2016).

Another study shows ongoing contest between bureaucratic and judicial approaches to the problem of landowner identification exists in the oil and gas sector. For instance, identification of true landowners cannot be resolved so a process of Alternative Dispute Resolution (ADR) has to be conducted to determine landownership. Over time, some have argued this processes are too lengthy.

This contest had been exaggerated by changes to the law that governs the incorporation of groups of customary landowners where the problem had been compounded by a disjunction between the forms of knowledge produced by lawyers and anthropologists engaged in their own pursuit of a solution under the terms of the *Oil and Gas Act 1998* (Filer, 2018). It has been argued that the government has now created a widening gap because of its failure to produce an additional regulation that should have governed the conduct of the social mapping and landowner identification studies that are a legal precondition to any benefit-sharing agreement in the oil and gas sector.

Kutubu Oil Project lookout within the Lake Kutubu Petroleum Development Licence area

Sometimes during development, cash benefits are actually distributed to landowners or their representatives, citing evidence of fraud and corruption in the distribution of business development grants to landowner companies that actually did begin during the project's construction phase prior to between 2008 and 2014 (Filer, 2018). Photo 4 is a scenic view within the Kutubu Oil. Oil was discovered in the area in the 1990s and many landowner identification work was done before the project became operational in the late 1990s.

Many of those anthropologists must be partly blamed for not providing a solution, since their form of knowledge has disguised the true nature of local custom, intensified local struggles over access to landowner benefits, and, in the process, even denied the rights of local women (Filer, 2018). Hence, the judicial approach may seem to be the only way to resolve issues with interference of anthropologists and bureaucrats.

The study concluded that the roots of the problem and its possible solutions are traced back to a succession of policies and practices that have their origin in the late colonial period, that were subsequently applied to the development of major mining projects, and then to the development of PNG's oil export industry in the 1990s. Apart from the Bougainville crises in the 1990s, many land issue problems in PNG stem from lack of negotiation with rightful landowners because often many landowners are involve, true landowners have been patronised or some illegitimate and paper landowners are claiming rights over the land.

Impact

Over 72 percent of the total labour force is employed in agriculture, which accounts for 35 percent of GDP. Most of the agricultural output is produced by members of extended families working on land held under customary title. The implied productivity of labour in agriculture is 4 percent that of industry and half that of services. There is potential to raise income by moving labour from agriculture and the rural sector to the rest of the economy (Gollin et al., 2014; cited in Filer, 2018).

Hence, the new Prime Minister of PNG Honourable James Marape recently announced in June 2019 that his government will revive agriculture to make PNG an agriculture nation it once enjoyed back in those day right after independence in 1975. During that early post-colonial era, PNG solely depends on agriculture and other renewable natural renewable resources like forestry and fisheries because mining and oil and gas have evolved years later. This has been captioned in the Vision 2050, MTDP3, and DSP 2010-2030 policies.

To look at the changes in landuse and ownership over time, let us look at a case study. Two customary patrilineal landowner sub-clan groups of coastal communities of Nanadai Clan of Gaire Village, Central Province and Panuwadan Clan of Sek Island in Madang Province were investigated (Kariwaga, 2018). Since there are varying customs across all communities in PNG, the views of the landowners vary according to the way they interact with their land. However, some common results have come from the study and it can be assumed that they represent the common views held by landowners across the country.

Figure 3.201 shows Customary landownership has degraded over the years with family units now owning more land, followed by individuals instead of the traiditonal owneship which is owned by major clans which is broken down to sub-clans.

Figure 3.202 shows that the breakdown in traiditoonal landownership because benefits were not equally distributed (46%), incresing population (27%), land disputes within clans (13%), shortage of land (10%) and land not easily accesed (4%).

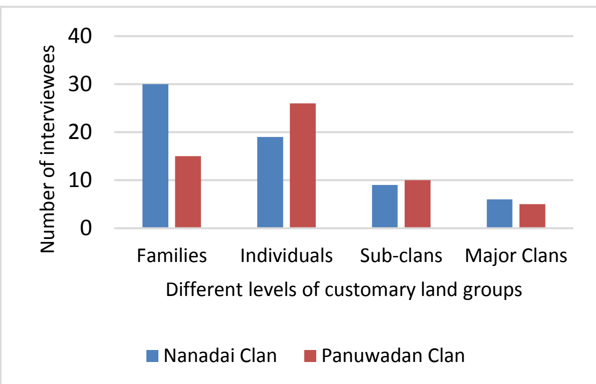


Figure 3.201: Various levels of customary landownership (Karigawa, 2018)

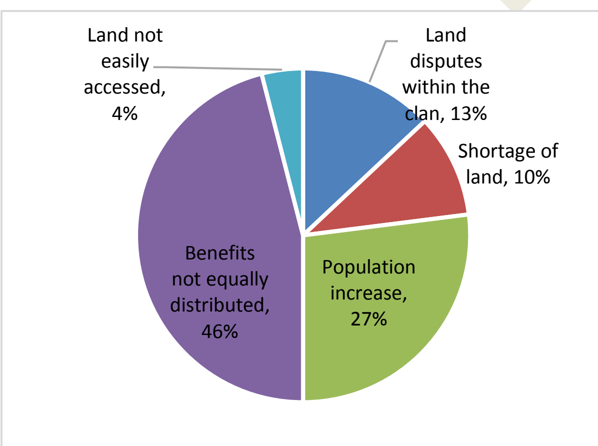


Figure 3.202: Causes of communinal breakdown in PNG (Karigawa, 2018)

Moreover, the study reveals the perception of people changes over time with land administration with majority see the administration as weak (42 vs 31 respondents), followed by strong administration (12 vs 9 respondents), very strong administration (7 vs 3 respondents) and lack of trust indicating very weak administration (4 vs 5 respondents) in both Gaire and Sek village respectively (Figure 3.203).

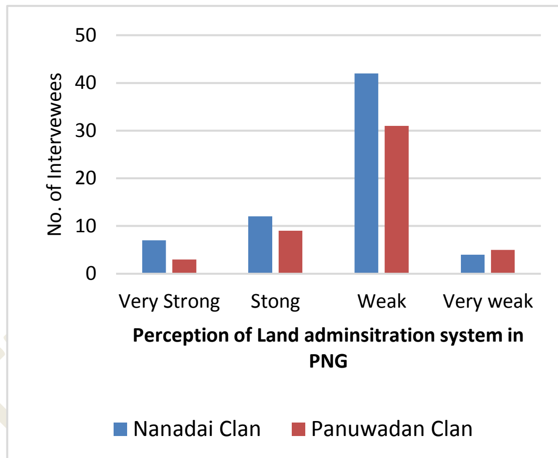


Figure 3.203: Land administration system in PNG (Karigawa, 2018)

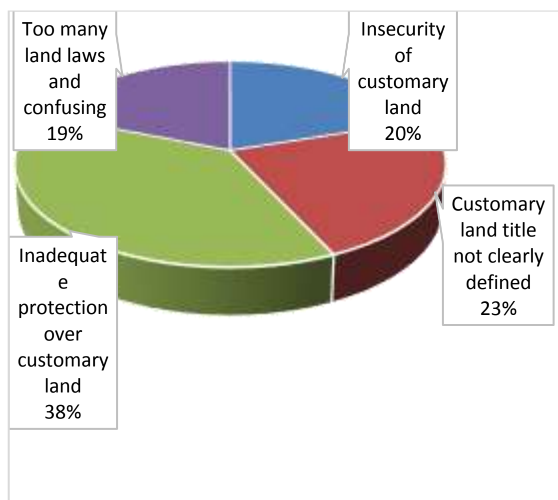


Figure 3.204: Views of landowners regarding existing land laws (Karigawa, 2018)

Figure 3.204 indicates many of the interviews see existing laws not strong to protect their land rights because they have inadequate protection over their land (38%), their customary land title is not clearly defined (23%), they feel insecure (20%) and thinks the law is confusing (19%).

Finally, Figure 3.205 indicates land the respondents felt land administration has flaws because of corruption and bribery in acquiring land (42%), poor recording system (28%), Processing of land titles is too lengthy and confusing (22%) and the old system is still used and is confusing to landowners (8%).

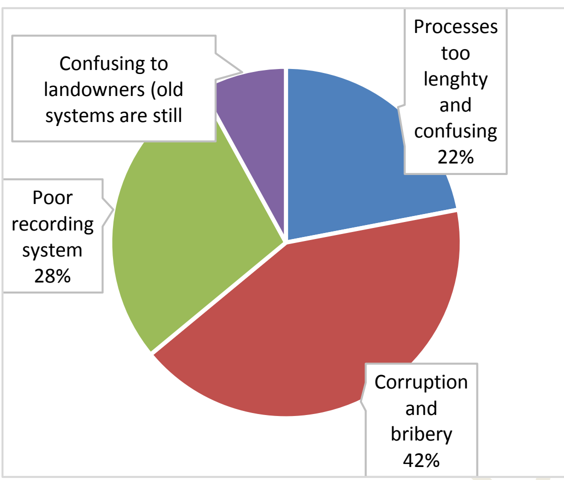


Figure 3.205: Land adminsitration flaws in PNG (Karigawa, 2018)

This above case studies in the forestry and agriculture sector, and mining and oil and gas, including urban development have set very important lessons regarding land acquisition and management ion PNG. Hence laws have been altered to fit the changing conditions so land can be easily freed for development. However, some processes are not too well understood by landowners. With changing behaviour, intermarriage and other factors, some legitimate landowners have been marginalised and their lands have been taken over by only few vocal and powerful families, those with user rights and few self-interest educated elites. The government through the Department of Lands and Physical Planning (DLPP) in late 2018 and early 2019 had conducted a land summit right across the country to find ways to address rising land issues and to develop mechanisms to assist landowners work with government and investors or other private entities to develop their land and resources.

The depleting economic situation in the country has affected many landowners and officers working in the DLPP and societal norms have been compromised. Some companies also see an opportunity to alter the system while others want to adhere to rules and regulation but are not doing enough. Consequently this may result in the failure of land management in PNG. Thus, DLPP has now gone into digitising all its records and installed a complain desk to deal with complaints and corruption in matters patterning to land. A draft Land-use policy was also dratted in 2018 to aid land management and development of land and resources in PNG.

Response and Recommendations

The provincial government and DLPP should conduct inventories in all provinces, hire students to document land groups and boundaries and archive them. The new land-use planning and policy under development must be implemented to ensure landowners are mobilised in getting their land registered in order to be given a fair share in any development activities in the country. Also, continuation of digital work and transparency in any land matters must be upheld within DPLL and provincial land departments.

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9.0. SECTION 4: CONCLUSION AND RECOMMENDATIONS

PNG in its young history has never been faced with increasing threats from direct and indirect drivers caused by globalisation and escalating population. The demand for goods and services has escalated rapidly in the last 44 years as pressures from both anthropogenic and natural causes on the environment increases and our livelihood has increased spontaneously. It has never been more urgent now to address those issues in a more robust and holistic approach than ever before. PNG and the world has never before being under immense pressure to conserve and protect its environment from a wide array of threats, and the future of this nation and our children depends much on the decisions and actions we make today that will last forever in the annals of history.

Looking at the the UN SDGs and the CBD's Aichi targets, most of the indicators identified therein the Report have shown multiple cross-cutting issues that are either inter-related which need to be addressed singly or collectively. This simply means one or few indicators are connected with another CBD and SDG targets. For instance, to address threatened species, one has to address poverty, food security, economic wellbeing and the development aspiration of the country. Another example is when addressing climate change, the government has to address multiple targets such as deforestation, conservation, reduction in GHG from the energy sector, trade and technological transfer, policies and urban development. These two examples are complex in developing countries such as PNG.

PNG is also faced with huge challenges such as resources for implement some or all its policies, to address corruption, build capacity for key organisations and staff to conduct enforcement of laws and monitoring activities. More researches are needed to fully understand the trend of the State of Environment PNG. Collaborative partnership is also lacking and most dataset collected are not centrally compiled and available for the government to easily analyse and make inform decisions. There is continuity of lack of education and awareness address issued faced by the country. There are many more issues that need to be addressed amicably in order to reduce the impact of activities that are affecting our environment, culture and natural assets.

Several global, regional and local drivers are altering the environment in PNG. They include globalisation and exposure to world markets, rising incomes and population, urbanisation, rapid expansion and growth of technologies, new and existing cultural norms and global climate change. These drivers are creating pressures on the land, marine, freshwater, atmosphere, built up ecosystems and cultural heritage. These pressures include land and resource development, overcrowding of urban centres, waste generation and energy consumption, and resource extraction. These pressures are, in varying degrees, affecting the environment and are measured in this Report which evaluates the state of key habitats, ecosystems, climate variables, and species.

Overall the state of the environment shows mixed result in the trend, status and data confidence indicating mixture of good, fair, poor and some unknown states (Figure 1.1). The staus of the environment is still good and some habitats and ecosystems are still intact or pristine but degrading with 43% being high, medium with 35% and low with 22% (Figure 1.2). Since data is lacking in many areas, data confidence can be summed as good with 22%, Fair, Fair to Poor and Good to Fair comprised 16% each while Good to Poor consists of only 5% (Figure 1.3). Hence more research are needed to verify the findings of the status and condition or trend of the envisornment in the future.

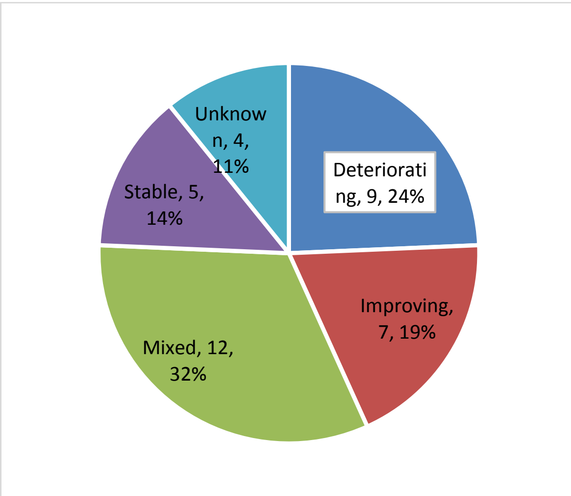

Figure 4.1: Trend of state of the Environment

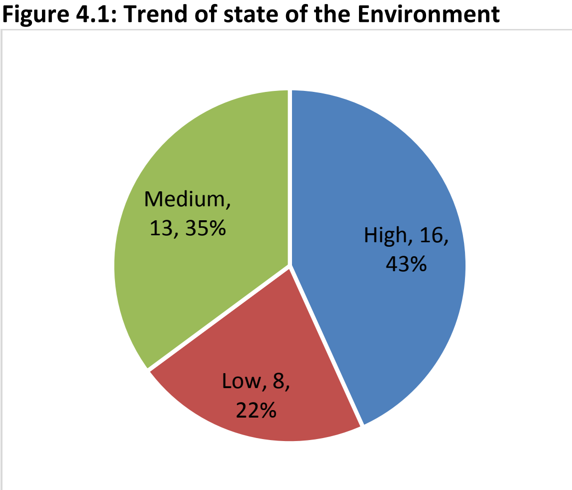

Figure 4.2. Status of state of the Environment

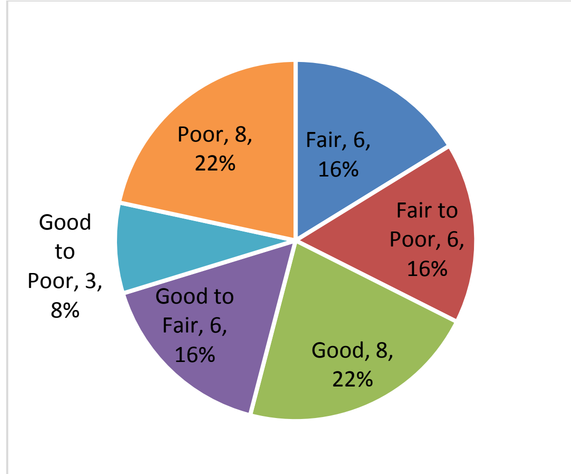

Figure 4.3. Data Confidence of state of the Environment

While gaps exist, PNG has exisiting laws, policies and regulations that promote sustainable use and protection of its environmental resources. Since the the MDG report in 2015, PNG has achieved very little and a number of MEA reports were not up to date being submitted to the MEA secratariats since 2009. However, a number of assessment reports have been recommending action on biodiversity, agriculture, water, marine management, climate change, and others. The national implementation and enforcement of these efforts is inconsistent and, in some cases, non-existent because they are largely dependent on external funding from NGOs and international sources, most of which are short-term and determined by the current international priorities and agendas.

Nonetherless, there is glimmer of hope for PNG to continue to strive and prosper if only she can preserve and manage is resources and problems. PNG needs to start now before it is too late to execute some of its plans and policies.

PNG is a signatory to various MEAs and has taken drastic steps in addressing its environment, cultural, social and economic sustainability challenges. With some appropriate development policies developed by the government of PNG is recent past, implementing these policies is a long shot from reality and needs total commitment from the government, development partners, developers and local land and sea owners.

Since the Government of PNG has ratified the United Nations's Agenda 2030 or the Sustainable Development Goal, this provides a guide to ensure PNG manage our resources well. The SDG encaptulates:

2. Economic sustainability in terms of production of goods and services on a continoual basis that does not cause harm to agriculture and the industry;
3. Environment sustainability;
4. Social sustainability which ensures adequate services are translated into equitable benefits of these services for all.

Thus the PNG government must move from the brown-based economy to the green growth economy that is promoting a robust sustainable economy. Hence sustainable economy for PNG means promoting the wellbeing of the environment, creating social cohesion with our environment, culture and the way we do things and ensuring there is inclusive growth in the economy that creates opportunities for Papua New Guineans. This is promoted in the MTDP 3 which looks at:

1. Promoting PNG's environmental sustainability goals;
2. Adopting and becoming resilience to climate change effects and contributing to global efforts to abate greenhouse gasemissions;
3. Managing and reducing the risks of natural disasters and increasing resilience to those natural events; and
4. Sustainable use of water.

Although the above goals of MTDP3 have overlooked biodiversity conservation, the onus is now on the government, developers, bilateral partners and landowners to collaborate and find amicable solutions to ensure those opportunity costs for forgoing the well being of the environment, culture and resources for the development and use of natual resources are minimise and their ecological footprints are reduced.

This can be done by becoming innovative and developing new methods and processes to meet new or exisiting challenges of climate change, invasive species, public sanitation and health, food security, economic development, biodiversity conservation and environmental management. Those creative approaches can be seen as a way to enhance organisational performance (of the government of PNG) into the future. That is, as resources are becoming limited or under threat, the way PNG do business must be modified either economically or environmentally.

There are many questions that also need to be ask. How can PNG achieve sustainable development when the country needs development? Will PNG continue to experience a degradng environment with depleting natural resources? What are the new methods and processes PNG is adopting or is applying to improve the management and state of the environment? How is PNG prepared to address the drivers, pressures and threats identified in this report? Does PNG need to make tough decisions across all sectors from landowners, to beauracratic and at political levels and what must it do? How can PNG strike a balance between resource use and sustainable management to achieve a positive outlook of its performance when this report is reviewed in 5 years time? These are some questions we should ask ourselves to ensure our environment is managed sustainably and is not compromised.

The best example of environmental management in PNG is the integration of contemporary and traditional conservation practices into the modern legislative framework and policies. One example is the traditional management or *tambu/tabu* which includes the conservation of both marine and terrestrial environments. On their own, traditional practices are not enough to protect the environment from modern day pressures such as whole-scale resource extraction and population growth. Hence, it needs a holistic approach in combining modern and traditional methods and stringent resource development practices.

There is decline or degradation of forests, which is due to the gradual encroachment on the land with population growth and the increase in agriculture landuse such as palm oil expansion. In the marine habitats and offshore fisheries, over harvesting is becoming a problem and shore too inshore fisheries. In terms of invasive species, climate change has allowed species to move from their traidional ecosystems to establish themselves in new ecosystem.

Thus traditional practices of environmental management need to be integrated into morden management plans, and supported by, a strong legislative framework, funding mechanisms, monitoring and law enforcement, research, collaboration, capacity building and political will to promote environmental protection for the overall success of environmental sustainability.

Recommendations

The key recommendations are focused primarily on enhanced implementation of existing policies and initiatives as well as increased in systematic environmental monitoring, management and research. The increase in agricultural activities, in particular traditional crop production or shifting cultivation and cash crops namely palm oil, is placing more pressure on the environment through loss of diversity, forest cover, soil nutrients and reduced food security. PNG has some some agriculture census done in the past and this has led to the development of several appropriate policies (National Rice Policy, Sutainability Palm Oil production, and National Agriculture Development Plan) to guide planning and management of the agriculture sector. More recently, the *Agriculture Administration Adjustment (AAA) Bill* currently before the NEC to be endorsed and enacted in parliament redefines the role of the Department of Agriculture and Livestock (DAL), all commodity boards and agencies, provincial agencies and the manner in which they interact with each other. The next bill is the *Agriculture Investment Corporation (AIC) Bill which* provides for the establishment and management of the Agriculture Investment Corporation and details how to secure funding and manage investments in the agriculture sector. Implementation of these bills, however, will require significant strengthening of dialogue, coordination and trust between institutions and stakeholders in a sector that is currently highly fragmented. An agriculture census will greatly enhance food security policy and currently a study by FAO will document food crops across PNG.

Given that over 22 percent of the "state" conditions in this report are Poor and Good, 16 per cent are Fair, Fair to Good and Good to Fair, while 8 percent are Good to Poor, and 44 percent fair, it is advisable that PNG conduct an environmental audit and legislative review of exisiting Laws. This must be in the form of research to help determine if existing laws and regulations are sufficient to protect the environment and guide development, or if the challenges lie in the implementation of the existing policies and regulations (Figure 4.1 to 4.3). In addition, ensure that new and emerging issues are analysed and where appropriate are incorporated into PNG law including issues such as Deep sea mining, Access benefit sharing. Environment Impact Assessment, monitoring and enforcement and data storage.

A major challenge in conducting the 2019 PNG SOE was compiling, analysing and processing data held by various departments, agencies and ministries. A key recommendation for future work is to build off the base line set in this Report and develop monitoring to fill the data gaps. A data storage solution is needed which has already developed by CEPA which will allow intra and inter-department/ministry data sharing through signing of Memorandum of Understanding or Memorandum of Agreement for data analysis and data sharing for the SOE and other reporting processes, including those to multilateral environmental agreements. A mandatory amendment to the existing laws should enable this to happen.

PNG is currently executing some land reformation on customary land and landuse planning.The new landuse policy considers capturing zonation, urban development, resource development and conservation in the draft landuse policy to address the ongoing environmental issues caused by unplanned developments and overcrowding of urban areas and landownership issues. Often unplanned development has resulted in insufficient sewage and solid waste treatment and infrastructure to accommodate the growing population from the rural areas into the urban centres. Systematic urban planning policies or strategic environmental assessments (SEA) can contribute to better housing and commercial development.

Most of the negative trends in the SoE indicators can be traced back to unplanned and unregulated development, settlement and commercial activities. PNG should consider complementing their environmental impact assessment (EIA) and Environment Impact Statement (EIS) process with a targeted programme of mitigation for many of the indicators addressed in the SoE:

- Strengthen monitoring and enforce standards of septic systems to reduce sewage effluent;
- Improve waste collection, landfill management and recycling as waste generation rates are likely to increase with the rising urban population;
- Develop urban planning and policies, as well SEA, to better address urban liveability and green spaces;
- Establish a professional Body or Association for Environment Impact Assessors. Practitioners are mandotary required to become members and their practices are guided by the constitution of the Association. If damages are done to the environment, their membership will become invalid, hence they may not practice or be suspended from practising EIA/EIS. Such penalty would ensure practices are conformed to regulations;
- CEPA has now increase fees for environment non compliance in the new PA bill. This would probably deter bad environment practices. A new environment maximum determined environment bond fee should be charge to companies exploiting the resources. Hence, any environment degradation or destruction means this money should be used to mitigate issues. These funds should be kept in CEPA's conservation and environment trust fund;
- Use an EIA and EIS to assist the regulatory focus on key projects and sites. This means human capacity, resources, knowledge and laboratory should be upgraded to ensure independent assement of EIA or EIS;
- Train Enforcement officers for monitoring and enforcement activities to deal with paralegal matters;
- Conduct a national environmental planning process using the SoE results and recommendations as a platform for future SoE;
- Mechanisms for monitoring and reviewing implementation must be developed, improved or strenghtened. With ongoing biodiversity surveys and data collection for other activities across PNG the gaps in biodiversity, scientific, cultural and environment knowledge are slowly being filled. However, there is still much to be uncovered. Hence systems such as the National Biodiversity Information System (NBIS) is being established within CEPA and will link to country interfaces on regional portals to deal with biodiversity. With a range of policies now in place a series of strategies and implementation plans are also being implemented and these are tracked through annual reports. Within CEPA this is outlined in part through the Protected Areas Implementation Plan (2018-2028) and the authority's overall implementation plan; and

- Develop templates for data collection and enact laws that allows for flow of information from top to bottom tiers of government to ensure data is collected for all environment indicators.

This report can serve as a key resource in Program of Work on Protected Areas (PowPA), National REDD+ Stategy, and other plans that work in parralle to program development and design. The SOE can also be used as a reporting tool for Multilateral Environmental Agreements (MEAs), such as the convention on biodiversity, or for updating PNG's National Biodiversity Strategic Action Plan (NBSAP).

PNG has played an instrumental role in securing the Paris Agreement toward implementation of REDD+ activities in the country. Future work and leadership by the PNG government can be supported by more completely accounting for its CO_2 emissions for land-use landuse change (LULUC) activities (forestry and agiculture), including transport and energy sector. PNG should also consider developing regulations on air pollution and air quality as this sector needs to be monitored and it represents a gap. Some of the activities that could help include:

- Air monitoring of urban areas and nearby rural areas to determine annual CO_2 emission;
- Prepare emission inventories of pollution sources;
- Established targeted policies and regulations to limit emissions (e.g. waste burning, polluting vehicles, Air conditioning and ozone depleting substances, and monitor meteorological particulate pollution); and
- Do digitised mapping or modelling or update existing models or maps of terrestrial and marine environment, biodiversity, climate, culture, language etc for reporting purposes (e.g POWPA used hexagon) based on digital Elavation Model (DEM) and other suitable models where applicable.

The marine fishery resource is also an area to look at. The increased commercial harvesting of tuna species has put more pressure on the offshore fisheries. It is highly recommended that PNG strengthens its enforcement, compliance and monitoring of tuna stocks, in particular the bigeye tuna and other endangered species which are caught as by-catch. The inshore fisheries of PNG are still intact but are under threat from declining. There is a need to monitor coral reefs and reef fish diversity and density to understand the trends in the inshore marine environment.

More research and collaborative work needs to be done to understand and document toxicity of all reef fish, water quality of lagoons and species population. Given the overall good condition of PNG near shore fish stocks and reef system, these are major concernon coral bleaching and the apparent phase shift from coral-to-algae dominance that is currently taking place in some waters. It should be addressed by fully understanding the source of the contamination, taking steps to prevent additional contamination, remediating the problems in any, and ensuring that no additional areas in PNG are contaminated.

There is much that needs to be done in regards PNG' s biosecurity including better protection of threatened species and habitats in the terrestrial environment – this requires further effort and action from government. More awareness is required because majority of the population live in rural areas. As Industila and resource development increase, so too the need to conserve and protect the environment from other ecological footprint.

PNG water quality in rural areas is still poor but at least urban water quality is better. Hence more water quality monitoring program must be done by EDA Ranua and Water PNG for drinable water and by CEPA concerning Water Districts of major water catchment areas. However, improvements can be made to data storage access and reporting to the public. The Water Monitoring Program at CEPA should be revived and maintained in an easy to use database to continue trend monitoring of water resources.

One area that needs more resources and monitoring is the establishment of a sewage treatment system, including all of urban centers in PNG.

One highlight for good data management and public access is the meteorological monitoring by the National Weather Services n, which has over 100 years of public records. If all data from mining, oil and gas, forestry, environment and conservation, culture and heritage can be improved, more accurate reports can be done.

The area of land and water under protection has expanded over the last 44 years, which has its challenges. PNG should continue to implement the PowPA and the PA policy and the PA Bill once become enacted to continue to do planning and managing protected and other areas, such as key terrestrial biodiversity sites and locally marine manged areas (LLMA). The major needs include funding to carry out community engagement and detailed management plans, including implementation and monitoring, capacity building and other activites identified in the 2018 METT Analysis by Leverington et al. (2018).

Another highlight for the PNG environment is that coral reef health, especially in the outer atolls, is some of the best in the region. The healthy coral has both extensive spatial and temporal range. Monitoring efforts and community outreach should be made to enhance fish biomass density.

Management of the offshore fishing industry has been a challenge for much of the region. Some recent successes include the establishment of the Parties to the Nauru Agreement and the introduction of the "Fishing Days Scheme" and and membership to the Western and Central Pacific Fisheries Commission WCFPC. The increased number of observers, improved auditing and development of a sustainable status have led to better commercial fisheries management in PNG. This also has imporved following PNG's recent panelty by EU in handing PNG with "Yellow Card' on its Tuna export to the EU. Eventually led to improvement inoffshore fishing operations and management of fishstock. Hence, the protection of the tuna fisheries should be continued, especially as global demand increases, to ensure a sustainable fishery and future incomes.

There is a dire need to mprove data sharing, data quality and statistics. Important government data portal in CCDA, CEPA, MRA, DAL, NDPM, NARI, FRI, and the UPNG Remote Sensing Center have been developed to store data collected by various agencies. However, there needs to be close collaboration the overall Statistical Capacity of Papua New Guinea because there has been declined in the period from 2005-2013 as reported by the World Bank.

Data sharing is an ongoing issue over the last 40 years and there is little evidence of this changing. No monitoring system in place and there is also no monitoring of the volume extent and nature of data that exists on the biodiversity and other datasets of PNG. Howvere, there are some good progress that need to be enhanced and resourced to improve data quality and relevance.

Finally the challenge for PNG to move on is to conduct efficient enforcement and monitoring, research, capacity building awareness raising and data storage. An office specifically for managing all MEA reports should be established within CEPA. The role of this office is to ensure it developed its own monitoring and evaluation programs, and is capable of managing funds and use them for such work on MEAs. This office needs to develop or digitised environment modelling maps using the Digital Elevation model (DEM) for both marine and terrestrial thematic environmental indicators.

In conclusion, this office must be accreditated with internationally recognised systems to managed funds for MEAs. This will enable the office to report directly to MEA secratariats and to access funding directly from donor and whatever management fees raised can be used to manage the MEAs focal poinst in PNG, including the SoE reporting. Also Appropriate MOUs ned to be singed by CEPA, line government agencies and other stateholders and provincial government to ensure collaborative work is done.

10.0 SECTION 5: APPENDICES

Appendix 1 Table 1: Achievement of Vision 2050 7 pillars and indicators to date measured against Aichi targets and Sustainable Development Goals

Indicator	Color code	Aichi target	SDG Goal
Pillar 1. Human capital development, gender, youth and people empowerment			
Local and International acceptance of our educational system		18, 19	4.1.1, 4.2.1
All school-age children are enrolled in primary education		18,19	4.1.1, 4.2.1
Gender distribution in education system		18,19	4.5.1, 5.1.1
Higher education institutions are world standard		1, 12, 18, 19	4.b.1
Increase from current eight percent human capacity to 30 percent		4	4.3.1, 4.4.1
Increased gross enrolment rate to 98 percent		18,19	4.1.1, 4.3.1
Increased gender participation		18,19	5.a.1, 5.c.1
Quality graduates and technocrats		1, 12, 18, 19	44.a.14.b.1
Improved basic qualification for all teachers at graduate level		1, 12, 18, 19	4.c.1
50 research science engineers per 10,000		19	4.b.1, 9.5.1
Research and development centres of excellence		1, 18, 19	4.a.1, 9.5.1
Pillar 2. Wealth creation			
Citizens' participation in the economy, especially in the manufacturing, agriculture, forestry, fisheries and tourism sectors		3	1.1.1, 1.4.1
PNG's total GDP and GDP contributed by manufacturing, agriculture, forestry, fisheries and tourism sectors		1-10	10.1.1, 10.4.1
Reduction in import of food items and zero export of logs		7	9.2.1
Increased contributions to the GDP by the manufacturing sector		4, 6	8.1.1 , 9.2.1
Growth in credit for agriculture, forestry, fisheries, tourism, and manufacturing sectors		4, 7, 8, 16	9.3.1, 12.b.1, 17.1.1
Increased productivity of import competing industries		4, 7, 8, 16	8.4.1, 9.2.1, 17.1
Increased business transaction with commercial banks and other lending institution		4	8.3.1, 10.2.1
Pillar 3. Institutional development and service delivery			
Productivity and performance of public service		4, 17	16.6.1, 16.6.2
Productivity and performance of the legal and judicial system		4, 17	16.6.2
Productivity and performance of the political system		4, 17	16.7.1, 16.7.2
Pillar 4. Security and international relations			
Low crime and conflict record		3	16.1.4, 16.3.1
Papua New Guinea is a safe, pleasant, and exciting society in which to live		19	16.1.4, 16.3.1
High business and investor confidence		7, 19	116.3.1, 6.5.1,

PNG becomes a highly preferred tourism destination		7, 11	8.9.1, 12.b.1
Postings (international trade)		6	10.5.1
Pillar 5. Environment sustainability and climate change			
Less logging for export		5, 7, 9, 11, 12, 14, 15	9,.2.1, 12.2.1, 15.2.1
Communities resilience is enhanced in village		1, 11, 18, 19	1.1.1, 12.2.1
Sustainable development policies completed		2, 4, 17	17.14.1
Oceans and marine and terrestrial areas protected		11, 12, 13	14.2.115.2.1
Forests are protected and sustained		5, 7, 11	15.2.1, 15.5.1
Professional competence and world standard research programs on environment and climate change (Conserve and wise use of natural resources and environment)		1, 2, 3, 4, 19	13.3.2, 15.2.1, 17.6.1
70 percent of PNG forest are conserved and managed for carbon trade purposes		5, 7, 11, 15	13.a.1, 15.2.1
Oceans and land resources managed		1, 2, 3, 4, 6	14.5.1, 15.4.1
Mitigation measures for all forms in industries, mining, energy, and waste		8, 10, 14	6.6.1, 7.2.1, 9.2.1, 12.2.1, 13.3.1,
Professional competence and world standard research programs on environment and climate change(conserve and wise use of natural resources and environment, language and cultural diversity)		1, 2, 3, 4, 19	4.a.1, 7.a.1, 114.a.1, 15.a.1
Increase tourism sector's contribution to GDP		16	12.b.1
Adhere to international agreements		13, 16, 17	10.b.1, 17.3.1, 17.14.1, 17.16.1
Pillar 6. Spiritual, cultural and community development			
Churches to play a more active role in people transformation and empowerment		1-16	17.14.1, 17.15.1
Churches and civil society to play a more effective role in ensuring government accountability		1-16	17.14.1, 17.15.1
People will love God, their citizens, their foreigners, their work, creation, and property will increase			17.14.1, 17.15.1
More leaders will manage life pressures of leadership and broken family relationship			17.14.1, 17.15.1
Churches to play active role in the delivery of basic services to the people			17.14.1, 17.15.1
Pillar 7. Strategic planning, integration and control			
Development plans and policies aligned with greater coordination and control		4, 11, 17, 20	17.14.1, 17.16.1
Greater involvement and collaboration with key stakeholders		4, 11, 16, 17	17.14.1, 17.16.1
Corporate and sectoral plans are aligned to Vision 2050's goals and objectives		4, 11, 16, 17, 20	17.14.1, 17.16.1

Appendix 2 Table 2: Achievement of DSP to date measured against Aichi targets and Sustainable Development Goals

DSP 2010-2030	Color code	Aichi target	SDG Goal
Develop and implement the ESEG policy		1	17.14.1
Develop environment and natural resource development plan for Economic Corridors		4, 9	15.1.2, 17.14.1
Comprehensive range of natural resource management guidelines that addresses drivers of deforestation		5, 7	15.1.2, 15.2.1
Waste management policies and guidelines for mining and petroleum projects operations and closure		8	6, 14, 15, 16, 17
Enhance management of land degraded by commercial extraction		8, 9, 14	15.3.1, 15.5.1
Enhance the coastal zone conservation management plan		6, 10	14.2.1, 14.c.1
Review of the Environmental Act 2000 and new legislation to create EPA			12.6.1, 17.14.1
Ensure more comprehensive waste management practices are employed		8	12.1.1, 12.5.1, 17.16.1
Streamline EPA monitoring and compliance and build capacity		1-16	16.6.2, 17.9.1
Standards and code of practices for projects category 1 and 2		1-10	17.16.1
Streamline permit procedures and processes		11-16	16.6.2, 16.b.1, , 17.9.1
Implement Multilateral Environmental Agreements (MEAs) like the UNCCD, UNCBD and UNFCCC		17	17.18.1
National Capacity Self Assessment (NCSA) of the global environmental conventions			17.18.1
Endangered species and habitats conservation and management plan for marine and terrestrial protected areas		11	14.2.1, 14.5.1, 15.1.2, 15.4.1,
Develop Terrestrial Protected Area Policy		11	17.14.1
Develop Marine Protected Area Policy		11	17.14.1
Strengthen customary practices for enhancing and preserving the environment and educate landowners on the importance of conserving the environment		18	14.2.1, 15.9.1, 15.c.1
REDD + and payment for ecosystems services (PES)		1, 14, 15, 16	113.2.1, 5.2.1, 15.4.1
Increase water catchment and water and sanitation programs		8	3.3.5, 6.1.1, 6.2.1, , 6.4.1, 6.a.1, 15.1.2
Maintained inventory of all licensed national water usage		7	6.1.1, 6.3.1, 6.3.2
Develop Sustainable Land Management Policy		7, 11	15.8.1, 17.14.1
Develop water resource management policy		6	6.b.1, 15.8.1, 17.14.1
Introduce land zoning systems to increase agricultural production		7	15.1.2, 17.14.1
Minimise land degraded by commercial extractive purposes		5	15.3.1,
Build information database for natural resources and environment management		19	17.18.1
Establish a database for environmental risk and hazard accounting		19	17.18.1

Appendix 3 Table 3: Achievement of STaRS to date measured against Aichi Targets and Sustainable Development Goal

A. Inclusive and Innovative green growth economic growth platform	Color code	Aichi target	SDG Goal
Dimension 1. National Green Growth Plan to create Enabling Conditions			
Shift government expenditure		2, 3, 4	16.6.2, 17.16.1
More effective enforcement of Legislation		5, 6, 7, 8, 9, 10, 16, 17, 20	16.b.1
Research and Development and Education and Training		1, 12, 13, 14, 19	4.3.1, 4.a.1, 12.a.1, 17.9.1
Resource and land rights regimes		16	16.6.2, 16.a.1,
Creating enabling conditions for psychological & behaviour change		1, 2, 3, 4	1.1.1, 1.3.1, 1.4.1,
Facilitating businesses to fully integrate sustainability & equity concerns		4, 13, 15	9.2.2, 9.3.1
Dimension 2. Green Growth Mainstreaming Mechanisms			
Public Environmental Expenditure Review			16.5.1, 16.6.1, 17.18.3
Strategic Environmental Assessment		18, 20	17.18.1
Council for Sustainable Development		4	16.6.2 , 17.16.1
Green Accounting/Alternative Development Measures		18	16.6.1, 1717.17.1,17.19.2
Dimension 3. Green Growth Policy Instruments to Tap Spatial and Resource System Opportunities			
Certification of sustainable production and trade		14, 15, 16	17.11.1, 17.19.1
Subsidy Reforms			17.12.1
Payments for Ecosystem Services		5, 15, 16, 18	17.14.1, 17.15.1
Environmental Fiscal Reforms		17, 20	7, 9, 12, 16, 17.19.1
Green Energy Investment Frameworks and Incentives			7.3.1
Inclusive Green Social Enterprises and Community based organizations			112.5.1, 6.6.2
Sustainable Public Procurement			12.7.1, 16.5.2, 16.6.2
Green Innovation		18, 19	9.2.1, 12.5.1, 17.15.1
Guiding principles for inclusive and innovative green economic growth			
Internalises externalities		20	16.a.1
Drive innovation		18, 19, 20	9.2.1, 9.a.1
Maintain economic growth		2, 4, 5-10	8.4.2, 10.4.1
Open and competitive markets/avoid trade restrictions		16	8.4.2, 17.12.1, 17.5.1

Creates decent work and green jobs		5-10, 13, 15	8.3.1, ,9.5.1, 12.1.1, 12.5.1
Governance- inclusive; democratic; participatory; accountable; transparent		2, 4, 5-10, 16, 20	16.6.2, 16.5.2, 16.10.2
Equitable, fair and just-between and within countries and between generations		16, 17	10.2.1, 10.3.1, 16.5.2
Poverty reduction, well-being, livelihoods and social protection; access to essential services		14, 16	1.1.11.4.1,
Facilitates education and skills development		1, 4, 19	4.1.1, 4.2.2, 4.4.1,
Supports human rights, workers rights		16, 18	5.1.1, 10.2.1, 10.4.1
Retains and protects biodiversity and ecosystems services		1-4, 5-10, 11-16	12.2.1, 12.4.1, 13.3.1,14.5.1, 15.4.1
Is resources and energy efficient		15	7.1.2, 7.2.1
Respects planetary boundaries or ecological limits or scarcity		1, 2, 4, 5, 6, 7, 8, 9, 10	13.2.1, 14.4.1, 15.2.1,
Sustainable production and consumption lifestyles		1, 2, 3, 4, 5, 6, 7, 8, 9, 10	12.2.1, 12.4.1, 12.5.1
Be low carbon and low emissions		15	13.3.1, 13.3.213.b.1
Precautionary approach			6.6.1, 13.b.1, 14.6.1, 15.1.2, 15.8.1
Is a means for achieving sustainable development		16, 17	88.1.18.2.1, 9.2.1, 9.3.1, 12.2.1, 12.4.1, 14.6.1, 15.2.1
Use integrated decision-making			16.7.1, 17.17.1
Beyond the GDP Principle			8.4.2, 9.2.1, 10.4.1, 12.2.2
Promotes international cooperation; avoid conditionalities on overseas development assistance and finance		16, 20	16.7.1, 17.17.1
Is resilient to risks and shocks		1, 2, 3, 4, 5, 6, 7, 8, 9, 10	13.2.1, 14.3.1, 15.5.1, 15.7.1

Appendix 4: Table 4. Water PNG water supply establishment (SOPAC, 2007)

Location	Source	Method of extraction	Degree of treatment	System production capacity	Future plan within next 10 years
Lae	Groundwater – 7 Bores at Taraka	Submersible Pumps	Chlorination only	36 ML/day	Source augmentation and system expansion. (after 2010)
Madang	Gum River	River Intake / Pumping	Sedimentation, Filtration and Chlorination	16 ML/day	Expansion of distribution system to new service areas
Wewak	Brandi River	River Intake / Pumping	Sedimentation, Filtration and Chlorination	6.5 ML/day	Source and Treatment Works to be upgraded.
Mt Hagen	Wara Kum River	River Intake / Pumping	Sedimentation, Filtration and Chlorination	6.5 ML/day	Source and Treatment Works to be upgraded.
Rabaul/Kokopo	Groundwater	Submersible Pumps	Chlorination only	3.0 ML/day	Rabaul – System Rehabilitation Kokopo – Rehabilitate E&M Assets
Kimbe	Groundwater	Submersible Pumps	Chlorination only	1.5 ML/day	Rehab source and distribution
Kavieng	Groundwater	Submersible Pumps	Chlorination only	1.5 ML/day	Rehab source and distribution
Lorengau	Lorengau River	Gravity-fed from intake pond	Sedimentation, Filtration and Chlorination	2 ML/day	Expand system to growth areas
Alotau	Goilawaligena River and Groundwater	Gravity-fed from River and submerside bore pump	Chlorination only	2.2 ML/day	- Possibly abandon river source and maximise groundwater source capacity - Rehab distribution system
Popondetta	Banguho River	River intake / Pumping	Sedimentation, Filtration and Chlorination	1.0 ML/day	Alternative source – groundwater and asset rehabilitation
Daru	Binaturi River	River intake / Pumping – via submarine pipe	Filtration and Chlorination	1 ML/day	Asset Rehabilitation and upgrading through partnership with PNG Sustainable
Kundiawa	Ur River	Gravity fed to treatment plant	Chlorination	1.5 ML/day	Asset Rehabilitation
Bereina	Borehole	Solar submersible pump with diesel backup	Chlorination	0.2ML/day	Asset Rehabilitation

Kwikila	Borehole	Submersible pump	Chlorination	0.2ML/day	Asset Rehabilitation
Mutzing	Borehole	Submersible pump	Chlorination	0.2ML/day	Asset Rehabilitation

Appendix 5. Table 5: Checklist of water quality and sanitation in PNG (Adapted from Water PNG, 2018)

Areas of evidence for assessment	Question	Score	Explanation for score
Budget allocation criteria	Have criteria (or a formula) been determined to allocate urban sanitation funding equitably to urban utilities or service providers and among municipalities and is it being consistently applied?	0	No known criteria or formula for allocating urban sanitation funding based on equity basis
Reducing inequality	Do local government or urban service providers (national or in 3 largest cities) have specific plans or measures developed and implemented for serving the urban poor?	0	No plans to target urban poor
Quantity (access)	Is the annual expansion of urban households gaining access to safe sanitation sufficient to meet the subsector targets?	0	Unknown who has what type of sanitation; urban sanitation left to individual households to deal with
Quantity (treatment)	Is the annual increase in the proportion of fecal waste that is safely collected and treated growing at the pace required to meet the subsector targets (for both onsite and sewerage)?	0	Private operators may use Water PNG treatment facilities where these exist or else dump waste in environment. Little known about fecal waste collection and treatment outside sewerage system
Reporting	Are there procedures and processes applied on a regular basis to monitor urban sanitation access and the quality of services and is the information disseminated?	0	Unclear who would do monitoring
SUSTAINING			
Collection and treatment	What is the proportion of total fecal waste generated that gets safely collected and treated?	1	Proportion of waste generated that is treated is unknown but is believed to be less than 50% due to lack of treatment facilities in urban centers.
Cost recovery	Are O&M costs of treatment systems (beyond household level facilities) assessed/known and fully met by either cost recovery through user fees and/or local revenue or transfers?	0	Sewerage fees collected and shown separately in finances. Fees cover O&M.
Discharge	Are there norms and standards for wastewater discharge for septage and sewerage treatment plants that are systematically monitored under a regime of sanctions (penalties)?	0	Unknown
Management of disaster risk and climate change	Do local government or service providers (national or in three largest cities) have plans for coping with natural disasters and climate change?	0	No assessment of climate impacts or disaster risks yet
Uptake	Has government (national or local) developed any policies, procedures or programs to stimulate uptake of urban sanitation services and behaviors by households?	0	No known incentives or stimulants to increase uptake of urban sanitation
Plans	Do government/service providers have business plans for expanding the proportion of citywide fecal waste that is safely collected and treated?	0.5	Eda Ranu and Water PNG have plans for increasing collection of fecal waste through sewerage systems. Costing is very general.
Private sector development	Does the government have ongoing programs and measures to strengthen the domestic private sector for the provision of sanitation services in urban or peri-urban areas?	0	No known programs to stimulate private sector development
Subsector progress	Is the subsector on track to meet the stated target?	0	No
Equity of use	What is the ratio of improved toilet access between the lowest and highest quintile in urban areas?	0	Unknown
Use of facilities	What percentage of people living in urban areas use improved toilet facilities (excluding shared facilities)?	0.5	Estimated 77% using improved toilets according to JMP and adjusted from DHS figures

Appendix 6: Table 6: Water PNG water supply establishment (SOPAC, 2007)

Location	Source	Method of extraction	Degree of treatment	System production capacity	Future plan within next 10 years
Lae	Groundwater – 7 Bores at Taraka	Submersible Pumps	Chlorination only	36 ML/day	Source augmentation and system expansion. (after 2010)
Madang	Gum River	River Intake / Pumping	Sedimentation, Filtration and Chlorination	16 ML/day	Expansion of distribution system to new service areas
Wewak	Brandi River	River Intake / Pumping	Sedimentation, Filtration and Chlorination	6.5 ML/day	Source and Treatment Works to be upgraded.
Mt Hagen	Wara Kum River	River Intake / Pumping	Sedimentation, Filtration and Chlorination	6.5 ML/day	Source and Treatment Works to be upgraded.
Rabaul/Kokopo	Groundwater	Submersible Pumps	Chlorination only	3.0 ML/day	Rabaul – System Rehabilitation Kokopo – Rehabilitate E&M Assets
Kimbe	Groundwater	Submersible Pumps	Chlorination only	1.5 ML/day	Rehab source and distribution
Kavieng	Groundwater	Submersible Pumps	Chlorination only	1.5 ML/day	Rehab source and distribution
Lorengau	Lorengau River	Gravity-fed from intake pond	Sedimentation, Filtration and Chlorination	2 ML/day	Expand system to growth areas
Alotau	Goilawaligena River and Groundwater	Gravity-fed from River and submerside bore pump	Chlorination only	2.2 ML/day	- Possibly abandon river source and maximise groundwater source capacity - Rehab distribution system
Popondetta	Banguho River	River intake / Pumping	Sedimentation, Filtration and Chlorination	1.0 ML/day	Alternative source – groundwater and asset rehabilitation
Daru	Binaturi River	River intake / Pumping – via submarine pipe	Filtration and Chlorination	1 ML/day	Asset Rehabilitation and upgrading through partnership with PNG Sustainable
Kundiawa	Ur River	Gravity fed to treatment plant	Chlorination	1.5 ML/day	Asset Rehabilitation
Bereina	Borehole	Solar submersible pump with diesel backup	Chlorination	0.2ML/day	Asset Rehabilitation
Kwikila	Borehole	Submersible pump	Chlorination	0.2ML/day	Asset Rehabilitation
Mutzing	Borehole	Submersible pump	Chlorination	0.2ML/day	Asset Rehabilitation

Appendix 7: Table 7. Water quality criteria for aquatic life protection. All values are in mg/l unless otherwise specified. (Environment Regulations 2002 Water Quality criteria No 28)

Parameters	Fresh water	Seawater
Ammonia-nitrogen	Dependent on pH and temperature (see Table 2.)	
Arsenic	0.05	0.05
Barium	1	1
Boron	1	2
Cadmium	0.01	0.001
Chlorine (total residue)	0.005 at pH 6	0.05
Chromium (as hexavalent form)	0.05	0.01
Colour	No alteration to natural colouration (for both fresh and seawater)	
Cobalt	Limit of detectability (for both fresh and seawater)	
Copper	1	0.03
Cyanide (as HCN)	0.005	0.01
Faecal Coliform Bacteria	≤200 per 100 ml (see Note below.)	
Fats	None	None
Floride	1.5	1.5
Grease	None	None
Insoluble residues	No insoluble residues or sludge formation to occur (for both fresh and seawater)	
Iron (in solution)	1	1
Lead	0.005	0.004
Manganese (in solution)	0.5	2
Mercury	0.0002	0.0002
Nickle	1	1
Nitrate (as NO_3^- + NO_2^-)	45	45

Odour	No alteration to natural odour (for both fresh and seawater)	
Oil	None	None
Oxygen	Not less than 6	Not less than 5
Pesticides	None	None
pH	No alteration to natural pH (for both fresh and seawater)	
Phenol	0.002	0.002
Potassium	5	450
Radioactivity	None	None
Selenium	0.01	0.01
Silver	0.05	0.05
Sulfate (as $SO4^{2-}$)	400	-
Sulfide (HS^{-})	0.02	0.02
Tar	None	None
Taste	No alteration to natural taste (for both fresh and seawater)	
Temperature	No alteration greater than 2°C (for both fresh and seawater)	
Tin	0.5	0.5
Toxicants (miscellaneous)	None	None
Turbidity	No alteration greater than 25 N.T.U (for both fresh and seawater)	
Zinc	5	5

Note.

- Metal concentrations are for dissolved substances (passing through a nominal 0.45µm medium).
- Criteria for Faecal Coliform Bacteria is based on not fewer than five samples taken over not more than a 30 day period, in which the median value of the faecal coliform bacteria content of the waters shall not exceed 200 per 100 ml.
- N.T.U. - Nephelometric Turbidity Unit.

Appendix 8 Table 8: Maximum Permitted Concentrations of Ammonia-Nitrogen for Protection of Freshwater Aquatic Life (Environment Regulations 2002 Water Quality criteria No 28)

Temperature	pH values		
(°C)	**7.0**	**8.0**	**9.0**
5	16.1	1.6	0.2
10	11	1.1	0.1
15	7.5	0.8	0.09
20	5.2	0.5	0.07
25	3.6	0.4	0.06
30	2.6	0.3	0.05
35	1.6	0.2	0.04

Appendix 9: Table 9. Extinct (Ex), Critically Endangered (CE) and Endangered (EN) species under IUCN Redlist 2019 (IUCN, 2019)

No.	Class	Family	Species	Common Nmae	Endemism	Redlist Category
1	ACTINOPTERYGII	CYPRINIDAE	*Tor putitora* (Hamilton 1822)	Putitor or Golden Mahseer	Southeast Asia and New Guinea	EN
2	ACTINOPTERYGII	ELEOTRIDAE	*Mogurnda furva* (Allen & Amp; Hoese, 1986)	Black Morgunda	PNG	CR
3	ACTINOPTERYGII	ELEOTRIDAE	*Mogurnda variegata* (Nichols, 1951)		PNG	CR
4	ACTINOPTERYGII	ENGRAULIDAE	*Thryssa rastrosa* (Roberts, 1978)	Fly River Thryssa	PNG	EN
5	ACTINOPTERYGII	LABRIDAE	*Cheilinus undulatus* (R Appell, 1835)	Humpback or Maori Wrasee	Global	EN
6	ACTINOPTERYGII	MELANOTAENIIDAE	*Glossolepis wanamensis* (Allen & Amp; Kailola, 1979)	Lake Wanam or Emerald Rainbowfish	PNG	CR
7	ACTINOPTERYGII	POMACANTHIDAE	*Chaetodontoplus vanderloosi* (Allen & Amp; Steene, 2004)	AngelFish	PNG	EN
8	ACTINOPTERYGII	PSEUDOMUGILIDAE	*Kiunga ballochi* (Allen, 1983)	Glass blue-eye	PNG	CR
9	AMPHIBIA	MICROHYLIDAE	*Choerophryne siegfriedi* (Menzies, 1999)	Mount Elimbari narrow-mouthed	PNG	CR
10	ANTHOZOA	ACROPORIDAE	*Anacropora spinosa* (Rehberg, 1892)	Briar Coral	Asia-PAcific	EN
11	ANTHOZOA	FUNGIIDAE	*Cantharellus noumeae* (Hoeksema & Amp; Best, 1984)	Mushroom Coral	PNG and New Caledonia	EN
12	ANTHOZOA	MUSSIDAE	*Lobophyllia serratus* (Veron, 2002)	Lobed Cactus Coral	Asia-Pacific	EN
13	ANTHOZOA	PECTINIIDAE	*Pectinia maxima* (Moll & Borel Best, 1984)	Anthoza Coral	Asia-Pacific	EN
14	ANTHOZOA	PORITIDAE	*Alveopora minuta* (Veron, 2002)	Flowerpot or Alvepora Coral	Asia-Pacific	EN
15	ANTHOZOA	PORITIDAE	*Porites eridani* (Umbgrov+e, 1940)	Stony Coral	Asia-Pacific	EN
16	AVES	ALCEDINIDAE	*Actenoides bougainvillei* (Rothschild, 1904)	Moustached Kingfisher	PNG	EN
17	AVES	COLUMBIDAE	*Otidiphaps insularis* (Salvin & Godman, 1883)	Black -naped Pheasant-pigeon	PNG	EN
18	AVES	PITTIDAE	*Pitta superba* (Rothschild & Hartert, 1914)	Superb Pitta	PNG	EN
19	AVES	PROCELLARIIDAE	*Pseudobulweria becki* (Murphy, 1928)	Beck's Petrel	PNG	CR
20	AVES	SCOLOPACIDAE	*Calidris tenuirostris* (Horsfield, 1821)	Great Knot	Global	EN
21	AVES	SCOLOPACIDAE	*Numenius madagascariensis* (Linnaeus, 1766)	Far Eastern Curlew	Global	EN
22	CHONDRICHTHYES	CARCHARHINIDAE	*Glyphis glyphis* (MÃller & Henle, 1839)	River or Speartooth shark	PNG and Australia	EN
23	CHONDRICHTHYES	LAMNIDAE	*Isurus oxyrinchus* (Rafinesque, 1810)	Shortfin Mako or Blue Pointer shark	Global	EN
24	CHONDRICHTHYES	LAMNIDAE	*Isurus paucus* (Guitart, 1966)	Longfin Mako Shark	Global	EN
25	CHONDRICHTHYES	PRISTIDAE	*Anoxypristis cuspidata* (Latham, 1794)	Knifetooth Sawfish	Global	EN
26	CHONDRICHTHYES	PRISTIDAE	*Pristis clavata* (Garman, 1906)	Dwarf Sawfish	PNG and Australia	EN

27	CHONDRICHTHYES	PRISTIDAE	*Pristis pristis* (Linnaeus, 1758)	Largetooth Sawfish	Global	CR
28	CHONDRICHTHYES	PRISTIDAE	*Pristis zijsron* (Bleeker, 1851)	Longcomb Sawfish	Indo-Pacific	CR
29	CHONDRICHTHYES	RHINCODONTIDAE	*Rhincodon typus* (Smith, 1828)	Whale Shark	Globally	EN
30	CHONDRICHTHYES	SPHYRNIDAE	*Eusphyra blochii* (Cuvier, 1816)	Winghead Shark	Central and Indo-Pacific	EN
31	CHONDRICHTHYES	STEGOSTOMIDAE	*Stegostoma fasciatum* (Hermann, 1783)	Zebra shark	Western Pacific and Indian Ocean	EN
32	HOLOTHUROIDEA	HOLOTHURIIDAE	*Holothuria lessoni* (Massin et al., 2009)	Golden Sandfish	Western and Central Pacific	EN
33	HOLOTHUROIDEA	HOLOTHURIIDAE	*Holothuria nobilis* (Selenka, 1867)	Black Teatfish	Indian Ocean and Western Central Pacific	EN
34	HOLOTHUROIDEA	HOLOTHURIIDAE	*Holothuria scabra* (Jaeger, 1833)	Golden Sandfish	Indo-Pacific	EN
35	HOLOTHUROIDEA	HOLOTHURIIDAE	*Holothuria whitmaei* (Bell, 1887)	Black Teatfish	Philippines and Pacific	EN
36	HOLOTHUROIDEA	STICHOPODIDAE	*Thelenota ananas* (Jaeger, 1833)	Pricky Redfish	Indo-Pacific	EN
37	INSECTA	CURCULIONIDAE	*Gymnopholus lichenifer* (Gressitt, 1966)	Lichen Weevil	PNG	EN
38	INSECTA	DYTISCIDAE	*Rhantus papuanus* (Balfour-Browne, 1939)	Water Beetle	PNG	Ex
39	INSECTA	PAPILIONIDAE	*Ornithoptera alexandrae* (Rothschild, 1907)	Queen Alexandra's Butterfly	PNG	EN
40	JUNGERMANNIOPSIDA	SCHISTOCHILACEAE	*Schistochila undulatifolia* (Piippo)	Schistochila Liverworth	PNG	CR
41	LECANOROMYCETES	LOBARIACEAE	*Sticta alpinotropica* (Aptroot)	Sticta Lichen	PNG	EN
42	LECANOROMYCETES	PARMELIACEAE	*Cetreliopsis papuae* (Randlane & Amp; Saag)	Cetreliposis Lichen	PNG	EN
43	LILIOPSIDA	ARECACEAE	*Ponapea hentyi* ((Essig) C.Lewis & Zona)	Ponapea Palm	Western Pacific	EN
44	LILIOPSIDA	ORCHIDACEAE	*Bulbophyllum bliteum* (J.J.Verm.)	Medusa's Bulbophyllum	New Guinea	EN
45	LILIOPSIDA	ORCHIDACEAE	*Bulbophyllum cimicinum* (J.J.Verm.)	Bug-Carrying Bulbophyllum	PNG	EN
46	LILIOPSIDA	ORCHIDACEAE	*Bulbophyllum hiljeae* (J.J.Verm.)		New Guinea	EN
47	LILIOPSIDA	ORCHIDACEAE	*Bulbophyllum tinekeae* (Schuit. & Amp; de Vogel)	Wrinkly Bulbophyllum	New Guinea	EN
48	LILIOPSIDA	ORCHIDACEAE	*Dendrobium kauldorumii* (T.M.Reeve)	Kauldrorum's Dendrobium	PNG	EN
49	LILIOPSIDA	ORCHIDACEAE	*Dendrobium pachythrix* (T.M.Reeve & P.Woods)	Pachytrix's Dendrobium	New Guinea	EN
50	LILIOPSIDA	ORCHIDACEAE	*Paphiopedilum bougainvilleanum* (Fowlie)	Bouganville Paphiopedilum	PNG	CR
51	LILIOPSIDA	ORCHIDACEAE	*Paphiopedilum glanduliferum* ((Blume) Stein)	Gland-bearing Paphiopedilum	PNG and Indonesia	EN
52	LILIOPSIDA	ORCHIDACEAE	*Paphiopedilum papuanum* ((Ridl. ex Rendle) L.O.Williams)	Papua Paphiopedilum	New Guinea	EN
53	LILIOPSIDA	ORCHIDACEAE	*Paphiopedilum violascens* (Schltr.)	Shimmering Purple Paphiopedilum	PNG	EN

54	LILIOPSIDA	ORCHIDACEAE	*Paphiopedilum wentworthianum* (Schoser & Amp; Fowlie)	Wentworth's Paphiopedilum	PNG and Solomon Islands	CR
55	LILIOPSIDA	ORCHIDACEAE	*Paphiopedilum* wilhelminae (L.O.Williams)	Wilhelminha's Paphiopedilum	PNG	EN
56	LILIOPSIDA	POACEAE	*Oryza schlechteri* (Pilg.)	Wild Rice	New Guinea	EN
57	MAGNOLIOPSIDA	CALOPHYLLACEAE	*Calophyllum acutiputamen* (P.F.Stevens)	Calophyllum	PNG	CR
58	MAGNOLIOPSIDA	CALOPHYLLACEAE	*Calophyllum morobense* (P.F.Stevens)	Calophyllum	PNG	EN
59	MAGNOLIOPSIDA	CALOPHYLLACEAE	*Calophyllum waliense* (P.F.Stevens)	Calophyllum	PNG	EN
60	MAGNOLIOPSIDA	COMBRETACEAE	*Terminalia archipelagi* (Coode)	Terminalia archipelagi	PNG	EN
61	MAGNOLIOPSIDA	DIPTEROCARPACEAE	*Hopea inexpectata* (P.S.Ashton)	Hopea	PNG	CR
62	MAGNOLIOPSIDA	EBENACEAE	*Diospyros benstonei* (Kosterm.)	Black Ebony	PNG	CR
63	MAGNOLIOPSIDA	EBENACEAE	*Diospyros gillisonii* (Kosterm.)	Black Ebony	PNG	EN
64	MAGNOLIOPSIDA	EBENACEAE	*Diospyros insularis* (Bakh.)	Black Ebony	PNG	EN
65	MAGNOLIOPSIDA	EBENACEAE	*Diospyros lolinopsis* (Kosterm.)	Black Ebony	PNG	CR
66	MAGNOLIOPSIDA	FABACEAE	*Pterocarpus indicus* (Willd.)	Rosewood	Southeast Asia and Oceania	EN
67	MAGNOLIOPSIDA	MELIACEAE	*Aglaia mackiana* (Pannell)	Aglaia	PNG	CR
68	MAGNOLIOPSIDA	MYRISTICACEAE	*Horsfieldia ralunensis* (Warb.)	Hosefiledia	PNG and Southeast Asia	EN
69	MAGNOLIOPSIDA	MYRTACEAE	*Xanthostemon oppositifolius* (Bailey)	Xanthostemon oppositifolius	PNG and Australia	EN
70	MAGNOLIOPSIDA	NOTHOFAGACEAE	*Nothofagus nuda* (Tristyngyne nuda) (Steen.)	Nothofagus	PNG	CR
71	MAGNOLIOPSIDA	PROTEACEAE	*Alloxylon brachycarpum*((Sleumer) P.H.Weston & Amp; Crisp)	Alloxylon	PNG and Indonesia	EN
72	MAGNOLIOPSIDA	PROTEACEAE	*Bleasdalea papuana* ((Diels) Domin)	Bleasdalea	PNG and Indonesia	EN
73	MAGNOLIOPSIDA	PROTEACEAE	*Helicia insularis* (D.Foreman)	Helicia	PNG	EN
74	MAGNOLIOPSIDA	PROTEACEAE	*Helicia peltata* (White)	Helicia	PNG	CR
75	MAGNOLIOPSIDA	PROTEACEAE	*Helicia polyosmoides* (D.Foreman)	Helicia	PNG	CR
76	MAGNOLIOPSIDA	PROTEACEAE	*Helicia subcordata* (D.Foreman)	Helicia	PNG	CR
77	MAGNOLIOPSIDA	RHIZOPHORACEAE	*Bruguiera hainesii* (C.G.Rogers)	Bruguiera	PNG	CR
78	MAGNOLIOPSIDA	RUBIACEAE	*Coffea arabica* (L.)	Coffea	PNG	EN
79	MAGNOLIOPSIDA	RUTACEAE	*Flindersia ifflaiana* (F. Muell)	Flindersia	PNG and Australia	EN
80	MAGNOLIOPSIDA	RUTACEAE	*Flindersia pimenteliana* (F. Muell)	Flindersia	PNG and Australia	EN
81	MAGNOLIOPSIDA	RUTACEAE	*Halfordia papuana* (Laut.)	Halfordia	PNG	CR

82	MAGNOLIOPSIDA	SANTALACEAE	*Santalum macgregorii* (F. Muell)	Santalum	PNG	EN
83	MAGNOLIOPSIDA	SAPINDACEAE	*Guioa grandifoliola* (Welzen)	Guioa	Southeast Asia, PNG and Australia	CR
84	MAGNOLIOPSIDA	SAPINDACEAE	*Guioa hospita* (Radlk.)	Guioa	New Guinea	CR
85	MAGNOLIOPSIDA	SAPOTACEAE	*Madhuca boerlageana* ((Burck) Baehni)	Madhuca	PNG and Indonesia	CR
86	MAGNOLIOPSIDA	SAPOTACEAE	*Manilkara kanosiensis* (H.J.Lan & B.Meeuse)	Manilkara	PNG and Indonesia	EN
87	MAMMALIA	BALAENOPTERIDAE	*Balaenoptera musculus* (Linnaeus, 1758)	Blue Whale	Global	EN
88	MAMMALIA	MACROPODIDAE	*Dendrolagus goodfellowi* (Thomas, 1908)	Ornate or Goodfellow's Tree-kanagroo	New Guinea	EN
89	MAMMALIA	MACROPODIDAE	*Dendrolagus matschiei* (FÃster & Rothschild, 1907)	Maatschie's or Huon Tree-kanagroo	PNG	EN
90	MAMMALIA	MACROPODIDAE	*Dendrolagus notatus* (Matschie, 1916)	Ifola Tree Kangaroo	PNG	EN
91	MAMMALIA	MACROPODIDAE	*Dendrolagus pulcherrimus* (Flannery, 1993)	Golden-mantled Tree-kangaroo	New Guinea	CR
92	MAMMALIA	MACROPODIDAE	*Dendrolagus scottae* (Flannery & Amp; Seri, 1990)	Tenkille or Scott's Tree-kangaroo	PNG	CR
93	MAMMALIA	MACROPODIDAE	*Dorcopsis atrata* (Van Deusen, 1957)	Black Dorcopsis or Black Forest Wallaby	PNG	CR
94	MAMMALIA	MACROPODIDAE	*Thylogale calabyi* (Flannery, 1992)	Calaby's Padamelon or Alphine Wallaby	PNG	EN
95	MAMMALIA	MACROPODIDAE	*Thylogale lanatus* (Thomas, 1922)	Mountain Padamelon	PNG	EN
96	MAMMALIA	MURIDAE	*Melomys matambuai* (Flannery, Colgan & Amp; Trimble, 1994)	Manus Melomys or Manus Island Mosaic-tailed Rat	PNG	EN
97	MAMMALIA	MURIDAE	*Paraleptomys rufilatus* (Osgood, 1945)	Northern Water Rat	New Guinea	EN
98	MAMMALIA	MURIDAE	*Paramelomys gressitti* (Menzies, 1996)	Gressitt's Mosaic Rat	PNG	EN
99	MAMMALIA	MURIDAE	*Pogonomys fergussoniensis* (Laurie, 1952)	D'Entrecasteaux Archipelago Pologomy or Tree Mouse	PNG	EN
100	MAMMALIA	MURIDAE	*Rattus vandeuseni* (Taylor & Amp; Calaby, 1982)	Van Deusen's Rat	PNG	EN
101	MAMMALIA	MURIDAE	*Solomys ponceleti* (Troughton, 1935)	Poncelet's Giant or Naked-tailed Rat	PNG and Solomon Island	CR
102	MAMMALIA	MURIDAE	*Solomys salebrosus* (Troughton, 1936)	Bouganville Naked-tailed Rat	PNG	EN
103	MAMMALIA	PERAMELIDAE	*Echymipera davidi* (Flannery, 1990)	David's Echymipera	PNG	EN
104	MAMMALIA	PERAMELIDAE	*Peroryctes broadbenti* (Ramsay, 1879)	Giant Bandicoot	PNG	EN
105	MAMMALIA	PETAURIDAE	*Dactylopsila tatei* (Laurie, 1952)	Tate's Triok or Ferguson Island Striped Possum	PNG	EN
106	MAMMALIA	PETAURIDAE	*Petaurus abidi* (Ziegler, 1981)	Northern Glider	PNG	CR
107	MAMMALIA	PHALANGERIDAE	*Phalanger lullulae* (Thomas, 1896)	Woodlark Cuscus	PNG	Endangered
108	MAMMALIA	PHALANGERIDAE (Flannery, 1987)	*Phalanger matanim* (Flannery, 1987)	Telefomin Cuscus	PNG	CR

109	MAMMALIA	PHALANGERIDAE	*Spilocuscus rufoniger* (Zimara, 1937)	Black-spotted Cuscus	New Guinea	CR
110	MAMMALIA	PTEROPODIDAE	*Aproteles bulmerae* (Menzies, 1977)	Blumer's Fruit Bat	New Guinea	CR
111	MAMMALIA	PTEROPODIDAE	*Pteralopex anceps* (K. Andersen, 1909)	Bougainville Monkey Faced Bat	PNG and Solomon Islands	EN
112	MAMMALIA	PTEROPODIDAE	*Pteralopex flanneryi* (Helgen, 2005)	Greater Monkey-faced Bat	PNG and Solomon Islands	CR
113	MAMMALIA	VESPERTILIONIDAE	*Pharotis imogene* (Thomas, 1914)	New Guinea big-eared Bat	PNG	CR
114	POLYPODIOPSIDA	CYATHEACEAE	*Alsophila klossii* ((Ridl.) R.M.Tryon)	Alsophila Cyathea Tree Fern	New Guinea	EN
115	REPTILIA	CARETTOCHELYIDAE	*Carettochelys insculpta* (Ramsay, 1886)	Pig-nosed Turtle	Australia and New Guinea	EN
116	REPTILIA	CHELIDAE	*Chelodina pritchardi* (Rhodin, 1994)	Pritchard's snake-necked Turtle	PNG	EN
117	REPTILIA	CHELONIIDAE	*Chelonia mydas* (Linnaeus, 1758)	Green Sea Turtle or Black Turtel or Pacific Green Turtle	Global	EN
118	REPTILIA	CHELONIIDAE	*Eretmochelys imbricata* (Linnaeus, 1766)	Hawksbill Sea Turtle	Global	CR
119	REPTILIA	TRIONYCHIDAE	*Pelochelys cantorii* (Gray, 1864)	Cantor's Giant Softshell Turtle	Southeast Asia and PNG	EN

Appendix 10: Table 10. List of major invasive species in PNG (Source NAQIA, 2019)

No	Kingdom	Family	Taxo_group	SpeciesName	Species_authority	Environment_system
1	*Plantae*	*Malvaceae*	*Vascular plant*	*Abelmoschus moschatus*	*Medik.*	*terrestrial*
2	*Plantae*	*Euphorbiaceae*	*Vascular plant*	*Acalypha lanceolata*	*Willd.*	*terrestrial*
3	*Animalia*	*Acanthasteridae*	*Echinoderm*	*Acanthaster planci*	*(Linnaeus, 1758)*	*marine*
4	*Plantae*	*Asteraceae*	*Vascular plant*	*Acanthospermum hispidum*	*DC.*	*terrestrial*
5	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Achyranthes aspera*	*L.*	*terrestrial*
6	*Plantae*	*Asteraceae*	*Vascular plant*	*Adenostemma platyphyllum*	*Cass.*	*terrestrial*
7	*Plantae*	*Fabaceae*	*Vascular plant*	*Aeschynomene americana*	*L.*	*terrestrial*
8	*Plantae*	*Fabaceae*	*Vascular plant*	*Aeschynomene indica*	*L.*	*terrestrial*
9	*Plantae*	*Asteraceae*	*Vascular plant*	*Ageratina adenophora*	*King & H. Rob. (Spreng.)*	*terrestrial*
10	*Plantae*	*Asteraceae*	*Vascular plant*	*Ageratum conyzoides*	*L.*	*terrestrial*
11	*Plantae*	*Asteraceae*	*Vascular plant*	*Ageratum houstonianum*	*Mill.*	*terrestrial*
12	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Alternanthera pungens*	*Kunth*	*terrestrial*
13	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Alternanthera sessilis*	*R. Br. ex DC. (L.)*	*terrestrial/freshwater*
14	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Amaranthus blitum*	*L.*	*terrestrial*
15	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Amaranthus cruentus*	*L.*	*terrestrial*
16	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Amaranthus dubius*	*Mart. ex Thell.*	*terrestrial*
17	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Amaranthus interruptus*	*R.Br.*	*terrestrial*
18	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Amaranthus spinosus*	*L.*	*terrestrial*
19	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Amaranthus viridis*	*L.*	*terrestrial*
20	*Animalia*	*Anabantidae*	*Ray-finned fish*	*Anabas testudineus*	*(Bloch, 1792)*	*freshwater/brackish*
21	*Plantae*	*Polygonaceae*	*Vascular plant*	*Antigonon leptopus*	*Hook. & Arn.*	*terrestrial*
22	*Plantae*	*Aristolochiaceae*	*Vascular plant*	*Aristolochia elegans*	*Mast.*	*terrestrial*
23	*Plantae*	*Apocynaceae*	*Vascular plant*	*Asclepias curassavica*	*L.*	*terrestrial*
24	*Plantae*	*Poaceae*	*Vascular plant*	*Axonopus compressus*	*P.Beauv. (Sw.)*	*terrestrial*
25	*Plantae*	*Bixaceae*	*Vascular plant*	*Bixa orellana*	*L.*	*terrestrial*
26	*Plantae*	*Nyctaginaceae*	*Vascular plant*	*Boerhavia erecta*	*L.*	*terrestrial*

27	*Plantae*	*Poaceae*	*Vascular plant*	*Brachiaria reptans*	*C.A.Gardner & C.E.Hubb. (L.)*	*terrestrial*
28	*Plantae*	*Fabaceae*	*Vascular plant*	*Calopogonium mucunoides*	*Desv.*	*terrestrial*
29	*Plantae*	*Apocynaceae*	*Vascular plant*	*Calotropis gigantea*	*W.T. Aiton (L.)*	*terrestrial*
30	*Animalia*	*Canidae*	*Mammal*	*Canis lupus familiaris*	*Linnaeus, 1758*	*terrestrial*
31	*Plantae*	*Brassicaceae*	*Vascular plant*	*Cardamine hirsuta*	*L.*	*terrestrial*
32	*Plantae*	*Apocynaceae*	*Vascular plant*	*Catharanthus roseus*	*G. Don (L.)*	*terrestrial*
33	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Celosia argentea*	*L.*	*terrestrial*
34	*Plantae*	*Asteraceae*	*Vascular plant*	*Centaurea solstitialis*	*L.*	*terrestrial*
35	*Plantae*	*Fabaceae*	*Vascular plant*	*Centrosema molle*	*Benth.*	*terrestrial*
36	*Plantae*	*Caryophyllaceae*	*Vascular plant*	*Cerastium fontanum subsp. vulgare*	*(Hartm.) Greuter & Burdet*	*terrestrial*
37	*Plantae*	*Caryophyllaceae*	*Vascular plant*	*Cerastium glomeratum*	*Thuill.*	*terrestrial*
38	*Plantae*	*Fabaceae*	*Vascular plant*	*Chamaecrista mimosoides*	*Greene (L.)*	*terrestrial*
39	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Chenopodium album*	*L.*	*terrestrial*
40	*Plantae*	*Poaceae*	*Vascular plant*	*Chloris barbata*	*Sw.*	*terrestrial*
41	*Plantae*	*Asteraceae*	*Vascular plant*	*Chromolaena odorata*	*R.M. King & H. Rob. (L.)*	*terrestrial*
42	*Animalia*	*Clariidae*	*Ray-finned fish*	*Clarias batrachus*	*(Linnaeus, 1758)*	*freshwater*
43	*Plantae*	*Lamiaceae*	*Vascular plant*	*Clerodendrum chinense*	*Mabb. (Osbeck)*	*terrestrial*
44	*Plantae*	*Lamiaceae*	*Vascular plant*	*Clerodendrum paniculatum*	*L.*	*terrestrial*
45	*Plantae*	*Melastomataceae*	*Vascular plant*	*Clidemia hirta*	*D.Don (L.)*	*terrestrial*
46	*Plantae*	*Fabaceae*	*Vascular plant*	*Clitoria ternatea*	*L.*	*terrestrial*
47	*Plantae*	*Commelinaceae*	*Vascular plant*	*Commelina benghalensis*	*L.*	*terrestrial*
48	*Plantae*	*Commelinaceae*	*Vascular plant*	*Commelina diffusa*	*Burm. f.*	*terrestrial*
49	*Plantae*	*Malvaceae*	*Vascular plant*	*Corchorus aestuans*	*L.*	*terrestrial*
50	*Plantae*	*Asteraceae*	*Vascular plant*	*Cosmos caudatus*	*Kunth*	*terrestrial*
51	*Plantae*	*Asteraceae*	*Vascular plant*	*Crassocephalum crepidioides*	*S. Moore (Benth.)*	*terrestrial*
52	*Plantae*	*Iridaceae*	*Vascular plant*	*Crocosmia ×crocosmiiflora*	*N.E.Br. (Lemoine)*	*terrestrial*
53	*Plantae*	*Fabaceae*	*Vascular plant*	*Crotalaria pallida*	*Aiton*	*terrestrial*
54	*Plantae*	*Fabaceae*	*Vascular plant*	*Crotalaria retusa*	*L.*	*terrestrial*

55	*Plantae*	*Euphorbiaceae*	*Vascular plant*	*Croton hirtus*		*terrestrial*
56	*Plantae*	*Asteraceae*	*Vascular plant*	*Cyanthillium cinereum*	*H. Rob. (L.)*	*terrestrial*
57	*Plantae*	*Poaceae*	*Vascular plant*	*Cynodon dactylon*	*Pers. (L.)*	*terrestrial*
58	*Plantae*	*Cyperaceae*	*Vascular plant*	*Cyperus cyperoides*	*Kuntze (L.)*	*terrestrial/freshwater*
59	*Plantae*	*Cyperaceae*	*Vascular plant*	*Cyperus distans*	*L.f.*	*terrestrial/freshwater*
60	*Plantae*	*Cyperaceae*	*Vascular plant*	*Cyperus rotundus*	*L.*	*terrestrial/freshwater*
61	*Plantae*	*Cyperaceae*	*Vascular plant*	*Cyperus sphacelatus*	*Rottb.*	*terrestrial/freshwater*
62	*Animalia*	*Cyprinidae*	*Ray-finned fish*	*Cyprinus carpio carpio*	*Linnaeus, 1758*	*freshwater/brackish*
63	*Plantae*	*Fabaceae*	*Vascular plant*	*Delonix regia*	*Raf. (Hook.)*	*terrestrial*
64	*Plantae*	*Fabaceae*	*Vascular plant*	*Derris elliptica*	*Benth. (Wall.)*	*terrestrial*
65	*Animalia*	*Liviidae*	*Insect*	*Diaphorina citri*	*Kuwayama, 1908*	*host*
66	*Plantae*	*Poaceae*	*Vascular plant*	*Digitaria insularis*	*Mez ex Ekman (L.)*	*terrestrial*
67	*Plantae*	*Poaceae*	*Vascular plant*	*Digitaria sanguinalis*	*Scop. (L.)*	*terrestrial*
68	*Plantae*	*Caryophyllaceae*	*Vascular plant*	*Drymaria cordata*	*Willd. ex Schult. (L.)*	*terrestrial*
69	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Dysphania ambrosioides*	*(L.) Mosyakin & Clemants*	*terrestrial*
70	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Dysphania pumilio*	*Mosyakin & Clemants (R. Br.)*	*terrestrial*
71	*Plantae*	*Poaceae*	*Vascular plant*	*Echinochloa stagnina*	*P.Beauv. (Retz.)*	*terrestrial*
72	*Plantae*	*Asteraceae*	*Vascular plant*	*Eclipta prostrata*	*L. (L.)*	*terrestrial*
73	*Plantae*	*Pontederiaceae*	*Vascular plant*	*Eichhornia crassipes*	*Solms (Mart.)*	*freshwater*
74	*Plantae*	*Asteraceae*	*Vascular plant*	*Elephantopus mollis*	*Kunth*	*terrestrial*
75	*Plantae*	*Poaceae*	*Vascular plant*	*Eleusine indica*	*Gaertn. (L.)*	*terrestrial*
76	*Plantae*	*Asteraceae*	*Vascular plant*	*Eleutheranthera ruderalis*	*Sch. Bip. (Sw.)*	*terrestrial*
77	*Plantae*	*Asteraceae*	*Vascular plant*	*Emilia sonchifolia*	*DC (L)*	*terrestrial*
78	*Plantae*	*Poaceae*	*Vascular plant*	*Eragrostis patula*	*Steud. (Kunth)*	*terrestrial*
79	*Plantae*	*Asteraceae*	*Vascular plant*	*Erechtites valerianaefolius*	*DC.*	*terrestrial*
80	*Plantae*	*Asteraceae*	*Vascular plant*	*Erigeron aegyptiacus*	*L.*	*terrestrial*
81	*Plantae*	*Myrtaceae*	*Vascular plant*	*Eugenia uniflora*	*L.*	*terrestrial*
82	*Animalia*	*Spiraxidae*	*Mollusc*	*Euglandina rosea*	*(Ferussac, 1818)*	*terrestrial*

83	*Plantae*	*Euphorbiaceae*	*Vascular plant*	*Euphorbia heterophylla*	*L.*	*terrestrial*
84	*Plantae*	*Euphorbiaceae*	*Vascular plant*	*Euphorbia hirta*	*L.*	*terrestrial*
85	*Plantae*	*Euphorbiaceae*	*Vascular plant*	*Euphorbia prostrata*	*Aiton*	*terrestrial*
86	*Plantae*	*Euphorbiaceae*	*Vascular plant*	*Euphorbia thymifolia*	*L.*	*terrestrial*
87	*Plantae*	*Moraceae*	*Vascular plant*	*Ficus elastica*	*Roxb. ex Hornem.*	*terrestrial*
88	*Plantae*	*Fabaceae*	*Vascular plant*	*Flemingia macrophylla*	*Merr. (Willd.)*	*terrestrial*
89	*Plantae*	*Asteraceae*	*Vascular plant*	*Galinsoga parviflora*	*Cav.*	*terrestrial*
90	*Animalia*	*Poeciliidae*	*Ray-finned fish*	*Gambusia affinis*	*(Baird & Girard, 1853)*	*freshwater/brackish*
91	*Animalia*	*Poeciliidae*	*Ray-finned fish*	*Gambusia holbrooki*	*Girard, 1859*	*freshwater/brackish*
92	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Gomphrena celosioides*	*Mart.*	*terrestrial*
93	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Gomphrena globosa*	*L.*	*terrestrial*
94	*Plantae*	*Lamiaceae*	*Vascular plant*	*Hyptis pectinata*	*Poit. (L.)*	*terrestrial*
95	*Plantae*	*Lamiaceae*	*Vascular plant*	*Hyptis rhomboidea*	*M.Martens & Galeotti*	*terrestrial*
96	*Plantae*	*Lamiaceae*	*Vascular plant*	*Hyptis suaveolens*	*Poit. (L.)*	*terrestrial*
97	*Plantae*	*Poaceae*	*Vascular plant*	*Imperata conferta*	*Ohwi (J.Presl)*	*terrestrial*
98	*Plantae*	*Poaceae*	*Vascular plant*	*Imperata cylindrica*	*Raeusch. (L.)*	*terrestrial*
99	*Plantae*	*Convolvulaceae*	*Vascular plant*	*Ipomoea aquatica*	*Forssk.*	*terrestrial/freshwater*
100	*Plantae*	*Convolvulaceae*	*Vascular plant*	*Ipomoea cairica*	*Sweet (L.)*	*terrestrial*
101	*Plantae*	*Convolvulaceae*	*Vascular plant*	*Ipomoea hederifolia*	*L.*	*terrestrial*
102	*Plantae*	*Convolvulaceae*	*Vascular plant*	*Ipomoea quamoclit*	*L.*	*terrestrial*
103	*Plantae*	*Convolvulaceae*	*Vascular plant*	*Ipomoea triloba*	*L.*	*terrestrial*
104	*Plantae*	*Euphorbiaceae*	*Vascular plant*	*Jatropha curcas*	*L.*	*terrestrial*
105	*Plantae*	*Euphorbiaceae*	*Vascular plant*	*Jatropha gossypifolia*	*L.*	*terrestrial*
106	*Plantae*	*Cyperaceae*	*Vascular plant*	*Kyllinga brevifolia*	*Rottb.*	*terrestrial/freshwater*
107	*Plantae*	*Verbenaceae*	*Vascular plant*	*Lantana camara*	*L.*	*terrestrial*
108	*Plantae*	*Fabaceae*	*Vascular plant*	*Leucaena leucocephala*	*(Lam.) de Wit*	*terrestrial*
109	*Animalia*	*Achatinidae*	*Mollusc*	*Lissachatina fulica*	*(Férussac, 1821)*	*terrestrial*
110	*Plantae*	*Onagraceae*	*Vascular plant*	*Ludwigia octovalvis*	*P.H. Raven (Jacq.)*	*terrestrial/freshwater*

111	*Plantae*	*Malvaceae*	*Vascular plant*	*Malvastrum coromandelianum*	*Garcke (L.)*	*terrestrial*
112	*Plantae*	*Plantaginaceae*	*Vascular plant*	*Mecardonia procumbens*	*Small (Mill.)*	*terrestrial*
113	*Plantae*	*Poaceae*	*Vascular plant*	*Melinis minutiflora*	*P.Beauv.*	*terrestrial*
114	*Plantae*	*Poaceae*	*Vascular plant*	*Melinis repens*	*Zizka (Willd.)*	*terrestrial*
115	*Plantae*	*Convolvulaceae*	*Vascular plant*	*Merremia peltata*	*Merr. (L.)*	*terrestrial*
116	*Plantae*	*Asteraceae*	*Vascular plant*	*Mikania micrantha*	*Kunth*	*terrestrial*
117	*Plantae*	*Fabaceae*	*Vascular plant*	*Mimosa diplotricha*	*Sauvalle*	*terrestrial*
118	*Plantae*	*Fabaceae*	*Vascular plant*	*Mimosa pigra*	*L.*	*terrestrial*
119	*Plantae*	*Fabaceae*	*Vascular plant*	*Mimosa pudica*	*L.*	*terrestrial*
120	*Plantae*	*Cucurbitaceae*	*Vascular plant*	*Momordica charantia*	*L.*	*terrestrial*
121	*Plantae*	*Commelinaceae*	*Vascular plant*	*Murdannia nudiflora*	*Brenan (L.)*	*terrestrial*
122	*Plantae*	*Malvaceae*	*Vascular plant*	*Ochroma pyramidale*	*Urb. (Cav. ex Lam.)*	*terrestrial*
123	*Animalia*	*Cichlidae*	*Ray-finned fish*	*Oreochromis mossambicus*	*(Peters, 1852)*	*freshwater/brackish*
124	*Animalia*	*Dynastidae*	*Insect*	*Oryctes rhinoceros*	*Linnaeus, 1758*	*terrestrial*
125	*Plantae*	*Oxalidaceae*	*Vascular plant*	*Oxalis corniculata*	*L.*	*terrestrial*
126	*Plantae*	*Poaceae*	*Vascular plant*	*Panicum maximum*	*Jacq.*	*terrestrial*
127	*Plantae*	*Asteraceae*	*Vascular plant*	*Parthenium hysterophorus*	*L.*	*terrestrial*
128	*Plantae*	*Poaceae*	*Vascular plant*	*Paspalum conjugatum*	*P.J.Bergius*	*terrestrial*
129	*Plantae*	*Poaceae*	*Vascular plant*	*Paspalum paniculatum*	*L.*	*terrestrial*
130	*Plantae*	*Poaceae*	*Vascular plant*	*Paspalum scrobiculatum*	*L.*	*terrestrial*
131	*Plantae*	*Passifloraceae*	*Vascular plant*	*Passiflora foetida*	*L.*	*terrestrial*
132	*Plantae*	*Poaceae*	*Vascular plant*	*Pennisetum purpureum*	*Schumach.*	*terrestrial*
133	*Plantae*	*Piperaceae*	*Vascular plant*	*Peperomia pellucida*	*Kunth (L.)*	*terrestrial*
134	*Animalia*	*Formicidae*	*Insect*	*Pheidole megacephala*	*(Fabricius, 1793)*	*terrestrial*
135	*Fungi*	*Hymenochaetaceae*	*Fungi*	*Phellinus noxius*	*G. Cunn., 1965 (Corner)*	*host*
136	*Plantae*	*Solanaceae*	*Vascular plant*	*Physalis angulata*	*L.*	*terrestrial*
137	*Plantae*	*Solanaceae*	*Vascular plant*	*Physalis minima*	*L.*	*terrestrial*
138	*Plantae*	*Urticaceae*	*Vascular plant*	*Pilea microphylla*	*Liebm. (L.)*	*terrestrial*

139	*Plantae*	*Piperaceae*	*Vascular plant*	*Piper aduncum*	*L.*	*terrestrial*
140	*Plantae*	*Plantaginaceae*	*Vascular plant*	*Plantago major*	*L.*	*terrestrial*
141	*Plantae*	*Poaceae*	*Vascular plant*	*Poa annua*	*L.*	*terrestrial*
142	*Animalia*	*Poeciliidae*	*Ray-finned fish*	*Poecilia reticulata*	*Peters, 1859*	*freshwater/brackish*
143	*Plantae*	*Polygalaceae*	*Vascular plant*	*Polygala paniculata*	*L.*	*terrestrial*
144	*Plantae*	*Poaceae*	*Vascular plant*	*Polypogon monspeliensis*	*Desf. (L.)*	*terrestrial*
145	*Animalia*	*Ampullariidae*	*Mollusc*	*Pomacea canaliculata*	*(Lamarck, 1828)*	*freshwater*
146	*Plantae*	*Portulacaceae*	*Vascular plant*	*Portulaca oleracea*	*L.*	*terrestrial*
147	*Plantae*	*Fabaceae*	*Vascular plant*	*Prosopis sp.*	*Linnaeus, 1767*	*terrestrial*
148	*Plantae*	*Fabaceae*	*Vascular plant*	*Pueraria phaseoloides*	*Benth. (Roxb.)*	*terrestrial*
149	*Animalia*	*Muridae*	*Mammal*	*Rattus exulans*	*(Peale, 1848)*	*terrestrial*
150	*Animalia*	*Muridae*	*Mammal*	*Rattus rattus*	*(Linnaeus, 1758)*	*terrestrial*
151	*Plantae*	*Euphorbiaceae*	*Vascular plant*	*Ricinus communis*	*L.*	*terrestrial*
152	*Plantae*	*Polygonaceae*	*Vascular plant*	*Rumex crispus*	*L.*	*terrestrial*
153	*Plantae*	*Lamiaceae*	*Vascular plant*	*Salvia coccinea*	*Buc'hoz ex Etl.*	*terrestrial*
154	*Plantae*	*Salviniaceae*	*Vascular plant*	*Salvinia molesta*	*Mitchell*	*freshwater*
155	*Plantae*	*Cucurbitaceae*	*Vascular plant*	*Sechium edule*	*Sw. (Jacq.)*	*terrestrial*
156	*Plantae*	*Fabaceae*	*Vascular plant*	*Senna alata*	*Roxb. (L.)*	*terrestrial*
157	*Plantae*	*Fabaceae*	*Vascular plant*	*Senna occidentalis*	*Link (L.)*	*terrestrial*
158	*Plantae*	*Fabaceae*	*Vascular plant*	*Senna tora*	*Roxb. (L.)*	*terrestrial*
159	*Plantae*	*Poaceae*	*Vascular plant*	*Setaria pumila*	*Roem. & Schult. (Poir.)*	*terrestrial*
160	*Plantae*	*Malvaceae*	*Vascular plant*	*Sida acuta*	*Burm. f.*	*terrestrial*
161	*Plantae*	*Malvaceae*	*Vascular plant*	*Sida cordifolia*	*L.*	*terrestrial*
162	*Plantae*	*Malvaceae*	*Vascular plant*	*Sida rhombifolia*	*L.*	*terrestrial*
163	*Plantae*	*Asteraceae*	*Vascular plant*	*Sigesbeckia orientalis*	*L.*	*terrestrial*
164	*Plantae*	*Solanaceae*	*Vascular plant*	*Solanum americanum*	*Mill.*	*terrestrial*
165	*Plantae*	*Solanaceae*	*Vascular plant*	*Solanum lycopersicum*	*L.*	*terrestrial*
166	*Plantae*	*Solanaceae*	*Vascular plant*	*Solanum mauritianum*	*Scop.*	*terrestrial*

167	*Plantae*	*Solanaceae*	*Vascular plant*	*Solanum nigrum*	*L.*	*terrestrial*
168	*Plantae*	*Solanaceae*	*Vascular plant*	*Solanum torvum*	*Sw.*	*terrestrial*
169	*Animalia*	*Formicidae*	*Insect*	*Solenopsis geminata*	*(Fabricius, 1804)*	*terrestrial*
170	*Plantae*	*Asteraceae*	*Vascular plant*	*Sonchus asper*	*(L.) Hill*	*terrestrial*
171	*Plantae*	*Poaceae*	*Vascular plant*	*Sorghum arundinaceum*	*Stapf (Desv.)*	*terrestrial*
172	*Plantae*	*Bignoniaceae*	*Vascular plant*	*Spathodea campanulata*	*P. Beauv.*	*terrestrial*
173	*Plantae*	*Rubiaceae*	*Vascular plant*	*Spermacoce exilis*	*C.D.Adams ex W.C.Burger & C.M.Taylo (L.O.Williams)*	*terrestrial*
174	*Plantae*	*Rubiaceae*	*Vascular plant*	*Spermacoce remota*	*Lam.*	*terrestrial*
175	*Plantae*	*Asteraceae*	*Vascular plant*	*Sphagneticola trilobata*	*Pruski (L.)*	*terrestrial*
176	*Plantae*	*Verbenaceae*	*Vascular plant*	*Stachytarpheta cayennensis*	*Vahl (Rich.)*	*terrestrial*
177	*Plantae*	*Verbenaceae*	*Vascular plant*	*Stachytarpheta jamaicensis*	*Vahl (L.)*	*terrestrial*
178	*Plantae*	*Caryophyllaceae*	*Vascular plant*	*Stellaria media*	*Vill. (L.)*	*terrestrial*
179	*Plantae*	*Asteraceae*	*Vascular plant*	*Synedrella nodiflora*	*(L.) Gaertn.*	*terrestrial*
180	*Plantae*	*Talinaceae*	*Vascular plant*	*Talinum paniculatum*	*Gaertn. (Jacq.)*	*terrestrial*
181	*Animalia*	*Formicidae*	*Insect*	*Tapinoma melanocephalum*	*(Fabricius, 1793)*	*terrestrial*
182	*Plantae*	*Bignoniaceae*	*Vascular plant*	*Tecoma stans*	*Juss. ex Kunth (L.)*	*terrestrial*
183	*Plantae*	*Apocynaceae*	*Vascular plant*	*Thevetia peruviana*	*K. Schum. (Pers.)*	*terrestrial*
184	*Plantae*	*Acanthaceae*	*Vascular plant*	*Thunbergia alata*	*Bojer ex Sims*	*terrestrial*
185	*Plantae*	*Asteraceae*	*Vascular plant*	*Tithonia diversifolia*	*A.Gray (Hemsl.)*	*terrestrial*
186	*Plantae*	*Commelinaceae*	*Vascular plant*	*Tradescantia zebrina*	*Bosse*	*terrestrial*
187	*Plantae*	*Aizoaceae*	*Vascular plant*	*Trianthema portulacastrum*	*L.*	*terrestrial*
188	*Plantae*	*Asteraceae*	*Vascular plant*	*Tridax procumbens*	*L.*	*terrestrial*
189	*Plantae*	*Malvaceae*	*Vascular plant*	*Triumfetta rhomboidea*	*Jacq.*	*terrestrial*
190	*Plantae*	*Fabaceae*	*Vascular plant*	*Ulex europaeus*	*L.*	*terrestrial*
191	*Plantae*	*Malvaceae*	*Vascular plant*	*Urena lobata*	*L.*	*terrestrial*
192	*Plantae*	*Verbenaceae*	*Vascular plant*	*Verbena bonariensis*	*L.*	*terrestrial*
193	*Plantae*	*Asteraceae*	*Vascular plant*	*Xanthium spinosum*	*L.*	*freshwater*

194	*Plantae*	*Asteraceae*	*Vascular plant*	*Youngia japonica*	*DC (L)*	*terrestrial*
195	*Plantae*	*Fabaceae*	*Vascular plant*	*Abrus precatorius*	*L.*	*terrestrial*
196	*Plantae*	*Malvaceae*	*Vascular plant*	*Abutilon indicum*	*Sweet (L.)*	*terrestrial*
197	*Plantae*	*Fabaceae*	*Vascular plant*	*Acacia angustissima*	*Kuntze (Mill.)*	*terrestrial*
198	*Plantae*	*Fabaceae*	*Vascular plant*	*Acacia concinna*	*DC. (Willd.)*	*terrestrial*
199	*Plantae*	*Fabaceae*	*Vascular plant*	*Acacia decurrens*	*Willd.*	*terrestrial*
200	*Plantae*	*Fabaceae*	*Vascular plant*	*Acacia mangium*	*Willd.*	*terrestrial*
201	*Plantae*	*Fabaceae*	*Vascular plant*	*Acacia mearnsii*	*De Wild.*	*terrestrial*
202	*Plantae*	*Asteraceae*	*Vascular plant*	*Acmella oleracea*	*R. K. Jansen (L.)*	*terrestrial*
203	*Plantae*	*Fabaceae*	*Vascular plant*	*Adenanthera pavonina*	*L.*	*terrestrial*
204	*Plantae*	*Pteridaceae*	*Vascular plant*	*Adiantum raddianum*	*C. Presl*	*terrestrial*
205	*Animalia*	*Culicidae*	*Insect*	*Aedes aegypti*	*(Linnaeus, 1762)*	*terrestrial/freshwater*
206	*Plantae*	*Asparagaceae*	*Vascular plant*	*Agave americana*	*L.*	*terrestrial*
207	*Plantae*	*Asparagaceae*	*Vascular plant*	*Agave sisalana*	*Perrine*	*terrestrial*
208	*Plantae*	*Fabaceae*	*Vascular plant*	*Albizia lebbeck*	*Benth. (L.)*	*terrestrial*
209	*Plantae*	*Fabaceae*	*Vascular plant*	*Albizia saman*	*(Jacq.) Merr.*	*terrestrial*
210	*Plantae*	*Euphorbiaceae*	*Vascular plant*	*Aleurites moluccanus*	*(L.) Willd.*	*terrestrial*
211	*Plantae*	*Sapindaceae*	*Vascular plant*	*Allophylus cobbe*	*Raeusch. (L.)*	*terrestrial*
212	*Plantae*	*Rhamnaceae*	*Vascular plant*	*Alphitonia excelsa*	*Reissek ex Benth. (Fenzl)*	*terrestrial*
213	*Plantae*	*Zingiberaceae*	*Vascular plant*	*Alpinia purpurata*	*K.Schum. (Vieill.)*	*terrestrial*
214	*Plantae*	*Apocynaceae*	*Vascular plant*	*Alstonia macrophylla*	*Wall. ex G. Don*	*terrestrial*
215	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Alternanthera philoxeroides*	*Griseb. (Mart.)*	*terrestrial/freshwater*
216	*Plantae*	*Fabaceae*	*Vascular plant*	*Alysicarpus vaginalis*	*DC. (L.)*	*terrestrial*
217	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Amaranthus tricolor*	*L.*	*terrestrial*
218	*Plantae*	*Anacardiaceae*	*Vascular plant*	*Anacardium occidentale*	*L.*	*terrestrial*
219	*Plantae*	*Marattiaceae*	*Vascular plant*	*Angiopteris evecta*	*Hoffmann (J.R. Forst.)*	*terrestrial*
220	*Plantae*	*Annonaceae*	*Vascular plant*	*Annona glabra*	*L.*	*terrestrial*
221	*Plantae*	*Annonaceae*	*Vascular plant*	*Annona squamosa*	*L.*	*terrestrial*

222	*Animalia*	*Formicidae*	*Insect*	*Anoplolepis gracilipes*	*(Smith, 1857)*	*terrestrial*
223	*Plantae*	*Cleomaceae*	*Vascular plant*	*Arivela viscosa*	*Raf. (L.)*	*terrestrial*
224	*Plantae*	*Poaceae*	*Vascular plant*	*Arundo donax*	*L.*	*terrestrial*
225	*Plantae*	*Poaceae*	*Vascular plant*	*Axonopus fissifolius*	*Kuhlm. (Raddi)*	*terrestrial*
226	*Plantae*	*Meliaceae*	*Vascular plant*	*Azadirachta indica*	*A. Juss.*	*terrestrial*
227	*Plantae*	*Poaceae*	*Vascular plant*	*Bambusa sp.*	*Schreb.*	*terrestrial*
228	*Plantae*	*Acanthaceae*	*Vascular plant*	*Barleria prionitis*	*L.*	*terrestrial*
229	*Plantae*	*Fabaceae*	*Vascular plant*	*Bauhinia acuminata*	*L.*	*terrestrial*
230	*Plantae*	*Fabaceae*	*Vascular plant*	*Bauhinia purpurea*	*L.*	*terrestrial*
231	*Animalia*	*Aleyrodidae*	*Insect*	*Bemisia tabaci*	*(Gennadius, 1889)*	*terrestrial*
232	*Plantae*	*Asteraceae*	*Vascular plant*	*Bidens pilosa*	*L.*	*terrestrial*
233	*Plantae*	*Phyllanthaceae*	*Vascular plant*	*Bischofia javanica*	*Blume*	*terrestrial*
234	*Plantae*	*Poaceae*	*Vascular plant*	*Brachiaria mutica*	*(Forssk.) Stapf*	*terrestrial*
235	*Plantae*	*Poaceae*	*Vascular plant*	*Briza minor*	*L.*	*terrestrial*
236	*Animalia*	*Chrysomelidae*	*Insect*	*Brontispa longissima*	*(Gestro, 1885)*	*terrestrial*
237	*Plantae*	*Scrophulariaceae*	*Vascular plant*	*Buddleja davidii*	*Franch.*	*terrestrial*
238	*Plantae*	*Cabombaceae*	*Vascular plant*	*Cabomba caroliniana*	*A. Gray*	*freshwater*
239	*Plantae*	*Fabaceae*	*Vascular plant*	*Caesalpinia bonduc*	*Roxb. (L.)*	*terrestrial*
240	*Plantae*	*Fabaceae*	*Vascular plant*	*Caesalpinia pulcherrima*	*Sw. (L.)*	*terrestrial*
241	*Plantae*	*Fabaceae*	*Vascular plant*	*Cajanus cajan*	*Millsp. (L.)*	*terrestrial*
242	*Plantae*	*Araceae*	*Vascular plant*	*Caladium bicolor*	*Vent. (Aiton)*	*terrestrial*
243	*Plantae*	*Arecaceae*	*Vascular plant*	*Calamus sp.*	*Linnaeus, 1753*	*terrestrial*
244	*Plantae*	*Fabaceae*	*Vascular plant*	*Calliandra haematocephala*	*Hassk.*	*terrestrial*
245	*Plantae*	*Fabaceae*	*Vascular plant*	*Calopogonium caeruleum*	*Sauvalle (Benth.)*	*terrestrial*
246	*Plantae*	*Annonaceae*	*Vascular plant*	*Cananga odorata*	*Hook. f. & Thomson (Lam.)*	*terrestrial*
247	*Plantae*	*Cannaceae*	*Vascular plant*	*Canna indica*	*L.*	*terrestrial*
248	*Plantae*	*Sapindaceae*	*Vascular plant*	*Cardiospermum halicacabum*	*L.*	*terrestrial*
249	*Plantae*	*Casuarinaceae*	*Vascular plant*	*Casuarina equisetifolia*	*L.*	*terrestrial*

250	*Plantae*	*Casuarinaceae*	*Vascular plant*	*Casuarina glauca*	*Sieber ex Spreng.*	*terrestrial*
251	*Plantae*	*Meliaceae*	*Vascular plant*	*Cedrela odorata*	*L.*	*terrestrial*
252	*Plantae*	*Malvaceae*	*Vascular plant*	*Ceiba pentandra*	*Gaertn. (L.)*	*terrestrial*
253	*Plantae*	*Poaceae*	*Vascular plant*	*Cenchrus brownii*	*Roem. & Schult.*	*terrestrial*
254	*Plantae*	*Poaceae*	*Vascular plant*	*Cenchrus ciliaris*	*L.*	*terrestrial*
255	*Plantae*	*Poaceae*	*Vascular plant*	*Cenchrus clandestinus*	*Morrone (Hochst. ex Chiov.)*	*terrestrial*
256	*Plantae*	*Poaceae*	*Vascular plant*	*Cenchrus echinatus*	*L.*	*terrestrial*
257	*Plantae*	*Apiaceae*	*Vascular plant*	*Centella asiatica*	*Urb. (L.)*	*terrestrial*
258	*Plantae*	*Ceratophyllaceae*	*Vascular plant*	*Ceratophyllum demersum*	*L.*	*freshwater*
259	*Animalia*	*Channidae*	*Ray-finned fish*	*Channa striata*	*(Bloch, 1793)*	*freshwater/brackish*
260	*Plantae*	*Costaceae*	*Vascular plant*	*Cheilocostus speciosus*	*C.D.Specht (J.König)*	*terrestrial*
261	*Plantae*	*Poaceae*	*Vascular plant*	*Chloris virgata*	*Sw.*	*terrestrial*
262	*Plantae*	*Poaceae*	*Vascular plant*	*Chrysopogon aciculatus*	*Trin. (Retz.)*	*terrestrial*
263	*Plantae*	*Lamiaceae*	*Vascular plant*	*Clerodendrum buchananii var. fallax*	*Bakh. (Lindl.)*	*terrestrial*
264	*Plantae*	*Lamiaceae*	*Vascular plant*	*Clerodendrum quadriloculare*	*Merr. (Blanco)*	*terrestrial*
265	*Plantae*	*Poaceae*	*Vascular plant*	*Coix lacryma-jobi*	*L.*	*terrestrial*
266	*Plantae*	*Araceae*	*Vascular plant*	*Colocasia esculenta*	*Schott (L.)*	*terrestrial*
267	*Animalia*	*Columbidae*	*Bird*	*Columba livia*	*Gmelin, 1789*	*terrestrial*
268	*Plantae*	*Combretaceae*	*Vascular plant*	*Combretum indicum*		*terrestrial*
269	*Animalia*	*Rhinotermitidae*	*Insect*	*Coptotermes sp.*	*Wasmann, 1896*	*terrestrial*
270	*Plantae*	*Asparagaceae*	*Vascular plant*	*Cordyline fruticosa*	*A.Chev. (L.)*	*terrestrial*
271	*Plantae*	*Fabaceae*	*Vascular plant*	*Crotalaria berteroana*	*DC.*	*terrestrial*
272	*Plantae*	*Fabaceae*	*Vascular plant*	*Crotalaria goreensis*	*Guill. & Perr.*	*terrestrial*
273	*Plantae*	*Fabaceae*	*Vascular plant*	*Crotalaria incana*	*L.*	*terrestrial*
274	*Plantae*	*Fabaceae*	*Vascular plant*	*Crotalaria juncea*	*L.*	*terrestrial*
275	*Plantae*	*Fabaceae*	*Vascular plant*	*Crotalaria micans*	*Link*	*terrestrial*
276	*Plantae*	*Fabaceae*	*Vascular plant*	*Crotalaria quinquefolia*	*L.*	*terrestrial*
277	*Plantae*	*Fabaceae*	*Vascular plant*	*Crotalaria spectabilis*	*Roth*	*terrestrial*

278	*Plantae*	*Fabaceae*	*Vascular plant*	*Crotalaria trichotoma*	*Bojer*	*terrestrial*
279	*Plantae*	*Fabaceae*	*Vascular plant*	*Crotalaria verrucosa*	*L.*	*terrestrial*
280	*Animalia*	*Culicidae*	*Insect*	*Culex quinquefasciatus*	*Say, 1823*	*terrestrial/freshwater*
281	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Cyathula prostrata*	*Blume (L.)*	*terrestrial*
282	*Plantae*	*Poaceae*	*Vascular plant*	*Cymbopogon citratus*	*Stapf (DC.)*	*terrestrial*
283	*Plantae*	*Cyperaceae*	*Vascular plant*	*Cyperus compressus*	*L.*	*terrestrial/freshwater*
284	*Plantae*	*Poaceae*	*Vascular plant*	*Cyrtococcum oxyphyllum*	*Stapf (Steud.)*	*terrestrial*
285	*Plantae*	*Poaceae*	*Vascular plant*	*Cyrtococcum patens*	*A.Camus (L.)*	*terrestrial*
286	*Plantae*	*Poaceae*	*Vascular plant*	*Cyrtococcum trigonum*	*A.Camus (Retz.)*	*terrestrial*
287	*Plantae*	*Poaceae*	*Vascular plant*	*Dactyloctenium aegyptium*	*Willd. (L.)*	*terrestrial*
288	*Plantae*	*Solanaceae*	*Vascular plant*	*Datura stramonium*	*L.*	*terrestrial*
289	*Plantae*	*Fabaceae*	*Vascular plant*	*Desmodium gangeticum*	*DC. (L.)*	*terrestrial*
290	*Plantae*	*Fabaceae*	*Vascular plant*	*Desmodium heterocarpon*	*DC. (L.)*	*terrestrial*
291	*Plantae*	*Fabaceae*	*Vascular plant*	*Desmodium intortum*	*Urb. (Mill.)*	*terrestrial*
292	*Plantae*	*Fabaceae*	*Vascular plant*	*Desmodium scorpiurus*	*Desv. (Sw.)*	*terrestrial*
293	*Plantae*	*Fabaceae*	*Vascular plant*	*Desmodium tortuosum*	*DC. (Sw.)*	*terrestrial*
294	*Plantae*	*Fabaceae*	*Vascular plant*	*Desmodium triflorum*	*DC. (L.)*	*terrestrial*
295	*Plantae*	*Fabaceae*	*Vascular plant*	*Desmodium uncinatum*	*DC. (Jacq.)*	*terrestrial*
296	*Plantae*	*Poaceae*	*Vascular plant*	*Dichanthium aristatum*	*C.E.Hubb. (Poir.)*	*terrestrial*
297	*Plantae*	*Poaceae*	*Vascular plant*	*Digitaria violascens*	*Link*	*terrestrial*
298	*Plantae*	*Dioscoreaceae*	*Vascular plant*	*Dioscorea bulbifera*	*L.*	*terrestrial*
299	*Plantae*	*Amaranthaceae*	*Vascular plant*	*Dysphania carinata*	*Mosyakin & Clemants (R. Br.)*	*terrestrial*
300	*Plantae*	*Poaceae*	*Vascular plant*	*Echinochloa colona*	*Link (L.)*	*terrestrial*
301	*Plantae*	*Poaceae*	*Vascular plant*	*Echinochloa crus-galli*	*P.Beauv. (L.)*	*terrestrial*
302	*Plantae*	*Poaceae*	*Vascular plant*	*Echinochloa pyramidalis*	*Hitchc. & Chase (Lam.)*	*terrestrial*
303	*Plantae*	*Poaceae*	*Vascular plant*	*Ehrharta stipoides*	*Labill.*	*terrestrial*
304	*Plantae*	*Arecaceae*	*Vascular plant*	*Elaeis guineensis*	*Jacq.*	*terrestrial*
305	*Plantae*	*Poaceae*	*Vascular plant*	*Elymus repens*	*(L.) Gould*	*terrestrial*

306	*Plantae*	*Fabaceae*	*Vascular plant*	*Enterolobium cyclocarpum*	*Griseb. (Jacq.)*	*terrestrial*
307	*Plantae*	*Poaceae*	*Vascular plant*	*Eragrostis amabilis*	*Wight & Arn. (L.)*	*terrestrial*
308	*Plantae*	*Poaceae*	*Vascular plant*	*Eragrostis brownii*	*Nees (Kunth)*	*terrestrial*
309	*Plantae*	*Poaceae*	*Vascular plant*	*Eragrostis cilianensis*	*Janch. (All.)*	*terrestrial*
310	*Plantae*	*Poaceae*	*Vascular plant*	*Eragrostis japonica*	*Trin. (Thunb.)*	*terrestrial*
311	*Plantae*	*Poaceae*	*Vascular plant*	*Eragrostis pilosa*	*P.Beauv. (L.)*	*terrestrial*
312	*Plantae*	*Poaceae*	*Vascular plant*	*Eragrostis unioloides*	*Nees ex Steud. (Retz.)*	*terrestrial*
313	*Plantae*	*Asteraceae*	*Vascular plant*	*Erigeron canadensis*	*L.*	*terrestrial*
314	*Plantae*	*Asteraceae*	*Vascular plant*	*Erigeron floribundus*	*(Kunth) Sch. Bip.*	*terrestrial*
315	*Plantae*	*Poaceae*	*Vascular plant*	*Eriochloa procera*	*C.E.Hubb. (Retz.)*	*terrestrial*
316	*Plantae*	*Myrtaceae*	*Vascular plant*	*Eucalyptus paniculata*	*Sm.*	*terrestrial*
317	*Plantae*	*Fabaceae*	*Vascular plant*	*Falcataria moluccana*	*Barneby & J.W.Grimes (Miq.)*	*terrestrial*
318	*Animalia*	*Felidae*	*Mammal*	*Felis catus*	*Linnaeus, 1758*	*terrestrial*
319	*Plantae*	*Moraceae*	*Vascular plant*	*Ficus benghalensis*	*L.*	*terrestrial*
320	*Plantae*	*Moraceae*	*Vascular plant*	*Ficus benjamina*	*L.*	*terrestrial*
321	*Plantae*	*Cyperaceae*	*Vascular plant*	*Fimbristylis dichotoma*	*Vahl (L.)*	*terrestrial/freshwater*
322	*Plantae*	*Salicaceae*	*Vascular plant*	*Flacourtia rukam*	*Zoll. & Moritzi*	*terrestrial*
323	*Plantae*	*Fabaceae*	*Vascular plant*	*Flemingia strobilifera*	*W.T.Aiton (L.)*	*terrestrial*
324	*Plantae*	*Urticaceae*	*Vascular plant*	*Fleurya interrupta*	*Gaudich.*	*terrestrial*
325	*Plantae*	*Fabaceae*	*Vascular plant*	*Gleditsia triacanthos*	*L.*	*terrestrial*
326	*Plantae*	*Fabaceae*	*Vascular plant*	*Gliricidia sepium*	*Walp. (Jacq.)*	*terrestrial*
327	*Plantae*	*Malvaceae*	*Vascular plant*	*Gossypium barbadense*	*L.*	*terrestrial*
328	*Plantae*	*Proteaceae*	*Vascular plant*	*Grevillea robusta*	*A. Cunn. ex R. Br.*	*terrestrial*
329	*Plantae*	*Zingiberaceae*	*Vascular plant*	*Hedychium coronarium*	*J.König*	*terrestrial*
330	*Plantae*	*Heliconiaceae*	*Vascular plant*	*Heliconia bihai*	*L. (L.)*	*terrestrial*
331	*Plantae*	*Heliconiaceae*	*Vascular plant*	*Heliconia sp.*	*Linnaeus, 1771*	*terrestrial*
332	*Plantae*	*Acanthaceae*	*Vascular plant*	*Hemigraphis reptans*	*T. Anderson ex Hemsl. (G. Forst.)*	*terrestrial*
333	*Plantae*	*Hydrocharitaceae*	*Vascular plant*	*Hydrilla verticillata*	*Royle (L.f.)*	*freshwater*

334	*Plantae*	*Poaceae*	*Vascular plant*	*Hymenachne amplexicaulis*	*Nees (Rudge)*	*terrestrial*
335	*Plantae*	*Hypericaceae*	*Vascular plant*	*Hypericum perforatum*	*L.*	*terrestrial*
336	*Animalia*	*Cyprinidae*	*Ray-finned fish*	*Hypophthalmichthys molitrix*	*(Valenciennes, 1844)*	*freshwater*
337	*Plantae*	*Lamiaceae*	*Vascular plant*	*Hyptis capitata*	*Jacq.*	*terrestrial*
338	*Plantae*	*Fabaceae*	*Vascular plant*	*Indigofera hirsuta*	*L.*	*terrestrial*
339	*Plantae*	*Fabaceae*	*Vascular plant*	*Indigofera suffruticosa*	*Mill.*	*terrestrial*
340	*Plantae*	*Convolvulaceae*	*Vascular plant*	*Ipomoea alba*	*L.*	*terrestrial*
341	*Plantae*	*Convolvulaceae*	*Vascular plant*	*Ipomoea violacea*	*L.*	*terrestrial*
342	*Plantae*	*Poaceae*	*Vascular plant*	*Ischaemum timorense*	*Kunth*	*terrestrial*
343	*Plantae*	*Oleaceae*	*Vascular plant*	*Jasminum sambac*	*Aiton (L.)*	*terrestrial*
344	*Plantae*	*Cyperaceae*	*Vascular plant*	*Kyllinga nemoralis*	*Dandy ex Hutch. & Dalziel (J.R.Forst. & G.Forst.)*	*terrestrial/freshwater*
345	*Plantae*	*Fabaceae*	*Vascular plant*	*Lablab purpureus*	*Sweet (L.)*	*terrestrial*
346	*Plantae*	*Fabaceae*	*Vascular plant*	*Lathyrus tingitanus*	*L.*	*terrestrial*
347	*Plantae*	*Poaceae*	*Vascular plant*	*Leersia hexandra*	*Sw.*	*terrestrial/freshwater*
348	*Plantae*	*Araceae*	*Vascular plant*	*Lemna perpusilla*	*Torr.*	*freshwater*
349	*Plantae*	*Asteraceae*	*Vascular plant*	*Lepidaploa remotiflora*	*H. Rob. (Rich.)*	*terrestrial*
350	*Plantae*	*Poaceae*	*Vascular plant*	*Leptochloa chinensis*	*Nees (L.)*	*terrestrial*
351	*Plantae*	*Fabaceae*	*Vascular plant*	*Leucaena diversifolia*	*Benth. (Schltdl.)*	*terrestrial*
352	*Plantae*	*Alismataceae*	*Vascular plant*	*Limnocharis flava*	*Buchenau (L.)*	*freshwater*
353	*Plantae*	*Linderniaceae*	*Vascular plant*	*Lindernia antipoda*	*Alston (L.)*	*terrestrial*
354	*Plantae*	*Linderniaceae*	*Vascular plant*	*Lindernia crustacea*	*F. Muell. (L.)*	*terrestrial*
355	*Plantae*	*Onagraceae*	*Vascular plant*	*Ludwigia hyssopifolia*	*Exell (G. Don)*	*terrestrial/freshwater*
356	*Plantae*	*Cucurbitaceae*	*Vascular plant*	*Luffa aegyptiaca*	*Schumach. & Thonn.*	*terrestrial*
357	*Animalia*	*Cercopithecidae*	*Mammal*	*Macaca fascicularis*	*(Raffles, 1821)*	*terrestrial*
358	*Plantae*	*Euphorbiaceae*	*Vascular plant*	*Macaranga tanarius*	*Müll.Arg. (L.)*	*terrestrial*
359	*Animalia*	*Pseudococcidae*	*Insect*	*Maconellicoccus hirsutus*	*(Green, 1908)*	*host*
360	*Plantae*	*Fabaceae*	*Vascular plant*	*Macroptilium atropurpureum*	*Urb. (DC.)*	*terrestrial*
361	*Plantae*	*Fabaceae*	*Vascular plant*	*Macroptilium lathyroides*	*Urb. (L.)*	*terrestrial*

362	*Plantae*	*Fabaceae*	*Vascular plant*	*Macrotyloma axillare*	*Verdc. (E.Mey.)*	*terrestrial*
363	*Plantae*	*Marsileaceae*	*Vascular plant*	*Marsilea minuta*	*L.*	*freshwater*
364	*Plantae*	*Fabaceae*	*Vascular plant*	*Medicago sativa*	*L.*	*terrestrial*
365	*Plantae*	*Melastomataceae*	*Vascular plant*	*Melastoma malabathricum*	*L.*	*terrestrial*
366	*Plantae*	*Meliaceae*	*Vascular plant*	*Melia azedarach*	*L.*	*terrestrial*
367	*Plantae*	*Malvaceae*	*Vascular plant*	*Melochia umbellata*	*Stapf (Houtt.)*	*terrestrial*
368	*Plantae*	*Convolvulaceae*	*Vascular plant*	*Merremia hederacea*	*Hallier f. (Burm. f.)*	*terrestrial*
369	*Plantae*	*Convolvulaceae*	*Vascular plant*	*Merremia hirta*	*Merr. (L.)*	*terrestrial*
370	*Plantae*	*Convolvulaceae*	*Vascular plant*	*Merremia umbellata*	*Hallier f. (L.)*	*terrestrial*
371	*Plantae*	*Asteraceae*	*Vascular plant*	*Mikania cordata*	*B.L. Rob. (Burm. f.)*	*terrestrial*
372	*Plantae*	*Asteraceae*	*Vascular plant*	*Mikania scandens*	*Willd. (L.)*	*terrestrial*
373	*Plantae*	*Fabaceae*	*Vascular plant*	*Mucuna pruriens*	*DC. (L.)*	*terrestrial*
374	*Plantae*	*Hydrocharitaceae*	*Vascular plant*	*Najas graminea*	*Delile*	*freshwater*
375	*Plantae*	*Fabaceae*	*Vascular plant*	*Neonotonia wightii*	*J.A.Lackey (Wight & Arn.)*	*terrestrial*
376	*Plantae*	*Apocynaceae*	*Vascular plant*	*Nerium oleander*	*L.*	*terrestrial*
377	*Plantae*	*Nymphaeaceae*	*Vascular plant*	*Nymphaea sp.*	*L.*	*freshwater*
378	*Plantae*	*Arecaceae*	*Vascular plant*	*Nypa fruticans*	*Wurmb*	*brackish*
379	*Plantae*	*Lamiaceae*	*Vascular plant*	*Ocimum basilicum*	*L.*	*terrestrial*
380	*Plantae*	*Lamiaceae*	*Vascular plant*	*Ocimum gratissimum*	*L.*	*terrestrial*
381	*Plantae*	*Rubiaceae*	*Vascular plant*	*Oldenlandia corymbosa*	*L.*	*terrestrial*
382	*Animalia*	*Salmonidae*	*Ray-finned fish*	*Oncorhynchus mykiss*	*(Walbaum, 1792)*	*freshwater/brackish/marine*
383	*Plantae*	*Poaceae*	*Vascular plant*	*Oplismenus burmannii*	*P.Beauv. (Retz.)*	*terrestrial*
384	*Plantae*	*Poaceae*	*Vascular plant*	*Oplismenus compositus*	*P.Beauv. (L.)*	*terrestrial*
385	*Plantae*	*Poaceae*	*Vascular plant*	*Oplismenus hirtellus*	*P.Beauv. (L.)*	*terrestrial*
386	*Plantae*	*Poaceae*	*Vascular plant*	*Oplismenus undulatifolius*	*Roem. & Schult. (Ard.)*	*terrestrial*
387	*Plantae*	*Lamiaceae*	*Vascular plant*	*Orthosiphon aristatus*	*Miq. (Blume)*	*terrestrial*
388	*Plantae*	*Poaceae*	*Vascular plant*	*Oryza rufipogon*	*Griff.*	*terrestrial/freshwater*
389	*Animalia*	*Osphronemidae*	*Ray-finned fish*	*Osphronemus goramy*	*Lacepède, 1801*	*freshwater/brackish*

390	*Animalia*	*Bovidae*	*Mammal*	*Ovis aries*	*Linnaeus, 1758*	*terrestrial*
391	*Plantae*	*Oxalidaceae*	*Vascular plant*	*Oxalis latifolia*	*Kunth*	*terrestrial*
392	*Plantae*	*Rubiaceae*	*Vascular plant*	*Paederia foetida*	*L.*	*terrestrial*
393	*Plantae*	*Achariaceae*	*Vascular plant*	*Pangium edule*	*Reinw.*	*terrestrial*
394	*Animalia*	*Papilionidae*	*Insect*	*Papilio demoleus*	*Linnaeus, 1758*	*terrestrial*
395	*Animalia*	*Formicidae*	*Insect*	*Paratrechina longicornis*	*(Latreille, 1802)*	*terrestrial*
396	*Plantae*	*Poaceae*	*Vascular plant*	*Paspalum dilatatum*	*Poir.*	*terrestrial*
397	*Plantae*	*Poaceae*	*Vascular plant*	*Paspalum vaginatum*	*Sw.*	*terrestrial/freshwater*
398	*Plantae*	*Passifloraceae*	*Vascular plant*	*Passiflora quadrangularis*	*L.*	*terrestrial*
399	*Plantae*	*Passifloraceae*	*Vascular plant*	*Passiflora tarminiana*	*Coppens & V.E. Barney*	*terrestrial*
400	*Plantae*	*Passifloraceae*	*Vascular plant*	*Passiflora tripartita var. mollissima*	*Holm-Niels. & P.M. Jørg. (Kunth)*	*terrestrial*
401	*Plantae*	*Fabaceae*	*Vascular plant*	*Peltophorum pterocarpum*	*K.Heyne (DC.)*	*terrestrial*
402	*Plantae*	*Poaceae*	*Vascular plant*	*Pennisetum clandestinum*	*Hochst. ex Chiov.*	*terrestrial*
403	*Plantae*	*Polygonaceae*	*Vascular plant*	*Persicaria lapathifolia*	*Gray (L.)*	*terrestrial*
404	*Plantae*	*Polygonaceae*	*Vascular plant*	*Persicaria minor*	*Opiz (Huds.)*	*terrestrial*
405	*Plantae*	*Polygonaceae*	*Vascular plant*	*Persicaria nepalensis*	*H. Gross (Meisn.)*	*terrestrial*
406	*Animalia*	*Blenniidae*	*Ray-finned fish*	*Petroscirtes breviceps*	*(Valenciennes, 1836)*	*brackish/marine*
407	*Plantae*	*Fabaceae*	*Vascular plant*	*Phaseolus lunatus*	*L.*	*terrestrial*
408	*Plantae*	*Verbenaceae*	*Vascular plant*	*Phyla nodiflora*	*Greene (L.)*	*terrestrial*
409	*Plantae*	*Phyllanthaceae*	*Vascular plant*	*Phyllanthus amarus*	*Schumach. & Thonn.*	*terrestrial*
410	*Plantae*	*Phyllanthaceae*	*Vascular plant*	*Phyllanthus reticulatus*	*Poir.*	*terrestrial*
411	*Plantae*	*Phyllanthaceae*	*Vascular plant*	*Phyllanthus urinaria*	*L.*	*terrestrial*
412	*Chromista*	*Peronosporaceae*	*Water mold*	*Phytophthora cinnamomi*	*Rands, 1922*	*host*
413	*Animalia*	*Serrasalmidae*	*Ray-finned fish*	*Piaractus brachypomus*	*(Cuvier, 1818)*	*freshwater*
414	*Plantae*	*Pinaceae*	*Vascular plant*	*Pinus patula*	*Schiede ex Schltdl. & Cham.*	*terrestrial*
415	*Plantae*	*Araceae*	*Vascular plant*	*Pistia stratiotes*	*L.*	*freshwater*
416	*Plantae*	*Fabaceae*	*Vascular plant*	*Pithecellobium dulce*	*Benth. (Roxb.)*	*terrestrial*
417	*Plantae*	*Pteridaceae*	*Vascular plant*	*Pityrogramma calomelanos*	*Link (L.)*	*terrestrial*

418	*Plantae*	*Lamiaceae*	*Vascular plant*	*Plectranthus scutellarioides*	*(L.) R.Br.*	*terrestrial*
419	*Plantae*	*Asteraceae*	*Vascular plant*	*Pluchea indica*	*Less. (L.)*	*terrestrial*
420	*Plantae*	*Fabaceae*	*Vascular plant*	*Prosopis juliflora*	*DC. (Sw.)*	*terrestrial*
421	*Plantae*	*Fabaceae*	*Vascular plant*	*Prosopis pallida*	*Kunth (Willd.)*	*terrestrial*
422	*Plantae*	*Myrtaceae*	*Vascular plant*	*Psidium guajava*	*L.*	*terrestrial*
423	*Plantae*	*Pteridaceae*	*Vascular plant*	*Pteris cretica*	*L.*	*terrestrial*
424	*Plantae*	*Fabaceae*	*Vascular plant*	*Pterocarpus indicus*	*Willd.*	*terrestrial*
425	*Plantae*	*Arecaceae*	*Vascular plant*	*Ptychosperma macarthurii*	*H.Wendl. ex Hook.f. (H.Wendl. ex H.J.Veitch)*	*terrestrial*
426	*Plantae*	*Fabaceae*	*Vascular plant*	*Pueraria montana var. lobata*	*Sanjappa & Pradeep (Willd.)*	*terrestrial*
427	*Animalia*	*Typhlopidae*	*Reptile*	*Ramphotyphlops braminus*	*Daudin, 1803*	*terrestrial*
428	*Animalia*	*Bufonidae*	*Amphibian*	*Rhinella marina*	*(Linnaeus, 1758)*	*terrestrial/freshwater*
429	*Animalia*	*Ixodidae*	*Arachnid*	*Rhipicephalus microplus*	*Canestrini, 1888*	*host*
430	*Animalia*	*Dryophthoridae*	*Insect*	*Rhynchophorus ferrugineus*	*Herbst*	*terrestrial*
431	*Plantae*	*Poaceae*	*Vascular plant*	*Rottboellia cochinchinensis*	*Clayton (Lour.)*	*terrestrial*
432	*Plantae*	*Rosaceae*	*Vascular plant*	*Rubus moluccanus*	*L.*	*terrestrial*
433	*Plantae*	*Rosaceae*	*Vascular plant*	*Rubus rosifolius*	*Sm.*	*terrestrial*
434	*Plantae*	*Poaceae*	*Vascular plant*	*Saccharum spontaneum*	*L.*	*terrestrial*
435	*Animalia*	*Salmonidae*	*Ray-finned fish*	*Salmo trutta*	*Linnaeus, 1758*	*freshwater/brackish/marine*
436	*Animalia*	*Salmonidae*	*Ray-finned fish*	*Salmo trutta*	*Linnaeus, 1758*	*freshwater/brackish/marine*
437	*Animalia*	*Salmonidae*	*Ray-finned fish*	*Salvelinus fontinalis*	*(Mitchill, 1814)*	*freshwater/brackish/marine*
438	*Plantae*	*Goodeniaceae*	*Vascular plant*	*Scaevola taccada*	*Roxb. (Gaertn.)*	*terrestrial*
439	*Plantae*	*Fabaceae*	*Vascular plant*	*Senna bicapsularis*	*Roxb. (L.)*	*terrestrial*
440	*Plantae*	*Fabaceae*	*Vascular plant*	*Senna hirsuta*	*H.S.Irwin & Barneby (L.)*	*terrestrial*
441	*Plantae*	*Fabaceae*	*Vascular plant*	*Senna obtusifolia*	*H.S.Irwin & Barneby (L.)*	*terrestrial*
442	*Plantae*	*Fabaceae*	*Vascular plant*	*Senna siamea*	*H.S.Irwin & Barneby (Lam.)*	*terrestrial*
443	*Plantae*	*Fabaceae*	*Vascular plant*	*Senna spectabilis*	*H.S.Irwin & Barneby (DC.)*	*terrestrial*
444	*Plantae*	*Fabaceae*	*Vascular plant*	*Senna surattensis*	*H.S.Irwin & Barneby (Burm. f.)*	*terrestrial*

445	*Plantae*	*Fabaceae*	*Vascular plant*	*Sesbania grandiflora*	*Pers. (L.)*	*terrestrial*
446	*Plantae*	*Poaceae*	*Vascular plant*	*Setaria italica*	*P.Beauv. (L.)*	*terrestrial*
447	*Plantae*	*Poaceae*	*Vascular plant*	*Setaria palmifolia*	*(J.Koenig) Stapf*	*terrestrial*
448	*Plantae*	*Poaceae*	*Vascular plant*	*Sorghum halapense*	*Pers. (L.)*	*terrestrial*
449	*Plantae*	*Poaceae*	*Vascular plant*	*Sporobolus elongatus*	*R.Br.*	*terrestrial*
450	*Plantae*	*Orobanchaceae*	*Vascular plant*	*Striga asiatica*	*Kuntze (L.)*	*terrestrial*
451	*Plantae*	*Fabaceae*	*Vascular plant*	*Stylosanthes guianensis*	*Sw. (Aubl.)*	*terrestrial*
452	*Animalia*	*Suidae*	*Mammal*	*Sus scrofa*	*Linnaeus, 1758*	*terrestrial*
453	*Plantae*	*Myrtaceae*	*Vascular plant*	*Syzygium malaccense*	*Merr. & L.M.Perry (L.)*	*terrestrial*
454	*Plantae*	*Malvaceae*	*Vascular plant*	*Talipariti tiliaceum*	*Fryxell (L.)*	*terrestrial*
455	*Plantae*	*Fabaceae*	*Vascular plant*	*Tephrosia candida*	*DC. (Roxb.)*	*terrestrial*
456	*Plantae*	*Fabaceae*	*Vascular plant*	*Tephrosia noctiflora*	*Baker*	*terrestrial*
457	*Plantae*	*Combretaceae*	*Vascular plant*	*Terminalia catappa*	*L.*	*terrestrial*
458	*Plantae*	*Poaceae*	*Vascular plant*	*Themeda arguens*	*Hack. (L.)*	*terrestrial*
459	*Animalia*	*Cichlidae*	*Ray-finned fish*	*Tilapia rendalli*	*(Boulenger, 1897)*	*freshwater/brackish*
460	*Plantae*	*Rubiaceae*	*Vascular plant*	*Timonius timon*	*Merr. (Spreng.)*	*terrestrial*
461	*Plantae*	*Commelinaceae*	*Vascular plant*	*Tradescantia spathacea*	*Sw.*	*terrestrial*
462	*Plantae*	*Cannabaceae*	*Vascular plant*	*Trema orientalis*	*Blume (L.)*	*terrestrial*
463	*Plantae*	*Zygophyllaceae*	*Vascular plant*	*Tribulus cistoides*	*L.*	*terrestrial*
464	*Plantae*	*Zygophyllaceae*	*Vascular plant*	*Tribulus terrestris*	*L.*	*terrestrial*
465	*Animalia*	*Osphronemidae*	*Ray-finned fish*	*Trichopodus pectoralis*	*Regan, 1910*	*freshwater*
466	*Animalia*	*Osphronemidae*	*Ray-finned fish*	*Trichopodus trichopterus*	*(Pallas, 1770)*	*freshwater*
467	*Plantae*	*Fabaceae*	*Vascular plant*	*Trifolium dubium*	*Sibth.*	*terrestrial*
468	*Plantae*	*Fabaceae*	*Vascular plant*	*Trifolium repens*	*L.*	*terrestrial*
469	*Plantae*	*Rutaceae*	*Vascular plant*	*Triphasia trifolia*	*P. Wilson (Burm. f.)*	*terrestrial*
470	*Plantae*	*Typhaceae*	*Vascular plant*	*Typha latifolia*	*L.*	*terrestrial/freshwater*
471	*Plantae*	*Fabaceae*	*Vascular plant*	*Uraria lagopodioides*	*DC.*	*terrestrial*
472	*Plantae*	*Hydrocharitaceae*	*Vascular plant*	*Vallisneria spiralis*	*L.*	*freshwater*

473	*Plantae*	*Fabaceae*	*Vascular plant*	*Vicia sativa subsp. nigra*	*(L.) Ehrh.*	*terrestrial*
474	*Plantae*	*Asteraceae*	*Vascular plant*	*Xanthium strumarium*	*L.*	*terrestrial*
475	*Bacteria*	*Xanthomonadaceae*	*Bacterium*	*Xanthomonas axonopodis pv. citri*		*host*
476	*Animalia*	*Poeciliidae*	*Ray-finned fish*	*Xiphophorus hellerii*	*Heckel, 1848*	*freshwater/brackish*
477	*Plantae*	*Rhamnaceae*	*Vascular plant*	*Ziziphus mauritiana*	*Lam.*	*terrestrial*
478	*Plantae*	*Poaceae*	*Vascular plant*	*Zoysia matrella*	*Merr. (L.)*	*terrestrial*

Appendix 11. Table 11: Papua New Guinea Health Statistics (www.Trade Economics.com/papua-new-guinea/health

Indicator	Percentage or Quantity
Prevalence of anaemia among women of reproductive age (% of women ages 15-49)	36.6%
Prevalence of anaemia among children (% of children under 5)	48.4%
Prevalence of anaemia among pregnant women	44.8%
Prevalence of anaemia among non-pregnant women of reproductive age (% of women ages 15-49)	36.0%
Number of deaths ages 5-14 years	1673
Cause of death by communicable disease and maternal, prenatal and nutrition conditions (% of total)	34.2%
Cause of death by non-communicable diseases (% of total)	55.9%
Number of infant deaths	9362
Cause of death, by injury (% of total)	9.8%
Number of under-five deaths	11,945
Number of neonatal deaths	5,247
Probability of dying at age 5-14 years (per 1000 children under age 5)	8.6
Adults (age 15+) living with HIV	42,000 persons
AIDS estimated deaths (UNAID estimates)	1100
Female adults with HIV (% of population ages 15+ with HIV)	57.77%
Prevalence of HIV, Total (% of population ages 15-49)	0.9%
Children (0-14) living with HIV	3,400 persons
Prevalence of HIV, female (% ages 15-24)	0.3%
Prevalence of HIV, male (% ages 15-24)	0.2%
Antiretroviral therapy coverage (% of people with advanced HIV infection)	52%
Adults (age 15+) newly infected with HIV	2400
Children (0-14) newly infected with HIV	500
Adults (ages 15+) and children (ages 0-14) newly infected with HIV	2800
Incidence of HIV (% of uninfected population ages 15-49)	0.06%
Children orphaned by HIV/AIDS	15000

Antiretroviral therapy coverage for PMTCT (% of pregnant women living with HIV)	33.00%
Adults (ages 15+) and children (ages 0-14) living with HIV	46,000 persons
Mortality rate, under-5 (per 1000)	54.3
Mortality rate, under-5, female (per 1000 live births)	49.70
Mortality rate, under-5,male (per 1000 live births)	58.90
Mortality from CVD, cancer, diabetes, or CRD between exact ages 30 and 70	36%
Mortality rate; neonatal (per 1000 live births)	23.5
Demand for family planning satisfied by modern methods (% of married women with demand for family planning)	40.6%
Contraceptive prevalence, modern methods (% of women ages 15-49)	24.3%
Contraceptive prevalence (% of women ages 15-49)	32.4%
Women who were first married by age 18 (% of women ages 20-24)	21.3%
Unmet need for contraception (% of married women ages 15-49)	27.4%
Immunisation, Hib3 (% of children ages 12-33 months)	72%
Immunisation, BCG (% of one year old children)	89%
Immunisation, DPT (% of ages 12-23 months)	72%
Immunisation, measles (% of ages 12-23 months)	70%
Immunisation, Pol3 (% of one year old children)	73%
Hospital beds	4.02
Community Health Worker	0.594
Nurses and midwives	0.532
Physicians	0.055
Risks of catastrophic expenditure for surgical care (% of people at risk)	28.8%
Risks of impoverishing expenditure for surgical care (% of people at risk)	55.8%
Notified cases of malaria (per 100,000 people)	162,108
Incidence of malaria (per 1000 population at risk)	122
Number of maternal deaths	460
Lifetime risk of maternal death (1 in :rate varies by country)	120
Lifetime risk of maternal death	0.81%
Prevalence of syphilis (% of women attending antenatal care)	6.7%

Pregnant women receiving prenatal care of at least four visits (% of pregnant women)	54.9%
Pregnant women receiving prenatal care	78.8%
Exclusive breast feeding (% of children under 6 months)	56.1%
ARI treatment (% of children under 5 taken to a health provider)	63.0%
Low-birthweight babies (% of births)	11.0%
Prevalence of underweight, weight for age, female (% of children under 5)	26.7%
Prevalence of underweight, weight for age, male (% of children under 5)	29.0%
Malnutrition prevalence, weight for age (% of children under 5)	27.9%
Malaria cases reported	297787.000
Maternal mortality ratio (modelled estimate per 100,000 live births)	215.000
Maternal mortality ratio (national estimate per 100,000 live births)	730.000
Diarrhoea treatment (% of children under 5 who receives ORS packet)	16.7%
Prevalence of overweight, female (% of female adults)	58.1%
Prevalence of overweight, male (% of male adults)	47.4%
Prevalence of overweight, male (% of adults)	52.9%
Prevalence of overweight, weight for height, female (% of children under 5)	13.0%
Prevalence of overweight, weight for height, male (% of children under 5)	14.4%
Prevalence of overweight (% of children under 5)	13.8%
Prevalence of stunting, height for age, female (% of children under 5)	13.7%
Prevalence of stunting, height for age, male (% of children under 5)	14.9%
Suicide mortality rate (per 100,000 people)	10.3%
Mortality caused by road traffic injury (per 100,000 people)	16.9%
Total alcohol consumption per capita (litres of pure alcohol, projected estimates, 15+ years of age)	3.1
Prevalence of wasting, weight for height, female (% of children under 5)	14%
Prevalence of wasting, weight for height, male (% of children under 5)	15%
Prevalence of wasting (% of children under 5)	14%
Prevalence of severe wasting, weight for height, female (% of children under 5)	7%
Prevalence of severe wasting, weight for height, male (% of children under 5)	6.1%
Prevalence of severe wasting, weight for height (% of children under 5)	6.5%

Tuberculosis treatment success rate (% of registered cases)	74%
Tuberculosis case detection rate (all forms)	79
Incidence of tuberculosis (per 100,000 people)	432
Tuberculosis death rate (per 100,000 people)	44
Newborns protected against tetanus	75%
External resources for health (% of total expenditure on health)	338%
Out-of-pocket health expenditure (% of total expenditure on health)	167%
Out-of-pocket health expenditure (% of private expenditure on health)	894%
Health expenditure per capita	1478 USD
Health expenditure per capita, PPP (Constant 2005 international $)	1752
Health expenditure, private (% of GDP)	12.77%
Health expenditure, public (% of total health expenditure)	1301%
Health expenditure, public (% of government expenditure)	153%
Health expenditure, public (% of GDP)	55.45%
Health expenditure, total (% of government expenditure)	68.22%
Consumption of iodized salt (% of households)	91.9%
Vitamin A supplementation coverage rate (% of children ages 6-59 months)	15%
Adolescent fertility rate (births per 1,000 women ages 15-19)	53.44
Completeness of infant death reporting (% of reported infant deaths to estimated infant deaths)	18.77%
Completeness of total death reporting (% of reported total deaths to estimated total deaths)	13.95%
Mortality rate, adult, female (per 1,000 female adults)	191
Mortality rate, adult, male (per 1,000 male adults)	256
Birth rate, crude	27.61
Death rate, crude	7.11
Mortality rate, infant, female (per 1,000 live births)	38.6
Mortality rate, infant (per 1,000 live births)	42.4
Mortality rate, infant, male (per 1,000 live births)	46.3
Life expectancy at birth, female (years)	68.08 years
Life expectancy at birth, total (years)	65.74 years
Life expectancy at birth, male (years)	63.14 years

Fertility rate, total (births per woman)	3.66
Survival to age 65, female (% of cohort)	68.76%
Survival to age 65, male (% of cohort)	58.8%