Papua New Guinea
Second National Communication

To the

Under the United Nations Framework Convention on Climate Change

April 2014

FOREWORD

Hon. John Pundari

Papua New Guinea (PNG) has been a Party to the United Nations Framework Convention on Climate Change (UNFCCC) since signing it at the UNCED in Rio de Janeiro, Brazil in June 1992. The UNFCCC was ratified by the Government of Papua New Guinea (GoPNG) in April 1993. The signing and ratification of the UNFCCC by the GoPNG is a testimony of our strong commitment to fulfilling our obligations to the Convention. It also signifies the concerns that PNG has about the issues pertaining to the impacts of climate change affecting its people and their survival.

An important pillar of this climate Convention is the commitment, common but differentiated responsibilities, by all Parties to take the necessary steps and measures to reduce greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. This is further strengthened and reflected by the commitment of all Parties to submit to the Conference of the Parties (COP) National Communications under Articles 4 and 12 of the Convention.

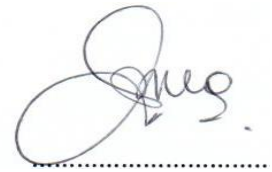
This Second National Communication has been prepared to fulfill PNG's commitment. It contains the necessary information about the country's major sources of GHG emissions and sinks, vulnerability and adaptation options together with the necessary mitigation measures, which PNG has implemented and will implement to adapt to climate change impacts and to further contribute to the global efforts in reducing GHG emissions.

The GoPNG has also gone ahead in embarking on a number of new initiatives aimed at supporting our commitment to the UNFCCC. These include mainstreaming climate change in our current national long-term political vision, plans and strategies, namely the Vision 2050 and the National Strategic Plan 2010-2030. Furthermore, the government's strategy on climate change, the PNG Climate-Compatible Development Strategy, already identifies key priority areas to improve our economic growth whilst reducing greenhouse gas emissions and enhancing climate resilience. Another milestone is the establishment of the Office of Climate Change and Development to facilitate and develop appropriate policies and where required, necessary legislation to address the issues relating to climate change. In addition, PNG is leading a proactive Coalition of Rainforest Nations, engaging in negotiations under the UNFCCC for its 52 member countries especially on REDD+ issues.

Although our GHG emissions as shown in this document are relatively insignificant, we are severely affected by the impacts of climate change resulting from global warming due to increased GHG concentrations in the atmosphere. Faced with this eminent problem, PNG wants to take the lead in meeting its obligation to the UNFCCC and we hope that those country parties whose emissions are much higher will take positive steps and take their responsibilities to do more towards reducing their GHG emissions. The direction PNG is taking is not only for

meeting our commitment to the UNFCCC, but importantly to address the issues relating to the future of our social and economic developments under the prevailing environment of climate change.

As the Minister responsible, I am optimistic that the programmes and projects that will eventuate from this Second National Communication will go a long way in assisting PNG to better manage the effects of climate change more effectively, for the well being of our environment and people of which we hold so dearly.



Honorable John Pundari, CMG, MP
Minister for Environment, Conservation & Climate Change

EXECUTIVE SUMMARY

Introduction

Papua New Guinea (PNG) signed and ratified as a Non-Annex I Party the UN Framework Convention on Climate Change in 1992 and 1994 resp. and the Kyoto Protocol in 1999 resp. 2002. The Initial National Communication was prepared in 2000, then got endorsed by cabinet in late 2001 and officially submitted after the ratification in 2002.

The Office of Climate Change and Development (OCCD) of the Ministry of Environment and Climate Change is the national focal point for the UNFCCC and is responsible for the preparation of this Second National Communication (SNC). OCCD carried out the work in close cooperation with various governmental and non-governmental organizations and the private sector.

This SNC provides information about the national circumstances, the greenhouse gas emissions inventory, the situation with respect to mitigation for, impact of and adaptation to climate change and the plans, programmes and projects in these areas. The preparation of the report has been made possible by funding support from the Global Environment Facility (GEF).

National Circumstances

Geography

Papua New Guinea comprises the eastern half of the island of New Guinea in the South-West Pacific; it includes also 600 smaller islands. The total land area is approx. 460,000 km^2. It is a tectonically very active area. The country is very divers in landscapes, terrestrial and aquatic habitats, flora and fauna. The cultural diversity is equally large with probably over 800 different languages.

PNG is a tropical country. It lies roughly between latitude 2 and 12° S and longitude141 and 156° E. The main climate drivers are the El Niño Southern Oscillation (ENSO) and, to a lesser extent, the position of the South Pacific Convergence Zone (SPCZ). ENSO has less influence in the northern part of the country.

Climate

There is little variation in annual average maximum and minimum temperatures. The country has a wet season from November-April and a dry season form May-Oct. But rainfall seasonality is rather weak except for the region around Port Moresby.

Land use

Most people in PNG are subsistence agriculturalists; they grow crops (or gather them from the forest) like tubers, fruits and nuts. The majority of the cropping is from fallow systems. Fallow systems involve clearing and cutting forest, some burning of felled vegetation, cultivation of crops for a number of years (3-5 years in the lowlands to continuous in the highlands) and then abandon the site to the natural process of regeneration (for a period of up to 25 years or longer).

This system is only viable with low population densities. During the last 40 years significant changes have occurred in food production. New crops and crop varieties have been introduced. A greater emphasis was put on vegetables, potatoes, rice and sugar cane and a number of cash crops for export.

Agriculture has been the economic backbone of PNG and will continue to be so for a long time. Agricultural growth however has been only around 1% the past decade. With a population growth of around 2.7%, it is clear that many rural families have had a negative income growth. Because of higher prices on the international markets for agricultural commodities the situation has improved a little recently.

Forests

PNG has one of the world's largest remaining tropical forests. The extent of change in area and condition is probably larger than officially recorded. From research it was estimated that 15% of the tropical forest has been cleared and 8.8% degraded through logging between 1972 and 2002. In the more accessible forests this can be as high as 1/3. The major drivers are logging in lowland forest and subsistence agriculture all over the country, with minor contributions from forest fires, plantations and mining.

Fisheries

PNG has an extensive fisheries sector ranging from inland river fisheries, through aquaculture to coastal, reef and deep-water fisheries. It has an Exclusive Economic Zone (EEZ) of more than 3 million km^2 with large and diverse marine resources and a fisheries zone of about 2.4 million km^2. Monitoring and control of this are real challenges. Access fees for deep-water fishing give revenues to PNG. Export earnings are important, but the real value lies in artisanal fisheries for a large portion of the population. Reliable data on the value of this are not available.

Biodiversity

The marine area of PNG is part of the coral triangle: the area with the world's highest known marine biodiversity. The coral reefs (40,000 km^2) and associated habitats are home to about 2800 species of fish: 10% of the world's total.

Rainforests cover more than 280,000 km^2 with an additional 70,000 km^2 of evergreen, swamp and mangrove forest. The flora of PNG is poorly known. Estimates for the number of vascular plant species range from 11,000 to 25,000, most of these are endemic to Papua or Papuasia (the region from New Guinea to the Solomon Islands).

PNG harbors a rich array of animals: 150,000 species of insects, 314 species of freshwater fish, 641 species of amphibians and reptiles, 740 species of birds and 276 species of mammals. About 1/3 of all species are endemic to Papua and 70% to Papuasia.

There are still large gaps in the scientific knowledge of PNG's biodiversity. Large areas of the country have yet to be surveyed.

Biodiversity is also a source for subsistence of many people. Local people use 1035 different plant species for various purposes. Wildlife plays an important role in traditional diets as the primary source of protein and fat. In coastal areas a wide variety of seafood is used.

Population

Population development in PNG is rather uncertain because of the lack of reliable (historic) data. The current population is estimated at about 6.6 million. The annual average growth rate is 2.7% (based on 2000 Census data). PNG has a young and fast growing population: 40% is under 15 years. Only 13% lives in urban areas.

Economy and Development

PNG has a relatively small dual economy: formal and informal. The formal economy is dominated by large-scale resource-based activities: mainly mining and oil; this provides government revenue and gives employ to 15% of the work force. The informal economy supports around 85% of the population through subsistence agriculture. Despite the abundance of natural resources (minerals, wood, fish), a large potential for tourism and a significant area of agricultural land, the economic development has stayed short of expectations. The rugged terrain and the high costs of development of infrastructure seriously hamper exploitation.

PNG is struggling to translate the rather good economic development in the past years into development outcomes. The Millennium Development Goals for 2015 remain out of sight. The Government still faces numerous challenges, including providing security to foreign investors, restoring integrity at state institutions and promoting economic efficiency at those institutions. Socio-cultural challenges include an HIV/AIDS epidemic, with the second highest infection rate of East Asia and the Pacific, and chronic law-and-order and land tenure issues.

Energy

The demand for energy will grow strongly with the growing population and the increase in living standards. The production of energy on the other hand will strongly influence the development and economic growth of the country.

The total primary energy supply to the country is estimated at around 1800 kilotons of oil equivalent: 78% oil, 18% gas and 4% other fuels. PNG is a net energy exporting country. The oil production in 2008 was around 38,000 barrels per day. The gas reserves are enormous. Most of this is undeveloped, mainly because of inaccessibility and high costs of exploitation. 72% of crude oil and Liquefied Natural Gas (LNG) was exported.

The total installed electricity production capacity was 582MW in 2010; 39,5% was hydroelectric, 37.3% diesel, 14.1% gas and 9.1% geothermal. Almost 90% of the population has no electricity; only Port Moresby and the RAMU-grid (the cities of Lae, Madang and the Highland region) and some small local areas have electricity. The existing supply system suffers from lack of maintenance.

The potential for renewable energy is enormous. Much is located in remote areas with little demand. The geothermal potential alone (22 TWh) can already cover the electricity needs of the

country, but only a limited amount has been exploited yet. The hydropower potential is even 8x larger (175TWh). Solar energy however is the largest potential source with 1300 – 2500 hours of sunshine per year (4.5 – 8 h/day) and an average of 400-800 W/m^2 of irradiation. Other, less abundant resources are biomass (at least when restricted to crop output and residues); Ocean Thermal energy Conversion (using e.g. the large tidal range near Port Moresby); and wind. No estimates have been produced yet on those potential energy sources.

Greenhouse Gas Inventory

The Greenhouse Gas Inventory (GHGI) has been made, using the IPCC guidelines and default emission factors and activity data from various sources. UNFCCC software was used to harmonize data, calculate emissions and to draw tables. In the process many governmental and non-governmental organizations as well as individual experts took part. Sectoral teams were formed for Energy, Industrial Processes, Agriculture, Land Use Change and Forestry and Waste. They visited the 12 Provinces and followed-up with e-mails and letters.

Energy

Based on data from the Internal Revenue Commission (IRC), emissions from fossil fuel combustion and LPG accounted for over 80% of emissions of CO_2 from the sector. A break down for sectors was not possible because of lack of data and disclosure issues. Total GHG emissions from the combustion amounts to 2436 Gg CO_2-equivalent (only 2000 data available; time series are not possible). A bunker fuels estimate (ships and planes) is 144Gg; these emissions are not part of the national inventory.

Industry

Emissions from the industry sector have been reported from Cement production, the use of Limestone and Dolomite, Metal Production, Paper production and Food & Drink Production. The total emission is about 615 Gg CO_2-equivalent, mostly as NMVOC. It is estimated that the data collection covered less than 50% of the total data.

Agriculture

Emissions have been calculated for Domestic Livestock; Sugar Cane burning; and leaching and emissions from Agricultural soils. Total emissions add up to 2045 Gg CO_2-equivalent, most of it (90%) from burning of savannas and agriculture residues.

Land Use Change and Forestry

In this category, the estimation of GHG emissions and removals from Forest plantations, non-forest trees, logging, fuel wood consumption and other wood use indicates a significant carbon sink. The net result is a more or less constant CO_2-removal in the period 1994 – 2008 of 180 Tg. The GHG emissions are around 13 Tg CO_2-equivalent (mainly as CO_2) and the removals 192Tg. The removal is mainly estimated from the area of forest plantation, natural forest and a limited number of non-forest trees. The real removal, when all trees had been added, would probably be even larger.

IPCC categories do not fit well with the PNG situation. E.g. the Upper and Lower Montane Forests, as distinguished as national forest categories, are not present in the IPCC-method.

Waste

The limited available data for this sector lead to an estimate of CH_4 emissions of 2.9 Gg from solid waste disposal sites, and 6.47 Gg from commercial wastewater and sludge. There are no proper waste management systems in the country. Wastewater management is in its infancy.

Programs with measures to facilitate mitigation of climate change

Strategies and policy

The objective of PNG with respect to mitigation is: to enable economic growth and investment while, at the same time, increase environmental quality and social inclusiveness. This will be achieved through investments in a low-carbon development of infrastructure and technology in combination with effective abatement measures in land use and forestry, energy, transport, waste management, and industry.

To achieve this, PNG has adopted the National Climate Change and Development Strategies (CCDS). The Vision 2050 provides the long-term perspective. This has to lead to a “Smart, Wise, Fair, Healthy and Happy Society”. The main challenge will be the shift from an economy dominated by mining and energy, towards an agriculture, forestry, fisheries, ecotourism and industry orientation by 2050. Many of the targets to achieve environmental sustainability relate to the REDD programme.

For a systematic implementation of the Vision 2050, the PNG Development Strategic Plan 2010-2030 was adopted, with frameworks, targets and more detailed strategies. In the Medium term Development Plan (MTDP), sector targets have been mapped out. This includes an Interim Action Plan (IAP) with a time frame of 6-12 months.

The enabling environment for a low-carbon growth is provided in the Climate Compatible Development Strategy (CCDS). This has a strong focus on REDD+ mechanisms. A National Climate Compatible Development Management Policy is in its final draft phase. It includes intensive stakeholder consultation. In this it is recognized that climate change mitigation and adaptation must be coupled with economic development, to ensure:

- Promotion of economic development through low-carbon growth
- Mitigation through participation in the global REDD+ scheme
- Adaptation to climate change related hazards.

Priority abatement options

Abatement options include:

- Reduced Impact Logging (RIL)
- Secondary Forest Management
- Afforestation / reforestation

- Community REDD+-schemes
- Review of agriculture leases
- Land Use Planning
- Agriculture extension programme
- Commercial plantation on non-forest land

The potential emission reduction adds up to around 107 Tg (or Mt) of CO_2-equivalent for the LULUCF-sector and an additional 25 Tg for the other sectors for the year 2030. This would mean a reduction of 60-80% compared to the BAU-scenario.

The average costs for these measures are 5.6 \$/tCO_2 (2.9 – 7.4).

Implementation Plans for pilots

In PNG a number of activities are already under way by the GoPNG, development partners, civil society organizations and the private sector. They include sectorial and geographical pilots. As examples of the first, the Forest Authority (PNGFA) prepared 5 pilot projects in the official 5 REDD+ pilot provinces to tackle RIL, Afforestation/reforestation, Sustainable Forest Management and Conservation; the areas are: Milne Bay, West New Britain, East Sepik, West Sepik and Eastern Highlands.

Several bilateral and multilateral projects also support the implementation of REDD+ in PNG or are related to the forestry sector. These include:

- PNG-Australia Forest Carbon Partnership, aiming at capacity building of institutions for the implementation of REDD+
- International Forest Carbon Initiative-Australia: support to NGOs and the Asia-Pacific Forestry Skills and Capacity Building Program
- Under negotiation is the development of a DSS to assist PNGFA in forest management
- Australia – PNG Kokoda Initiative: aimed at protection of the Kokoda track and Owen Stanley Ranges and improvement of lives of communities in those regions. Forest carbon might be an income-generating issue. It involves use of GIS and satellites
- The EU is funding the development of inventory and mapping systems. Two other initiatives are under negotiation: a remote sensing project and a project focusing on improvement of productivity and quality in teak plantations
- GEF support for sustainable forest management is under development; it aims at high conservation value areas (both terrestrial and marine) with community-based conservation. GEF support also includes capacity building for sustainable land management
- GIZ supports the development of a Pacific Regional REDD+ Policy Framework, to guide the processes at regional and national scale and facilitate access to financial resources
- A two-year's proposal has been submitted to the ITTO for capacity development in the forestry sector (both in government and at concession level)
- JICA and the Japanese government support the improvement of forest monitoring and data management; it focuses on hard- and software but also includes training of staff at government and research institutions

- UN-REDD: the PNG National REDD programme is a capacity building programme to develop and improve capabilities in the country on MRV
- NGO-initiatives: several NGOs have developed projects for sustainable livelihoods and forest conservation. The experiences will be brought into the REDD+ readiness process. Initiatives in Manus Island (Village REDD+ project by WCS with support from AusAID), West New Britain, Sandaun and Madang are included as well as NORAD support to the Foundation for People and Community Development and The Eco-Forestry Forum's REDD+ Road Show to raise community awareness
- Public-Private-Partnerships have not yet been developed, but are thought to be vital for the implementation of the National Climate Change and Development Policy. They are intended for climate change investments (financing, technology transfer, mitigation and adaptation), implementation measures with stakeholders, capacity building, education and awareness raising.

Impact Assessment and Adaptation to Climate Change

In some of the strategic activities and projects in the section on mitigation, adaptation is also already included. Wherever possible this integration and the mainstreaming into development planning are to be welcomed. But a number of programs and projects deal specifically with adaptation.

Impact and vulnerability assessment

At the global level impact and vulnerability assessments have been made which include a broad overview of the PNG situation. The climate factors impacting on PNG include: a rise in annual average temperatures by 2030 between 0.4 and 1.0 °C, with more hot days and warm nights; an increase in average annual and seasonal rainfall in the course of the century; inconsistent drought projections; may be a decrease in the number of tropical cyclones, but likely higher maximum wind speeds of cyclones with a higher intensity of rainfall around them. Sea level rise will continue; by 2030 this will be between 4 and 15 cm and around the turn of the century 20-60 cm, leading to higher impacts of storms.

Due to its physical and geographical characteristics, many parts of PNG are highly vulnerable to climate change and sea level rise. The majority of socio-economic activities and infrastructure development is in coastal areas or vulnerable areas along rivers or in highlands.

The (potential) impacts can be summarized as follows:

- Increased coastal flooding, mainly on the north shores
- Increased inland flooding in valleys and wetlands, both in lowlands and highlands
- Erratic precipitation with increased risks of landslides
- Malaria could become endemic in higher mountain areas which are up till now malaria-free
- Important climate-sensitive crops (sweet potato, coffee, cocoa) will suffer from changes in climate (temperature and rainfall)

- Increase in sea surface temperature and acidity can severely damage the coral reefs (bleaching).

Adaptation measures: selection methodology

The measures have been reviewed based on the principle of: “avoiding the unmanageable and manage the unavoidable”. From research it has been found that PNG can capture benefits and limit costs to avert 70% of the expected damage through the application of cost-effective measures in selected high-risk areas, sectors and communities (cost-curve-approach: cost-effective when cost-benefit ratio is less than 1).

Adaptation strategies

The overall goal of adaptation is to increase the country’s resilience to climate change; reduce its adverse effects on various sectors and minimize human suffering; and maximize the use of opportunities, which arise from climate change. The overarching strategies are:

- Improvement of capacities of institutions in risk assessment; increase awareness, enhance capacities to deal with risks, promote research etc.
- Mainstreaming climate change into development planning; this is done by creating entry points in priority sectors and at priority levels (adaptation technical working groups); experiences at one place are replicated elsewhere
- Adaptation research to fill gaps in knowledge and ensure adaptability
- Target vulnerable areas, sectors, ecosystems, infrastructure, and groups in society and make them resilient.

The first two points are the first pillars in the long-term strategy. A third pillar is to develop financing instruments, e.g. by creating a multi-donor trust fund for climate change adaptation and compatible development.

Strategic priorities

From the process of mainstreaming with the priority sectors and areas, a number of strategic priorities arose:

- **Coastal flooding**: potential measures include infrastructure (dikes, levees, sea walls, breakwaters, beach nourishment, elevating structures, reef revival, mangrove restoration and expansion etc.), technology (e.g. adaptation in homes, storm / flood detection system), systemic (e.g. improve disaster response, Integrated Coastal Zone Management) and financial ones (e.g. insurance schemes); various locations have been selected.
- **Inland flooding**: potential measures include: infrastructure (dikes, levees, flood storage, river training, diversion, drainage), technology (flood monitoring network, including private and local information), systemic (flood warning, awareness, local reporting, monitoring of buffer zones, capacity building), and financial (mobilization of structural funds, insurance schemes); the city of Lae is the prioritized location as well as locations along flood prone rivers (e.g. Sepik, Bumbu).

- **Drinking water and sanitation**: this is already a priority area for policy, but because of climate change (and the flooding risks that come with it) the challenges are only increasing. The focus will be on (a) 19 provincial towns where the PNG Water board will upgrade or develop sustainable, reliable and environmentally friendly water and sanitation services for population, industries and institutions; (b) rural district towns, where the PNG Water board will lead in developing the services to a level of 65% in 2015; and (c) rural communities, where the PNG Water board will support the government agencies and stakeholders with research and technology development as well as capacity building.
- **Agriculture**: the challenges come mostly from erratic rainfall. The potential measures come from community best practices and additional expertise from NARI. The measures are distinguished in:
    - Short-term responses are **(a) pro-active (pre-drought**): like soil moisture preservation and reduction of evapotranspiration, creating reserves of planting material, frost protection, planting in swamp and marsh areas **(b) reactive (mid drought)**: storage and weevil control of tubers using indigenous methods, which have proven to be effective; managing livestock during droughts; collecting manures to use in gardens; water management (digging additional wells, protection from contamination; drip irrigation; reuse water; rainwater harvesting; fire prevention); ready access to sago; weevil management and **(c) post drought**: mainly use of early maturing varieties of crops (sweet potato and may be other crops like maize and bean, which can make use of the extra available nitrogen in the soil after a drought).
    - Long-tem responses include the selection of drought-tolerant varieties of sweet potato, banana and cassava; storage and preparation of rice, maize, beans, corn and some legumes; innovative water management and conservation strategies and systems.
    - Extension services and information dissemination: establishing Resource Centers, promote drought-coping strategies and arrange for good coordination (horizontally and vertically) between institutions and agencies.
- **Health sector**: next to the drinking water and sanitation related issues, malaria is the main challenge for this sector. From a long list of infrastructure, technological, systemic and financial measures, the following measures have been selected, based on cost-effectiveness:
    - Insecticide-treated bed net distribution (LLIN)
    - Artemisinin Based Therapy (ACT) as first-line treatment
    - Indoor Residual Spraying (IRS)
    - Malaria prevention for pregnant women
    - Introduction of mosquito-larvae eating fish in fish ponds
    - Building wells and reducing mosquito breeding grounds
    - Building additional healthcare centers
    - Introduction of bio-pesticides (plants)
    - Monitoring of mosquito resistance to treatment
    - Planting of trees to create shade.

The measures under the first 3 bullets are expected to protect over 3 million people (50%) at a cost of around 400 m$. If no actions are taken the costs from malaria would rise to 50 m$ a year in 2030.

The government started a PNG Malaria Control Strategic Plan with funding support from GFATM, Rotarians Against Malaria and others. The programme is to strengthen the capacity at organizations, officers and the general population and to provide them with adequate information; to improve diagnosis, treatment, control and prevention and to supply the people with LLIN and sufficient healthcare.

- **Forestry**: conservation of Intact Forest Landscapes, National Parks and Wildlife Management Areas is key to biodiversity conservation in PNG and serves to cope with climate change challenges as well. Next to strengthening the protection of these areas, especially community participation in forest management (including pest control) will be enhanced. Providing tangible returns through carbon mechanisms will be the key.
- **Fisheries**: strong conservation measures are required to remove most of the stresses to marine systems and allow them to cope with the changing climate. This requires an ecosystem approach with a focus on upstream control of human activities. For many fish species the creation (or enlargement) of marine reserves will be necessary. Financial mechanisms will have to come from global cooperation.
- **Biodiversity**: many measures in this section have been discussed already under the earlier topics (forests and marine systems in particular). Some points deserve additional attention: **coral reef** restoration and preservation, which requires a cultural shift (fishing techniques) and investment in infrastructure (sanitation and industrial waste water management); coastal site planning and **mangrove** management; **sand dunes and sandy beaches**, where especially the protection of turtles and their eggs need community based actions.

Other issues relevant for the achievement of the objectives of the convention

Some crosscutting issues are important to achieve the objectives of the Convention.

Research and Systematic Observation

The National Weather Service, in operation since 1975, operates and coordinates a number of weather- and climate-related observation networks: the National Weather Service Surface network, the National Weather Service Upper Air Network, the Climate Network Volunteer, the Radar network and the Rainfall Network; it participates in the Global Climate Observation System and the Global Upper Air Network.

From this the rainfall and temperature data, the ENSO diagnosis, the occurrence and pathways of tropical cyclones, the sea level rise and other climate-related phenomena are reported for analysis and policy advice.

Technology Transfer

At the moment transfer of environmentally friendly technologies is not a structural activity in PNG. A Nationally Designated Entity can help in harmonizing this and improve the access to those technologies. Several important projects however are already underway in this category. They include several CDM-hydropower, oil and palm oil projects. Also in the area of MRV for the National GHGI and especially for REDD+, a number of projects is supported by international organizations. In the area of adaptation bilateral and multilateral / international cooperation leads already to the application of technology from other countries in PNG.

Capacity Building

Under the various topics before (including the Technology Transfer activities which most of the time have a capacity development component), capacity building has already been included. Activities at the moment arise from projects or imminent needs. A more systematic needs assessment might lead to more efficient capacity building. After an assessment at the various governmental institutions and levels and at NGOs and educational institutions, a capacity development programme can be developed, including:

- Preparing manuals or guidance documents for:
    - writing CC-strategies and preparing CC-plans
    - mainstreaming CC into development planning
    - preparing CC-scenarios and applying them at national and provincial level
- Trainings for staff at relevant institutions (ministries, provinces) in using the guidance documents
- Training on technical issues and the use of models in developing CC-plans
- Developing course material and educational programmes at different levels (primary, secondary, high school, university)
- Training of trainers
- Making available relevant background material, models and data
- Creating enabling environments for research and policy advice on climate change (including hardware and software and the institutional arrangements)

A programme like that can be part of the next stage of the Climate Change Plan. Financing such a programme will require funding support from international organizations.

Information and networking

Access to Internet facilities is rapidly evolving in PNG. Most of the research organizations have their data electronically stored. There is however a need for a centralized storing, compiling and disseminating facility for climate-related data and information.

Education, Training and Public Awareness

Basic elements of climate science are part of the natural sciences in Primary and Secondary education. For higher and academic education dedicated climate-related programmes still have to be developed. This will have to include the production of teaching material / resource book(s).

Interagency Trainings have been developed already under OCCD-coordination in the Agriculture, Forestry, Fisheries and Health sectors.

Most activities to raise or improve public awareness of the issue of climate change and the activities going on in this area are coordinated by the OCCD. Intensive consultation took place with stakeholders, including government, civil society, private sector and local communities in 16 provinces.

OCCD also developed a radio drama (10 episodes) on climate change topics; it held a cartoon competition and conducted a workshop for university students to increase awareness on climate change topics.

Constraints and Gaps

PNG has still a long way to go on the path to full implementation of the Convention. Several limitations will have to be overcome.

Reporting process

Reporting now is at a project basis. The basic capacity for a more continuous process has to be set-up. The intended Climate Compatible Development Center might help in this.

National Greenhouse Gas Inventory

Basic information for this is scattered and often not accessible. A legal framework and a Designated Agency are necessary tools. When country-specific emission factors are needed (as in forestry), dedicated research has to be strengthened.

Impact and adaptation

Assessment of impacts is available at a rather abstract level. Because of the large variety in landscapes in the country and the inaccessibility of large areas, a more detailed assessment will remain a major challenge. Regionalization of climate scenarios is also a challenge for the same reasons. The basis for impact assessments lies in detailed information about the present situation and the development over time. Systematic observation needs strengthening and probably more observation points, next to more intensive use of satellite data and modeling techniques.

Mitigation measures

Important steps have been taken already especially under the REDD+ programme. Large-scale application of the lessons learned will require PPP-constructions, capacity development and more awareness raising activities to involve communities and the general population in the programme.

In the energy and industry sector the need for improved technology will require more intensive international cooperation. There is an abundance of sources for renewable energy. The use of these requires strong governmental efforts, access to international investment opportunities and technologies, and the participation of the private sector.

Technology development and transfer

It is necessary to assess the level of technological needs, including endogenous demand, in mitigation and adaptation at the ministerial, agency and provincial levels. Technical experts and professionals need to be trained in order to facilitate the prompt and successful adoption of new technologies. It is important to seize opportunities to steer development towards a low-carbon economy through the implementation of climate change projects, particularly CDM projects.

Capacity Building, education, training and awareness raising

Many initiatives exist already in this area. A clear programme for capacity building and training, based on a thorough need assessment however is still missing. The same holds for a higher education programme.

Awareness of the importance of a healthy natural environment is part of the national culture of PNG. Additional efforts are needed to include climate change in this. OCCD already has taken steps to raise awareness with a broad range of stakeholders. This needs to be continued.

Finances

PNG has a lack of funding for most of the activities, which need to be carried out to respond to climate change. The government budget has only limited possibilities. PNG will lean heavily on funding by international organizations and bi- and multilateral cooperation. A solid plan to deal with climate change will help in accessing those opportunities.

Enabling environment

Implementation of compatible development management policy and the Framework Convention is not just a matter of money. It also requires a legal and regulatory framework. Especially when it comes to monitor, reporting, verification, compliance checking and, when necessary, enforcing, at present the basis is still very narrow.

Conclusions

The implementation of the Convention in PNG shows substantial gaps. PNG is confronted with many constraints due to its development status and its natural situation.

The most important gaps stem from the lack of sufficient capacity (both in quantity and in quality) at all levels of government, in research, and with stakeholders. Capacity is not only knowledge, but also instrumentation for research, monitoring and reporting on climate change.

To solve this, the second most important gap is finances. Being a developing country means that PNG can only afford to spend limited budget to capacity development and to climate change projects in general. Access to international funds is crucial to achieve progress.

Institutional arrangements to include climate change into development policy still need improvement.

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ACRONMYS

AAAS	American Association for the Advancement of Science
ABG	Autonomous Bougainville Government
ACNARS	Australian Contribution to a National Agricultural Research System
ACT	Artemisinin based Combination Therapy
ADB	Asian Development Bank
AF	Adaptation Fund
ALOS	Advanced Land Observation Satellite
ALU	Agriculture and Land Use
APEC	Asia-Pacific Economic Cooperation
ARD	Association for Rural Development
AusAID	Australian Agency for International Development
AWS	Automatic Weather Station
BAU	Business as Usual
BSDS	Benefit Sharing and Distribution System
CB	Cost-Benefit
CBD	Convention on Biological Diversity
CBO	Community-Based Organization
CC	Climate Change
CCAP	Coastal Community Adaptation Project
CCDC	Climate Compatible Development Center
CCDS	Climate Compatible Development Strategy
CCRI	Cocoa and Coconut Research Institute
CDC	Center for Disease Control and Prevention
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
COP	Conference of Parties
CSIRO	Commonwealth Scientific and Industrial Research Organization
CTCN	Climate Technology Centre & Network
CTI	Coral Triangle Initiative
DAL	Department of Agriculture and Livestock
DDT	Dichlorodiphenyltrichloroethane
DEC	Department of Environment and Conservation
DLPP	Department of Lands and Physical Planning
DNA	Designated National Authority
DNE	Designated National Entity
DOS	Development Option Study
DoW	Department of Works
DPE	Department of Petroleum and Energy
DSP	Development Strategic Plan
DSS	Decision Support System
ECA	Economics of Climate Adaptation
ED-DPE	Energy Division DPE
EEZ	Exclusive Economic Zone
EFF	Eco-Forestry Forum
EIP	Electricity Industry Policy
ELCOM	PNG Electricity Commission
ENSO	El Niño-Southern Oscillation
EPA	Environmental Protection Agency
ESEG	Environmentally Sustainable Economic Growth
FAO	Food and Agriculture Organization
FAO	Food and Agriculture Organization of the United Nations
FCCFA	Forest and Climate Change Framework for Action
FCPF	Forest Carbon Partnership Facility
FLEGT	Forest Law Enforcement, Governance and Trade
FPCD	Foundation for People and Community Development
FPIC	Free, Prior and Informed Consent
FRI	Forest Research Institute
FTE	Full-time Equivalent
GCOS	Global Climate Observation System
GEF	Global Environment Facility
GEF	Global Environment facility

GEF-STAR	GEF System of Transparent Allocation of Resources
GFATM	Global Fund to fight Aids, Tuberculosis and Malaria
GFDRR	Global Fund for Disaster Risk Reduction
Gg	Gigagram
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
GIS	Geographical Information System
GIZ	Gesellschaft für Internationale Zusamenarbeit
GoPNG	Government of Papua New Guinea
GPS	Global Positioning System
GUAN	Global Upper-Air Network
GWh	Gigawatt hours
IAP	Interim Action Plan
ICAD	Integrated Conservation and Development
ICCC	Independent Consumer and Competition Commission
ICT	Information Communication Technology
IFCI	International Forest Carbon Initiative
IFL	Intact Forest Landscape
IIED	International Institute for Environment and Development
IMR	Institute of Medical Research
INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
IRC	Internal Revenue Commission
IRS	Indoor Residual Spraying
ITTO	International Tropical Timber Organization
JICA	Japanese International Cooperation Agency
LDS	Lutheran Development Services
LIDAR	Light Detection and Ranging
LLG	Local Level Government
LLIN	Long Lasting Insecticide Treated Bed Net
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LUCF	Land Use Change and Forestry
LULUCF	Land Use, Land Use Change and Forestry
MARSH	Mangrove Rehabilitation for Sustainably Managed Healthy Forest
MEA	Multiannual Environmental Agreement
MRA	Mineral Resources Authority
MRV	Measuring Reporting and Verification
MTDP	Medium Term Development Plan
NADP	National Agriculture Development Plan
NAMA	Nationally Appropriate Mitigation Action
NAP	National Action Plan
NARI	National Agriculture Research Institution
NBSAP	National Biodiversity Strategic Action Plan
NCCDMP	National Climate Compatible Development Master Plan
NCCP	National Climate Change Compatible Policy
NCD	National Capital District
NCDC	National Capital District Commission
NDC	National Disaster Center
NDE	National Designated Entity
NDoH	National Department of Health
NEC	National Executive Council
NFA	National Fisheries Authority
NFI	National Forest Inventory
NGO	Non Governmental Organization
NISIT	National Institute of Standards and Industrial Technology
NMVOC	Non-Methane Volatile Organic Compound
NORAD	Norwegian Agency for Development Cooperation
NP	National Park
NPA	National Protected Area
NRI	National Research Institute
NWS	National Weather Service
OPRA	Oil Palm Research Association

OTEC	Ocean Thermal Energy Conversion
PACCS AP	Pacific Australian Climate Change Science and Adaptation Planning Program
PEEP1	Promoting Energy Efficiency in the Pacific, phase 1
PES	Payment for Ecological Services
PIC	Pacific Island Countries
PGK	PNG Kina (national currency)
PIREP	Pacific Islands Renewable Energy Project
PMV	Public Motor Vehicle
PNG	Papua New Guinea
PNGBD	PNG Business Directory
PNGCCAP	Papua New Guinea Climate Change Assistance Project
PNGFA	PNG Forest Authority
PNGFRI	Papua New Guinea Forest Research Institute
PNGNFA	Papua New Guinea National Forest Authority
PNGNWS	Papua New Guinea National Weather Service
PNGRIS	Papua New Guinea Resource Information System
PPCR	Pilot Program on Climate Resilience
PPL	PNG Power Limited
PPP	Public Private Partnership
PV	Photo Voltaic
REDD+	Reducing Emissions through combating Deforestation and Forest Degradation (including role of conservation, sustainable management and enhancement of carbon stocks
REL	Reference Emissions Level
RIL	Reduced Impact Logging
RL	Reference Level
R-PP	Readiness Preparation Proposal
SABL	Special Agricultural Business Lease
SGS	Société Générale de Surveillance
SOI	Southern Oscillation Index
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
SPCZ	South Pacific Convergence Zone
SPREP	South Pacific Regional Environment Programme
TAP	Technology Action Plan
TEC	Technology Executive Committee
TNA	Technology Needs Assessment
TT	Technology Transfer
TWG	Technical Working Group
TWP	Tropical Western Pacific
UNCCD	United Nations Convention on Combating Desertification and Land Degradation
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations education, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention Climate Change
UNRE	University of Natural Resources and Environment
UOT	University of Technology
UPNG	University of Papua New Guinea
UPNGRSC	UPNG Remote Sensing Centre
V&A	Vulnerability and Adaptation
WB	World Bank
WCS	Wildlife Conservation Society
WMA	Wildlife Management Area
WMO	World Meteorological Organization
WPWP	Western Pacific Warm Pool
WRI	World Resources Institute

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INTRODUCTION

a) Requirements/Obligations under the UNFCCC

Papua New Guinea, as a Non-Annex I Party to the United Nations Framework Convention on Climate Change, (UNFCCC or Convention) since 1992, and its Kyoto Protocol since 1999, needs to meet this global commitment to collectively fight the impact of climate change. Each Party to the UNFCCC needs to vigorously plan and implement adaptive and mitigation measures and report back to the Convention on these national actions. As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), Papua New Guinea (PNG) is required to prepare and submit to the Conference of the Parties (COP) to the UNFCCC, a national communication, in accordance with Article 12, paragraph 1 of the Convention. In this context, PNG prepared its initial national communication (INC) in 2000, which was formally endorsed by cabinet in late 2001 and submitted in 2002, after ratifying the Convention on March 16, 1993 and the Kyoto Protocol on March 28, 2002.

Since the submission of the INC in 2002, the Government of Papua New Guinea (GOPNG) has also prepared reports relating to other multilateral environmental agreements (MEA), most notably the National Biodiversity Strategic Action Plan (NBSAP) under the United Nations Convention on Biological Diversity (CBD) and the National Action Plan (NAP) under the United Nations Convention on Combating Desertification and Land Degradation (UNCCD).

b) Scope of the national communication

This report is a Second National Communication (SNC) under the UNFCCC, prepared by the GoPNG, in fulfillment of its obligations under the Convention. The SNC provides information on the national circumstances, national greenhouse gas inventory, assessment of mitigation policies and measures, assessment of impacts, vulnerability and adaptation to climate change, and other information relating to research and systematic observation, technology transfer, education, training and public awareness, capacity building, and information and networking. The SNC also provides information on how the GoPNG is currently addressing issues and concerns relating to adverse impacts of climate change as well as the emerging needs and priorities for adaptation and mitigation, that would require further human, technical and financial support in managing climate change in the country.

The scope of information includes the national greenhouse gas inventory, mitigation assessment, and vulnerability and adaptation assessment. The SNC was prepared with funding support from the Global Environment Facility (GEF), as an operating entity of the financial mechanism of the Convention, through the United Nations Development Programme (UNDP), as an implementing agency of the GEF. The implementation and preparation of the SNC was executed through the Department of Environment and Conservation, in close cooperation with the various governmental, non-governmental and private sector organizations.

1. NATIONAL CIRCUMSTANCES

1.1 Geographical Characteristics

Papua New Guinea (Fig. 1.1) comprises the eastern half of the island of New Guinea. It is a geomorphologically diverse country in the South-West Pacific Ocean and contains four large provincial islands and over 600 smaller islands. The total land area of the country is 459,854 km2 (Saunders 1993), with enormous social, cultural, and biophysical diversity. The country is located on the boundary between the northward moving Australian continental plate, and the northwest moving Pacific plate, which makes it one of the tectonically active areas in the world. The main islands are characterized by block-faulted, folded, and mountainous interiors. The highest peak is Mt. Wilhelm in the Simbu Province, which rises to 4,510 meters above sea level. The deltaic flood plains provide the largest areas of lowlands especially along the south coast, where freshwater swamplands are common.

Figure 1. Map of Papua New Guinea

Terrestrial habitats range from extensive lowlands with rainforest, savanna, grassland, and freshwater swamps to upland montane rainforests and alpine grassland (Table 1). The marine and aquatic environments appear equally diverse. Papua New Guinea's native flora comprise an estimated 15,000 to 20,000 species of vascular plants, including approximately 2,000 species of orchids, and more than 2,000 species of pteridophytes (ferns and fern allies; Johns 1993).

Papua New Guinea culture is richly varied and people have lived in the lowlands for at least 40,000 years (Groube et al. 1986) and in the highlands for more than 24,000 years (White and O'Connell 1982). More than 750 different linguistic groups have been identified, with a variety of cultural responses to the environment. Great linguistic diversity in PNG is unmatched elsewhere and it has been suggested that the number of languages used is likely to be over 800.

1.2 History

The making of history in Papua New Guinea has always been associated with its agriculture. Over 250 food-plant species have been recorded and 43 of these have been always cultivated, 51 are cultivated and harvested as wild resources, and 157 are gathered from forests, savannas, and grasslands (Paijmans 1976). Most people are subsistence agriculturalists growing mainly tuber crops and planting some fruit and nut trees.

The majority of PNG agriculture systems are present fallow systems, or systems, which have evolved from forest fallow systems. Fallow systems involve clearing and cutting forest, some burning of felled vegetation, cultivation of crops, and abandonment of the site to natural processes of regeneration. The period of cropping ranges from three to five years in the lowlands to continuous cultivation in some highland areas. The fallow period ranges from no fallow to about 25 years' fallow; although in some areas the fallow period is up to 50 years.

Despite many reports to the contrary (mainly from South-East Asia) tropical forest fallow systems can be stable. Fallow systems are environmentally friendly because a tree cover over often erodible and naturally poor soils is maintained. Stable shifting agriculture systems do not destroy rainforest by cutting and burning trees; they cycle through secondary forest. Shifting cultivators avoid using previously uncultivated forests, if possible, because of the difficulties and dangers of felling the trees, and because generally secondary forest contains more useful plants and animals than primary rainforest.

Latitudinal differences in solar energy, temperature, rainfall, and soil nutrients are some of the ecological constraints on agricultural systems (Bayliss-Smith and Feachem 1977). Often a farmer is unable to directly control the constraints of solar radiation, temperature, and rainfall but is able to adapt to changes brought about by these constraints. Papua New Guinea agriculturalists have been able to adapt to changes brought about by climate change and the socio-economic conditions, so that agriculture has remained the mainstay of rural societies for over 3,000 years. Some of these responses and mitigating factors have resulted in the development of most elaborate farming techniques, such as mounding, terracing, mulching, ditching, draining, and irrigation systems which are now considered to have developed independently of the major agricultural areas of the world. Some writers ascribe development of such techniques to the introduction of new crops, population growth, and increased demands for social production (Brookfield 1972) and a combination of all of these factors. This technological change / innovation were a result of agricultural intensification that is now evident in Papua New Guinea.

Most land-use observations before independence in 1975 were those derived from other investigations such as gold exploration and cope-plantation establishment. However, more systematic investigations of the geology and landscape, as well as land evaluation investigations were carried out by the Commonwealth Scientific and Industrial Research Organization (CSIRO), Division of Land Use Research. The methodology for land-evaluation investigations was based on the land systems survey (Christian and Stewart 1953). A land system is defined as a unique assemblage of the features of land, such as soils, vegetation, landforms, rainfall, land use, and population. These surveys were designed mainly to assess the suitability of land for mechanized agriculture and pastoralism; and were based on air-photo

interpretation and field checking, which was limited to a representative selection of each area of the country investigated.

A total of 15 land systems were surveyed covering about 50 per cent of the total land area of the country. Land use was divided into three broad categories, subsistence cultivation, cash cropping (indigenous), and plantation. Most people in each land system were involved in subsistence cultivation. Cash cropping of mainly tree crops, such as coconuts, cocoa, coffee, and some rice, was practiced by the indigenous population in both lowland and highland areas, although in the latter some pyrethrum (*Pyrethrum cinerariifolium*), passion fruit, tea, and some livestock were introduced. Plantations were owned and managed by the non-indigenous population in both lowland and highland areas.

The average cultivated area and land under use (20 per cent and 24 per cent, respectively) for the southern region is lower than the highland region (40 per cent and 43 per cent, respectively), while the northwestern region has an average of 34 per cent cultivated and 42 per cent total land under use. The land area under some use in the island region is somewhat higher, with an average of 47 per cent cultivated land and 48 per cent land under some use. Thus, the total land area under any form of use is much greater than it is in the southern, northwestern, and highland regions. The total cultivated land is 25 percent (Source: Saunders 1993). The total land area, brought into commercial production (i.e. plantations) by non-indigenous people, ranged from 6,400 ha in East Sepik for coconut and cocoa to over 148,000 ha for coffee and pastures in the highlands. These figures may have changed since then, due to the increase in population accompanied by greater economic and social demands.

Owing to the incompleteness of the population figures between 1964 and 1976, it was difficult to obtain figures for the whole country. Even if in all land-system surveys land-use intensity was not clear, it was defined for some areas, such as the highlands and the lower parts of the Sepik and Western provinces. Where sweet potato (*Ipomoea batatas*) was dominant in densely populated areas of the highlands, intensive, almost permanent short-fallow cultivation was evident. McAlpine (1970) suggested that the length of cultivation and fallow cycles differed greatly in the highland areas and was probably related to land pressure, environment, and cultivation techniques, although it was mentioned that no field measurements were made in support of this suggestion.

A number of major events during the pre-independence period saw an increase in the introduction of new crop varieties and emphasis on animal husbandry. The first major food and nutrition survey was conducted during 1947 and resulted in the introduction of improved pig and poultry strains and several major new projects were commenced. By 1951, the emphasis on food crops was shifted to plantation crops (McKillop 1976), but the distribution of seed of introduced vegetable crops continued.

Plantation agriculture commenced much earlier than the introduction of new food-crop varieties. The first legislation to encourage locals (Papuans) to grow cash crops was formulated in 1894 by the Lieutenant-Governor Sir William Macgregor almost 10 years after the British had annexed Papua. In 1903, indigenous cash cropping became the mainstay of the colonial government's policy concerning agricultural development. Regulations were introduced for compulsory

planting of economic trees such as coconuts, rubber, and citrus trees (Waddell and Krinks, 1968).

Prior to the Second World War, expatriate-owned plantations were a major source of cash-crop production, covering 24,705 ha of land. After the war, some of these plantations could not survive due to shortage of labor, low commodity prices, and high shipping costs (Crocombe 1964). Indigenous agriculture thus was to be the only hope for the future because it did not require hired labor and huge capital as was previously experienced on expatriate-owned plantations. Each village (or group of villages) was encouraged to plant cash crops as a group and, as new aspirations and increased demands for development became inevitable, the government then introduced a policy for increasing village production, which subsequently shifted away from group planting by encouraging each family to cultivate cash crops by the 1950s (Morawetz 1967; Waddell and Krinks 1968). Growth of interest in cash cropping among the people was stimulated also by the implementation of a variety of land-tenure and marketing schemes, which were entirely directed towards indigenous producers. Thus, from 1951 onwards, agricultural extension efforts concentrated exclusively on cash crops (Bourke et al. 1981). Land systems under various uses were therefore divided into subsistence cultivation, cash cropping, both indigenous and non-indigenous, and plantation systems, which were exclusively expatriate-owned and have been described in the previous section.

As the push for cash crop production increased so did the introduction and distribution of new food crop varieties of sweet potato, cassava, and banana. Other crops such as peanuts, pineapples, mango, pawpaw, and guava became widely accepted in the villagers' diet (Bourke et al. 1981). During the 1970s government efforts to replace food imports were directed towards introduced vegetables, potatoes, rice and a greater emphasis on export cash crop production. Vegetables such as tomatoes, cabbages, potato and sweet potato were cultivated on a large scale particularly for urban markets. Large-scale rice and sugar cane production was being planned. Sugar production has been operated and managed by an overseas company since 1983.

Promoted by greater concern over increasing levels of malnutrition in rural PNG, more emphasis was placed on research and staffing, which resulted in a 1975 Nutrition Survey to assess, among other things, the levels of malnutrition in all provinces. This culminated in the formulation of the National Food and Nutrition Policy (NFNP). The main aim of the NFNP was to increase the proportion of total food supplies produced domestically. Much of the land was brought into some form of use because of the impending need for cash crop and food production. Consequently, significant changes have occurred in food production during the last 40 years, which has led to other changes in food production and the nutrition system.

1.3 Population

It has been difficult to understand the long-term population trends of Papua New Guinea mainly because of the fact that censuses have been conducted only for a relatively short period. Censuses were conducted in 1966, 1971, 1980, and 1990. Only the latter two attempted a complete enumeration of the rural and urban populations. The population of PNG has grown from 3.8 million in 1990 to an estimated 7.6 million in 2010. This increase represents a growth rate of 2.3 per cent per annum.. It appears that the population growth rate declined during the

1970s and rose slightly during the 1980s. Thus, the growth rate declined from an annual average of 2.6 per cent during the period 1966-1971 to 2.1 percent in 1971-1980, and rose again slightly to 2.3 percent between 1980 and 1990. The officially calculated growth rate for the period 1990-2000 is 2.3 per cent, based on an intercensal average (Hayes 1993).

The data as presented suggest that the population growth rate has changed little over a period of 25 years, but census-based estimates of vital rates indicate that both the birth rate and death rate have declined over the same period. However, given the current estimation of the population growth rate of 2.3 per cent, and the increasing threat of logging and conversion of primary rainforest, it is highly likely that more land will have been brought into use by the turn of the century and later. The present fallow systems, which rely on low population densities and large areas of undisturbed forest, will be shortened. Assuming little or no technological change, shorter fallows will cause forest and land degradation and environmental stress. Farming of degraded lands will not be sustainable in the longer term without innovations such as introduction of new crops, new technology, and soil-fertility maintenance techniques.

The spatial distribution of the population indicates that the southern and northwestern coastal regions have low population densities (4 and 7 persons/km^2, respectively), while the islands and highland regions are more densely populated (10 and 22 persons per square km, respectively). The Western, Gulf, and West Sepik Provinces remain sparsely populated. Over one-third of PNG's population is concentrated in the 13.5 per cent of the total land area in the highland region. Although 22 persons per square km is the average density for the 10 highland regions, it is reported that in some fertile highland valleys densities exceed 200 persons km^2 (Allen 1984), and it is in these areas that reports of "population pressure" on land have been most frequent.

The current population of Papua New Guinea is estimated at 6.6 million with an annual average growth rate of 2.7 percent (based on the 2000 Census). Forty percent of the total population is under 15 years old, a reflection of young and fast growing population. Most of the population lives in rural communities based on the traditional village structure and dependent on subsistence farming supplemented by cash cropping. Around 13% of the Papua New Guinea population lives in urban areas (2000 Census).

1.4 Climate and Weather

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.

Being located in the tropics, it is not surprising to see very little variation in the maximum and minimum temperatures (Figures 1.2 and 1.3). Temperatures showed warming trends in both the maximum and minimum temperatures across the regions with higher increases in the night time temperatures. (Figures 1.2-1.4 Source National Weather Service)

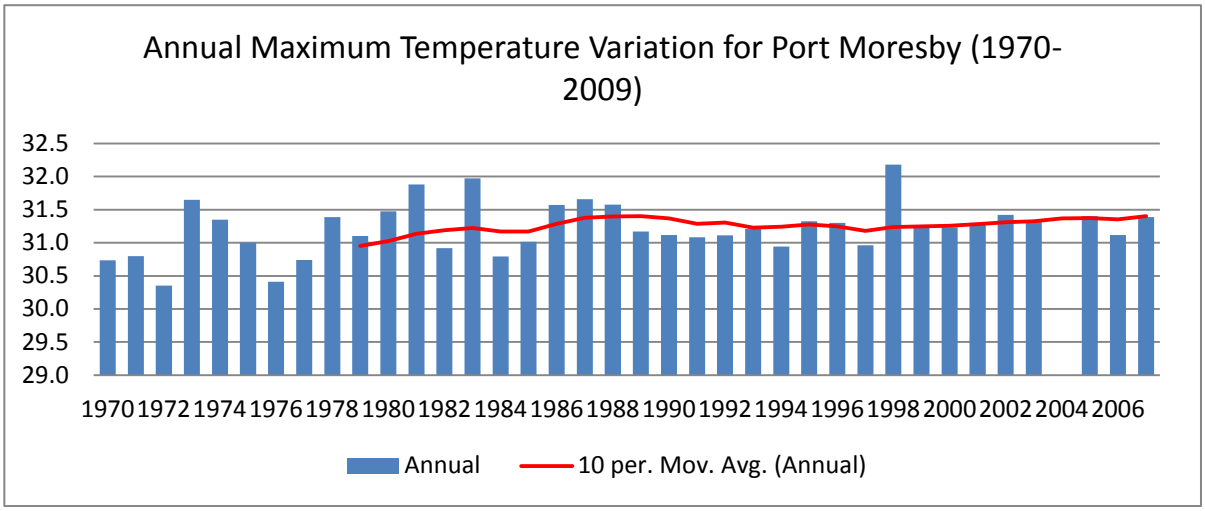


Figure 2 Annual cycles of temperature at Port Moresby

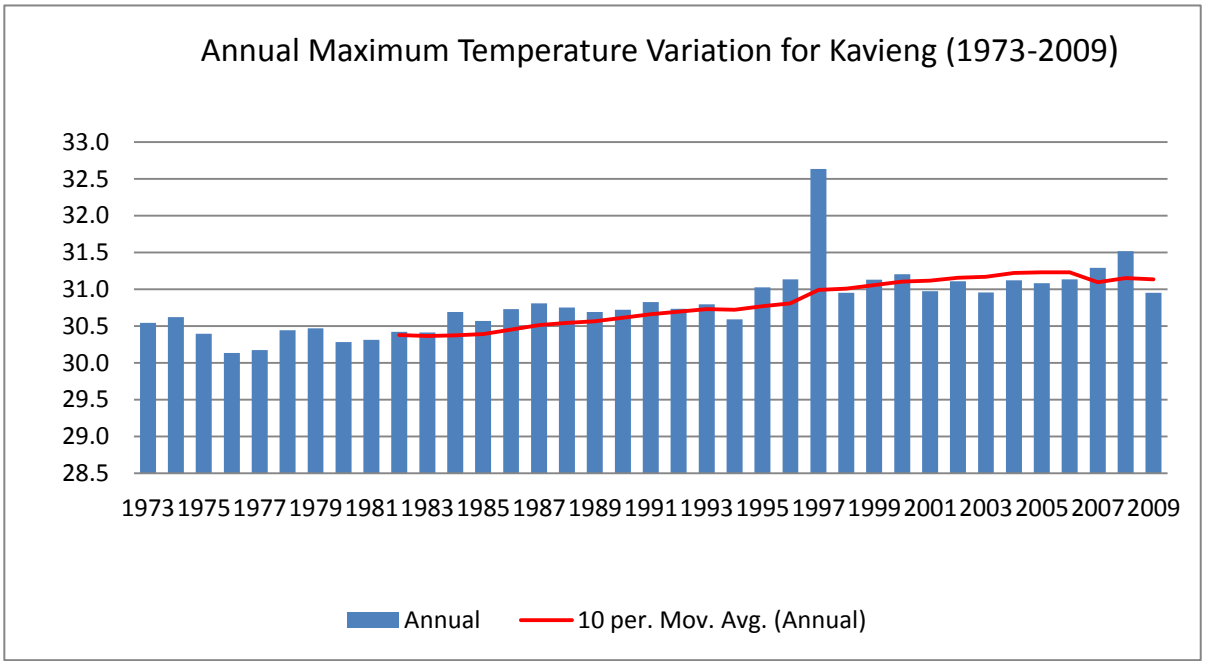


Figure 3 Annual cycles of temperature at Kavieng

The monthly mean rainfall in Figure 1.4 shows the wet season from Nov-Apr and the dry season from May-Oct. PNG experienced El Niño in 1997, which caused the high temperature. Rainfall seasonality is weak in all locations except for Port Moresby. The inter-annual variability in rainfall varies greatly across the regions. The trends in Figure 1.4 show all regions to have increasing rainfall during the wet season since 1950 (such as Port Moresby) except the Northern region which had significant decreases (Kavieng; see Figure 1.5). However, the Northern region showed significant increases in rainfall during the dry season.

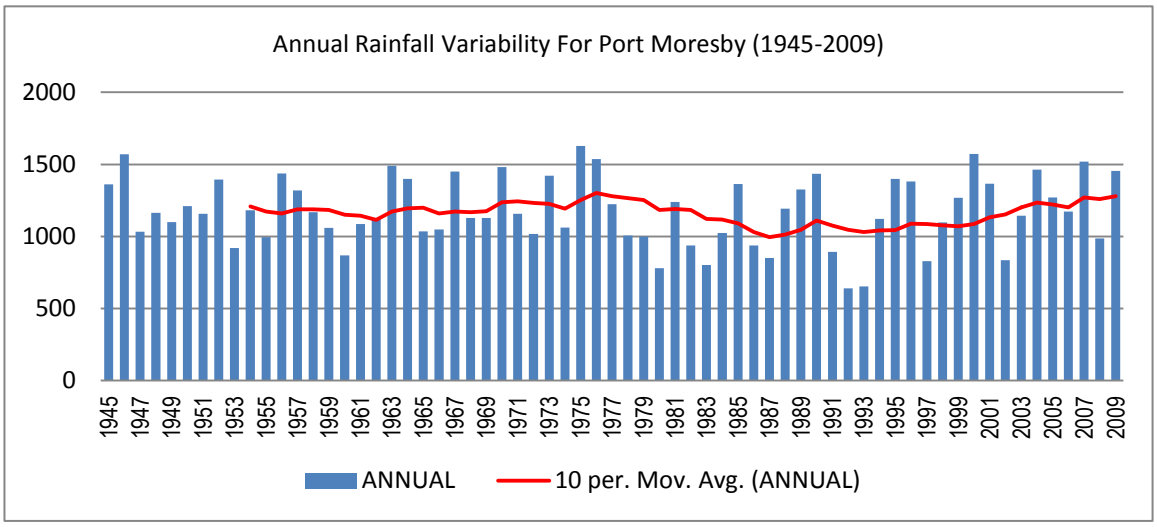


Figure 4 Monthly Mean Rainfall for Port Moresby

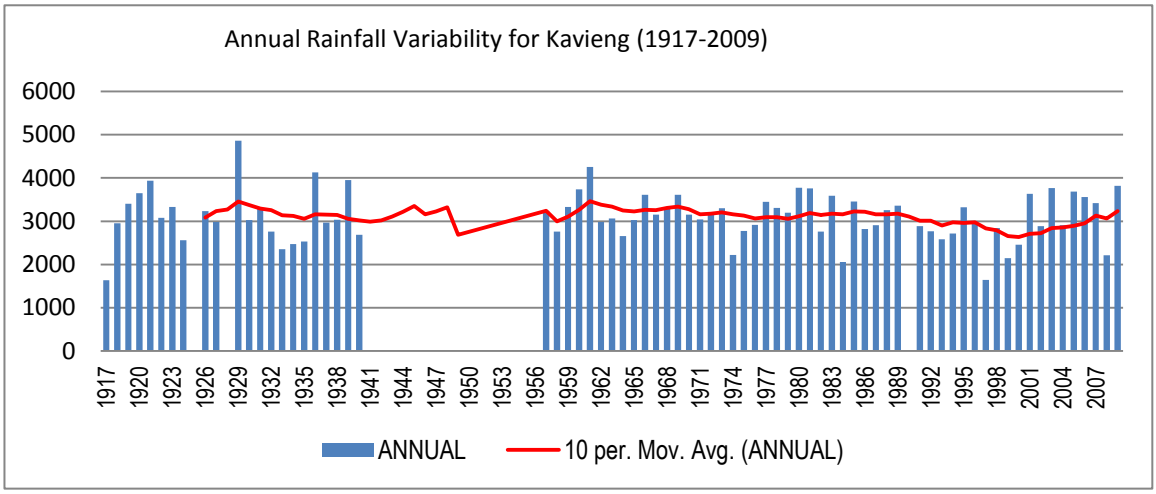


Figure 5 Monthly Mean Rainfall for Kavieng

1.5 Economy

PNG has a relatively small dual economy, made up of a formal and informal economy. The formal economy is dominated by large-scale resource projects, particularly in mining and petroleum, and provides a large proportion of government revenue. The informal economy supports 85% of the people through semi-subsistence agriculture. The formal sector employs around 15% of the workforce.

PNG has an abundance of natural resources including large reserves of minerals, extensive forestry and fishery assets, significant agricultural land and many beautiful locations with potential for ecological and cultural tourism. Despite the potential of these resources, PNG's economic performance has fallen short of expectations. Following a relatively stable

macroeconomic performance in the first decade after independence, PNG experienced a series of macroeconomic crises in the 1990s.

The country is currently experiencing an economic recovery, with improvements in several macroeconomic indicators. The PNG economy returned to growth in 2003 after several years of decline, with economic growth of 6.5 per cent in 2007 and 6.6 per cent in 2008. Inflation, after increasing to over 10% in 2008, has been estimated at 6.2% in 2009. Interest rates have been reduced in 2009. Foreign reserves are at comfortable levels. The improvement in macroeconomic performance has not, however, translated into improved service delivery and therefore continues to face considerable medium-term economic challenges. Concerns include degraded infrastructure, law and order problems and a weakly performing public service.

PNG struggles to translate strong economic growth and political stability into improved development outcomes, and it remains unlikely that PNG will achieve any of the Millennium Development Goals by 2015.

PNG's population suffered significant declines in living standards during the years of poor economic performance. Although the country does not exhibit the widespread abject poverty present in some developing countries, poor health and social indicators show that poverty is a serious problem. While PNG's main social indicators, such as life expectancy and maternal and child mortality rates, have improved since 1975, they are still well below the averages for lower middle-income countries. Primary health care provision is limited. Infectious diseases claim many lives; there are serious public health risks from endemic diseases such as malaria, and an emerging HIV/AIDS epidemic. An estimated 2.56% of adults in PNG carry the HIV/AIDS virus.

Papua New Guinea (PNG) is richly endowed with natural resources, but exploitation has been hampered by rugged terrain, land tenure issues, and the high cost of developing infrastructure. Mineral deposits including copper, gold, and oil, account for nearly two-thirds of export earnings. Natural gas reserves amount to an estimated 227 billion cubic meters. A consortium led by a major American oil company is constructing a liquefied natural gas (LNG) production facility that could begin exporting in 2014. As the largest investment project in the country's history, it has the potential to double GDP in the near-term and triple Papua New Guinea's export revenue. An American-owned firm also opened PNG's first oil refinery in 2004 and is building a second LNG production facility. The government faces the challenge of ensuring transparency and accountability for revenues flowing from this and other large LNG projects.

Since 2002, there has been stability to the national budget, mainly through expenditure control; however, the government relaxed spending constraints in 2006 and 2007 as elections approached. In recent years, GoPNG has opened up markets in telecommunications and air transport, making both more affordable to the people.

Numerous challenges still face the government, including providing physical security for foreign investors, regaining investor confidence, restoring integrity to state institutions, promoting economic efficiency by privatizing moribund state institutions, and balancing relations with Australia, its former colonial ruler. Other socio-cultural challenges could upend the economy including an HIV/AIDS epidemic, with the second highest infection rate in all of East Asia and the Pacific, and chronic law and order and land tenure issues.

1.6 Agriculture

Agriculture has been the economic backbone of Papua New Guinea (PNG) for a long time, and will continue to be so for many years to come, by providing food, income and employment to the vast majority of the rural population. Increased revenues from the mineral and energy sector in recent years have not significantly contributed to the improvement of the standard of living of the rural communities. Over the decade 1990-2000, the agriculture sector growth was averaging only around 1% while the population growth was averaging 2.3%. This has adversely affected most of the rural families that depend exclusively on agriculture for their livelihood. With the exception of oil palm, agriculture industries were either stagnant or have had a negative growth. However, the situation has improved marginally over the last decade (2000-2010), primarily due to higher prices for the agricultural commodities in the international market. PNG has different and numerous livestock and crops that grows and live in the different agro-ecological environments as further elaborated in the table 1.1.

Table 1 List of Crops and Livestock that are adapted to different agro-ecological environment in PNG

Type of Crop/ Livestock	Altitude Range (m.a.s.l.)	Provinces
Sweet potato	0 – 1,500	All provinces
Banana	0 – 1,200	Central, Morobe, East New Britain, Madang
Cassava	0 – 1,000	All provinces
Taro	0 – 1,500	Madang, East Sepik, Western, West New Britain, New Ireland
Sago	0 – 600	All 14 coastal provinces
Yam	0 – 1,200	All provinces
Rice	0 – 1,200	Central, Morobe, East New Britain, Bougainville, New Ireland, Madang, East Sepik, Eastern, Chimbu, Western Highlands
Wheat	> 1,600	Eastern, Chimbu, Western, Enga
Coconut	0 – 600	All 14 coastal provinces
Cocoa	0 – 600	East New Britain, Bougainville, New Ireland, West New Britain, Manus, Madang, Morobe, East Sepik, West Sepik, Oro, Milne Bay, Central, Gulf
Coffee	0 – 1,800	Western Highlands, Eastern Highlands, Morobe, Simbu, East Sepik, Enga, Southern Highlands.
Oil palm	0 – 300	West New Britain, New Ireland, Milne Bay, Oro, Sandaun
Rubber	0 – 600	Western, Central, Gulf, Oro, East Sepik, West Sepik, Sandaun, Manus, New Ireland
Vanilla	0 - 600	East Sepik, Central, Morobe, Manus, Sandaun, New Ireland, Madang, East and West New Britain
Cardamom	0 – 1,700	East New Britain, Simbu, Oro, Morobe
Chili	0 – 1,500	Western Highlands, Enga, Southern Highlands
Black pepper	0 – 1,200	East New Britain

Ginger	0 – 1,500	Eastern Highlands, Simbu, Madang, Oro, Morobe, East New Britain, West New Britain
Turmeric	0 – 1,500	Central, West New Britain, East New Britain, Oro, Morobe, Madang, Eastern Highlands, Simbu, East Sepik
Pyrethrum	> 1,500	Western Highlands, Enga
Floriculture	0 – 2,000	All provinces
Large ruminants (cattle)	0 – 2,000	Eastern Highlands, Southern Highlands, East Sepik, Sandaun, Morobe, Madang, New Ireland, East New Britain, West New Britain, Bougainville, Central, Milne Bay, Gulf, Oro, Western
Small ruminants (sheep and goats)	0 – 2,000	Eastern Highlands, Southern Highlands, East Sepik, Sandaun, Morobe, Madang, New Ireland, East New Britain, West New Britain, Bougainville, Central, Milne Bay, Gulf, Oro, Western

Source: NADP Volume 1. m.a.s.l.: meters above sea level

1.7 Land systems

Most land-use observations before independence in 1975 were those derived from other investigations such as gold exploration and cope-plantation establishment. However, more systematic investigations of the geology and landscape, as well as land evaluation investigations, were carried out by the Commonwealth Scientific and Industrial Research Organization (CSIRO), Division of Land Use Research. The methodology for land-evaluation investigations was based on the land systems survey (Christian and Stewart 1953). A land system is defined as a unique assemblage of the features of land, such as soils, vegetation, landforms, rainfall, land use, and population. These surveys were designed mainly to assess the suitability of land for mechanized agriculture and pastoralism; and were based on air-photo interpretation and field checking which was limited to a representative selection of each area of the country investigated.

A total of 15 land systems were surveyed covering about 50 per cent of the total land area of the country. Land use was divided into three broad categories, subsistence cultivation, cash cropping (indigenous), and plantation. Most people in each land system were involved in subsistence cultivation. Cash cropping of mainly tree crops, such as coconuts, cocoa, coffee, and some rice, was practiced by the indigenous population in both lowland and highland areas, although in the latter some pyrethrum (*Pyrethrum cinerariifolium*), passion fruit, tea, and some livestock were introduced. Plantations were owned and managed by non-indigenous population in both lowland and highland areas.

Based on land-system surveys undertaken between 1954 and 1976, it was estimated that 20 per cent of PNG land was under shifting cultivation. Some estimates of areas were given for different categories of land use in lowland and highland areas. For instance, area under subsistence cultivation per capita was estimated to be between 0.08 and 0.24 ha, with an average of 0.12 ha (McAlpine 1967, 1970). The total land area, brought into commercial production (i.e. plantations) by non-indigenous people, ranged from 6,400 ha in East Sepik for coconut and cocoa, to over 148,000 ha for coffee and pastures in the highlands. These figures may have since changed due to the increase in population accompanied by greater economic and social demands.

1.8 National Agriculture Research Institution

Under the Government's 1996 Medium-Term Development Strategy, NARI became one of the major initiatives towards contributing to and realizing sustainable development in the agriculture sector. The Institute was officially launched on 5th May 1997, and formally took over the research and research-related technical functions of DAL in June 1998.It identifies and adopts new varieties of crops, especially thermal resistant crops and alternative cropping patterns, capable of withstanding extremes of weather, long dry spells, flooding, and variable moisture availability.

Agriculture will need to be progressively adapted to projected climate change and our agricultural research systems must be oriented to monitor and evaluate climate change and recommended changes in agriculture practices accordingly. This will be supported by the convergence and integration of traditional knowledge and practice systems, information technology, geospatial technologies and biotechnology. New credit and insurance mechanisms will be devised to facilitate adaptation of desired practices. The focus would be on improving productivity of rain fed agriculture.

1.9 Forestry

Papua New Guinea contains one of the world's largest remaining areas of tropical forest, home to 6-8% of the world's biodiversity. However, the extent of change and condition has occurred to a greater extent than previously recorded. 'In a study assessing deforestation and forest degradation in Papua New Guinea by comparing a land-cover map from 1972 with a land-cover map created from nationwide high-resolution satellite imagery recorded since 2002, showed that there were 28,251,967 ha of tropical rain forest in 2002'' Shearman et al., 2008. However between 1972 and 2002, a net 15 percent of Papua New Guinea's tropical forests were cleared and 8.8 percent were degraded through logging.

The drivers of forest change have been concentrated within the accessible forest estate where a net 36 percent were degraded or deforested through both forestry and non-forestry processes. Since 1972, 13 percent of upper montane forests have also been lost. It was estimated that over the period 1990–2002, overall rates of change generally increased and varied between 0.8 and 1.8 percent/yr., while rates in commercially accessible forest have been far higher, ranging between 1.1 and 3.4 percent/yr. These rates are far higher than those reported by the FAO over the same period.

Thus the study concluded that rapid and substantial forest change has occurred in Papua New Guinea, with the major drivers being logging in the lowland forests and subsistence agriculture throughout the country with comparatively minor contributions from forest fires, plantation establishment, and mining.

1.10 Fish Resources

With one of the largest Exclusive Economic Zones (EEZ), of 3.1 million square kilometers, Papua New Guinea contains a large and diverse marine resource. Some earlier estimates of catch indicate that approximately 250,000 tonnes of fish of mainly tuna (skipjack and yellow fin) were taken from PNG water each year. Other commercial fisheries are prawns, lobster, reef-

fish, near-shore tuna and deep-sea shark, which have the potential for high value export markets.

Papua New Guinea has an extensive and valuable fisheries sector ranging from inland river fisheries, aquaculture, coastal (beche-de-mer) and reef fisheries to the prawn trawl and large-scale deep-water tuna fisheries. The range of participants covers artisanal community to medium sized domestic prawn and tuna long line operators to large international fleets in the deep-water tuna fishery.

The PNG fisheries zone of 2.4 million square kilometers is the largest in the South Pacific. The fisheries zone includes an extended reef system, numerous islands and an extensive coastline. These create huge opportunity but also present an enormous challenge for monitoring and control.

The total market value of PNG catch is estimated at K350 to K400 million on average although information on the true value of artisanal fisheries is difficult to obtain and cyclical factors and commodity price movements, especially tuna, cause huge value swings from year to year. It is believed that there is significant potential to increase the economic value and returns to PNG of these fisheries through better management and development programs.

Export earnings are important, but the importance of fisheries to the local markets and subsistence economy is also of major importance to the PNG people and economy. Reliable data on these markets is not available.

Access fees from deep-water fishing nations currently form the bulk of the revenues received and managed by National Fisheries Authority. Other sources include license fees from other operators, assistance from donors and penalties arising from prosecutions under the Fisheries Management Act (National Fisheries Authority, 2014).

1.11 Biodiversity

Papua New Guinea lies just north of Australia, and has many outlying islands to the north and east, with an expanse of some 800,000 square kilometers of ocean, including 40,000 km^2 of coral reefs and EEZ. Lying at the collision line of the Australian and Pacific tectonic plates, Papua New Guinea is remarkably diverse in terms of landscapes, ecosystems, and (with West Papua together) constitute the third largest expanse of tropical rainforest on the planet after the Amazon and Congo forests (Brooks et al. 2006). Rainforests cover 28.2 million hectares of Papua New Guinea and comprise 80% of the forest estate (Shearman et al., 2008). The rest of the forest estate comprises dry evergreen forest, swamp forest, and mangroves. The total forest estate covers approximately 71% of the land area of Papua New Guinea. The remaining non-forest area includes extensive areas of lowland to mid-montane grassland (much of which may be anthropogenous), subalpine and alpine shrub land and grassland, human settlements, and water bodies (Shearman et al., 2008).

The flora of Papua New Guinea is poorly known. Estimates for the number of vascular plant species for the entire island of New Guinea range from 11,000 (Collins et al. 1991), to 13,858 (Roos et al. 2004), to 16,203 (Govaerts 2001), based on species-area relationships and publishing trends, to 20,000-25000 species (including undescribed taxa) calculated on the

assumption that orchid and fern species, which are relatively well known, comprise about a quarter of the overall flora (Johns, 1995; Johns in Supriatna et al. 1999). About 6% of the world's flora (based on numbers in Hoft 1992) is found in PNG. Endemism probably exceeds 30% for Papua New Guinea and is well over 70% for Papuasia (i.e. most species that are not endemic to the country of Papua New Guinea are endemic to Papuasia – the SW Pacific region from New Guinea to the Solomon Islands).

Papua New Guinea is extremely mountainous, with extensive areas above 3000 m. The highest mountain, Mt. Wilhelm (4509 m) frequently receives snow. Rainfall generally exceeds 2000 mm annually in most areas, with some areas receiving more than 10,000 mm. Rainfall is often seasonal and some areas, particularly in Western and Central provinces, have extensive dry seasons and which are covered with woodland-savanna. There are more than 5,000 lakes, and extensive river systems and wetlands. The species-rich mainland coastline includes more than 8,000 kilometers of mangrove swamps, lagoons, wetlands, coral reefs and atolls, plus island archipelagos, and hundreds of offshore islands.

Papua New Guinea harbors a rich array of animals including an estimated 150,000 species of insects, 314 species of freshwater fishes (82 endemic), 641 species of amphibians and reptiles (328 endemic), 740 species of birds (600 resident; 77 endemic), and 276 species of mammals (69 endemic). Overall approximately a third of the species are endemic to Papua New Guinea and more than 70% are endemic to Papuasia.

PNG waters are considered part of the coral triangle, the area of the world's highest known marine biological diversity. Its coral reefs and associated marine habitat are home to about 2800 species of fishes, about 10% of the world total. Almost all reef types, found in PNG waters, are within fringing and/or barrier reefs, with an estimated area of 40,000 km^2. In addition, PNG has some of the largest unpolluted tropical freshwater systems in the Asia Pacific region.

Given the high rainfall and generally rugged topography, rivers are usually fast-flowing with very high discharges. Consequently, except in the broader, lowland areas, most rivers in Papua New Guinea have a poorly developed aquatic fauna and flora. The coastal plains are swampy areas traversed by meandering rivers with associated oxbow lakes. The lower reaches of the rivers have extensive floodplains that may be seasonally inundated giving rise to vast swamps. Small wetlands are found in the highlands and on the islands.

It is important to note that there are large gaps in the scientific knowledge of Papua New Guinea's biodiversity. The number of frog species, currently 302, is likely to double when all species have been discovered and scientifically named. The number of species of reptiles and mammals is also expected to significantly increase, as these taxa become better known. Enormous areas of the country have yet to be systematically surveyed and there is a growing need for a national biological survey to assist in assessing and managing Papua New Guinea's great biological wealth.

People have depended heavily upon Papua New Guinea's plentiful and diverse biological resources for subsistence. Melanesian societies have developed an extensive and detailed knowledge of Papua New Guinea's flora and fauna, and some 1,035 different plant species are known to be used for various purposes (Powell 1982). Wildlife plays an important part in

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, mollusks, and turtles, dominate local diets.

Papua New Guinea is the fourth smallest of the megadiversity countries, but unquestionably one of the most unusual and interesting, especially in terms of diversity in human cultures. The human population of Papua New Guinea makes up a small fraction of the world's total but represents more than 12% of the world's languages.

1.12 Energy

As Papua New Guinea's economic performance continues to grow strongly in the next few years, the demand and supply of energy will grow as well. Energy production, distribution, transmission and management will be critical for the development and growth of the country. The total installed electricity capacity (2010) is 582 MW, comprising hydro-electric (39.5%), diesel (37.3%), natural gas (14.1%), and geothermal (9.1%). The total primary energy supply estimated (2007) is 1,835 kilotonnes oil equivalent (ktoe) of which oil and petroleum products account for 78%, natural gas 18% and other fuels 4%.

Papua New Guinea is a net energy exporter. The Asia-Pacific Economic Cooperation (APEC) prepared an energy balance for PNG in 2000. The net primary energy supply was 573 ktoe. Light crude oil and petroleum accounted for 61%, natural gas 25% and hydro 14%. 79% indigenous commercial energy production (i.e. oil) was exported.

In 2008, oil production rose to 38,080 barrels a day, from three oil fields. With the commissioning of its first refinery (Napanapa Oil Refinery owned by Interoil) in 2004, crude is now refined locally. Approximately 72% (2313 ktoe) of indigenous crude oil and LNG production is exported.

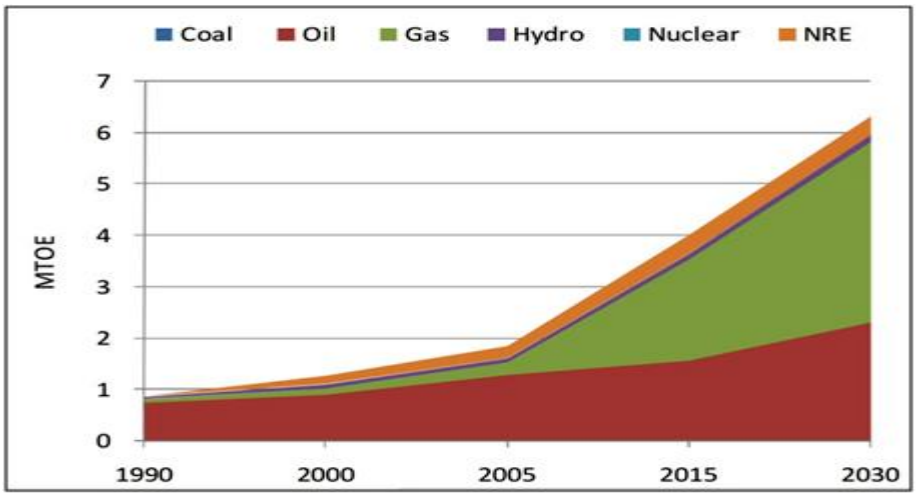
The GoPNG allocated an estimated USD20 million of its annual budget to oil and gas explorations. The total proven and probable gas reserves are over 14 trillion cubic feet, half of which constitutes the proven reserve. Much of the reserves are undeveloped except for Hides gas field, which supplies around 14-15 million standard cubic feet a day for power generation.

Energy and Energy Efficiency Sector

Papua New Guinea is a net energy exporter, and its self-sufficiency in fossil fuels puts it in a different position from other smaller Pacific Island countries. Oil production in 2008 was 38,080 barrels a day from three oil fields. With the commissioning of its first refinery plant in 2004, crude is now refined locally. Sixty-five percent of the refinery's output is consumed locally for different end-uses in the industrial and transport sectors, as well as for electricity generation. The remaining 35 percent is exported overseas. A new world-scale export oriented Liquefied Natural Gas (LNG) project is presently under development in PNG and is expected to start operation in 2014.

Based on the Asia-Pacific Economic Cooperation (APEC) Energy Balance report 2009, PNG's primary energy supply is projected to increase at an average annual rate of 5.1 percent, from 1.8 Mtoe in 2005 to 6.3 Mtoe in 2030 (*see Figure 1.6*). Oil and natural gas will constitute most of

the share in the total primary energy supply. The demand for oil will be concentrated in the industrial sector, followed by electricity and transport, while the demand for natural gas will be driven by the electricity generation.



Source: APEC Energy Demand and Supply Outlook – 4th edition, 2009

Figure 6 Primary Energy Supply in PNG

Power Generation Sector

The PNG Power Limited (PPL) is a fully integrated power authority responsible for generation, transmission, distribution and retailing of electricity nationwide. PPL was corporatized under the Electricity Commission (Privatization) Act 2002 as the successor company to the Papua New Guinea Electricity Commission (ELCOM). In 2009, PPL was delegated a regulatory role by ICCC and their responsibilities include approving licenses for electrical contractors, providing certifications for electrical equipment and appliances to be sold in PNG, and providing safety advisory services and checks for major installations.

Electricity Supply

Based on the PEEP1 report for PNG, the total installed capacity in PNG was estimated to be *547 MW* with 40% hydro and 38% thermal (mostly from diesel fired power stations) for the 2008-2009 periods. The remaining installed capacity was constituted by geothermal and natural gas power plants. Of this total installed capacity nationwide, *295 MW* belongs to PPL, comprising *148 MW of hydro (50%)* and *137 MW of thermal (47%) power plants*. The remaining installed capacity belongs to mining and manufacturing industries, as well as 150 to 200 small rural electricity systems (called “C-Centers”) that are operated by local government authorities.

In 2007, PNG generated 3112 GWh of electricity (a 3.3% increase from 2006). The sources of generation were thermal at 72% and hydro at 28% (the share of hydro has remained steady over the past three years so thermal generation increased by 3.3% to meet demand).

In PNG almost 90% of the population does not have electricity. There are only two grids: one in Port Moresby and the Ramu grid. The latter grid covers the cities of Lae, Madang and the

Highlands region. PNG Power, the national utility, operates these three interconnected distribution systems and many provincial power systems. Additionally, about 100 small rural electricity systems (C-centers) are operated by local authorities at government administration centers, powered by diesel generators, small hydropower facilities, and in some cases, solar photovoltaic (PV).

Electricity supply is often unreliable and relatively expensive in PNG and thus contributes to poverty in rural areas and constraints growth in urban areas. The majority of electricity generation is based on fossil fuel combustion (petroleum products) with little regard for GHG emissions and sustainability. Base load generation for Port Moresby is provided by hydro-electricity. However much of the country's hydropower capacity is over 30 years old and has not been maintained efficiently due to financial constraints. There is at present no national grid system due to the challenges posed by PNG's difficult topography as well as the considerable distances between various towns or load centers. PPL operates three separate urban grids and 14 other independent provincial systems. In addition, there are a number of C-Centers and privately owned facilities in rural areas. The three separate urban grids operated by PPL include:

Port Moresby System: The Port Moresby system serves the National Capital District, the commercial, industrial and administrative center of Papua New Guinea. The Port Moresby system also serves surrounding areas in the Central Province. The total installed capacity under the Port Moresby System is 116.2 MW (the Rouna Hydro Power Stations - 62.2MW, Moitaka thermal power station – 30 MW, and Kanudi Power Station (diesel, privately owned) – 24 MW).

Ramu System: The Ramu system serves the load centers of Lae, Madang and Gusap in the Momase Region and the Highlands centers of Wabag, Mendi, Mt Hagen, Kundiawa, Goroka, Kainantu and Yonki. The economy of the regions supplied by the Ramu system is based on mining, oil, gas, coffee, tea, and timber and industrial productions. The main source of generation is the Ramu Hydro Power Station with an installed capacity of 75 MW, and a run-of-river Pauanda station in the Western Highlands Province with 12MW installed capacity. Power is also purchased when required from the privately owned Baiune Hydro Power Station at Bulolo in Morobe Province, and varies between 1 to 2 MW depending on availability. Transmission line outages, energy and peak demands are met by diesel plants at Madang, Lae, Mendi and Wabag. These plants serve as stand-by units.

Gazelle Peninsula System: The Gazelle Peninsula system serves the townships of Rabaul, Kokopo and Keravat to service Gazelle's economy based on copra, coconut oil, cocoa, timber and fishing. The Gazelle Peninsula system is powered by a 10MW hydropower system at Warangoi, Ulagunan Diesel Power Station with 8.4MW, and 0.5MW from Kerevat Diesel Power Station.

Based on PPL's billing data, the total sales in 2011 were 776 GWh. The Regional Energy Indicator study conducted by SPC shows combined transmission and distribution (T&D) losses of around 20%.

Energy Efficiency Policies and Regulations

The Department of Petroleum and Energy (DPE) through its Energy Division (ED) is responsible for preparing energy policies, planning initiatives, data collection and analysis as well as advising the government on energy sector issues. Over the past years, three policy drafts, including the Draft Energy Policy, the Draft Electricity Industry Policy (EIP) and the Draft Rural Electrification Policy, have been circulated within the ED-DPE and discussed widely within the Government and concerned stakeholders. To-date none of these policies have been approved and endorsed by the National Parliament. The Energy Division of DPE is the custodian of Energy Technical Regulation, which includes energy efficiency and conservation.

Price and other aspects of electricity supply operations in PNG are regulated by the Independent Consumer and Competition Commission (ICCC), an independent regulator of the electricity industry established through an Act of Parliament in 2002 (ICCC Act 2002). There are two Acts cover the provision of power supplies within PNG, i.e.: (1) the Electricity Industry Act of 2000 (formerly Elcom Act), and; (2) the Government Power Stations Act.

Key Energy Efficiency Stakeholders

Review of various reports and studies have suggested that the following agencies may have a role relevant to development and implementation of Energy Efficiency projects and activities in PNG. These are:

- Energy Division (ED), Department of Petroleum and Energy (DPE): Responsible for energy policy development; energy planning; data collection; energy advice to PNG Government including in areas of fuel prices, subsidies and electricity tariffs;
- PNG Power Limited (PPL): Responsible for generation, transmission and distribution of power nationally, and; technical regulation of electricity provision;
- Department of Environment and Conservation (DEC): Responsible for establishing environmental standards; conducting environmental impact assessments; and center for accessing GEF financing;
- Office of Climate Change and Development (OCCD): National Focal Point for all climate change mitigation and adaptation programmes in the country, responsible for the establishment of the National Climate Compatible Development Management Policy and Act;
- Independent Consumer and Competition Commission (ICCC): Responsible for setting electricity tariffs; fuel-price control, and; awards power generation licenses;
- Other agencies, including but not limited to, PNG National Statistical Office, National Institute of Standards and Industrial Technology (NISIT) and Industry Associations such as the PNG Chamber of Commerce and Industry.

1.13 Transport

With over 85% of PNG's population living in rural and remote areas, good transport infrastructure is critical for development. Roads and highways are essential for people to take their goods to market to earn an income, for people to get to schools and hospitals and delivery of government services to the people in rural areas. As of 1999, Papua New Guinea has a total of 19,600 km of all weather highways, of which only 686 km is paved. Where there are roads there are many privately operated Public Motor Vehicles (PMVs), mostly minivans, which function as unscheduled buses. In 2001, the Philippines government had given PNG several jeepney units (Philippines popular public transport) for Papuan citizens to use.

The longest road in the country is the Highlands Highway, which links Lae and Madang to the Highlands region. The Boluminski Highway links Kavieng and Namatanai in New Ireland Province. A highway linking Wewak in East Sepik Province and Vanimo in West Sepik Province was completed in September 2007. The Kiunga-Tabubil Highway is a privately maintained road that links highland communities in the Western Province. The country has 10,940 km of waterways, and commercial port facilities at Port Moresby, Alotau, Oro Bay, Lae, Kimbe, Kieta Madang, Buka, Rabaul/Kokopo, Kiunga, Wewak and Vanimo. The major exports are mining and raw materials, with some containerized trade through Port Moresby and Lae. Import volumes exceed exports, resulting in increased shipping costs as the inbound leg compensates for empty capacity on the outbound journey. Principal trade routes are southward to Australian ports, and northward to Singapore. Air travel is the single most important form of transport in Papua New Guinea, for the transport of humans and high density/value freight. Airplanes made it possible to open up the country during its early colonial period. Even today the two largest cities, Port Moresby and Lae, are only directly connected by airplane. The main challenges regarding development of transport infrastructure are the following:

- GoPNG has not been able to fund all the necessary maintenance for local road and port infrastructure
- The largest ports in Port Moresby and Lae are deteriorating
- Only 12 of the 22 airports are certified to a minimum standard
- Lack of skilled workers such as project managers and civil engineers.

The Liquefied Natural Gas Project will exacerbate these challenges by adding additional stress to the existing workforce and infrastructure.

The Transport Sector Support Program through the AusAID project is the main initiative for the sector, with an annual expenditure of $65 million. The Program aims to assist the PNG Government to improve governance, capacity and service delivery in transport infrastructure agencies and helps to fund the maintenance of infrastructure. At the same time, Australia is encouraging the PNG Government to take on more responsibility and funding for infrastructure maintenance. The program currently works with the land, maritime and aviation transport sub-sectors. The current phase of the program is scheduled to end in 2012, and it is expected to move straight into another five-year phase. Support to the sector is required over the long-term.

2. NATIONAL GREENHOUSE GAS INVENTORY

2.1 Introduction

Papua New Guinea prepared its first national GHG inventory (GHGI) in 2002 as part of the preparation of its initial national communication to the United Nations Framework Convention on Climate Change (UNFCCC). The results of the first GHGI based on 1994 emissions estimates indicate that PNG as a whole is a net sink[1], having produced and/or contributed 1,553 Gigagram (Gg) of carbon dioxide (CO_2) equivalent; 4.27 Gg of methane (CH_4) and 12.20 Gg nitrous oxide (N_2O) from the agriculture sector (Initial National Communication, 2002). The land use and forestry sector contributed 413 Gg of CO_2 equivalent and removed 112.5 million tonnes of carbon dioxide mainly by forestry plantations. However, the largest contributor to the GHG emissions in PNG in 2002 was the energy sector, which contributed 947.57Gg CO_2 accounting for over 60% of the emissions. Thus, the estimation of GHG inventory in 2002 was only possible for four categories of emissions and removals: energy, industrial processes, land use change and forestry, and agriculture. While every attempt was made to collect relevant and available data for the estimation of GHG emissions, the lack of sufficient data and the limited access to the available data affected the GHG estimation in the inventory.

This is the second GHGI that PNG has produced in accordance with the requirements of, and its obligations under, the UNFCCC. The scope of the GHGI is consistent with the UNFCCC guidelines adopted at the UNFCCC Eighth Conference of the Parties and, as contained in decision 17/CP.8 and its annex.[2]

2.2 Methodology

The inventory was conducted using the *Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories*, hereinafter referred to as the IPCC Guidelines and the IPCC Good Practice Guidance 2000, for estimating and reporting on its national GHG inventory. In this regard emissions factors used were those provided in the IPCC guidelines; default factors for energy, industrial processes, agriculture, land use change and forestry and waste.

2.3 Scoping the GHG inventory

The collection of activity data started with a scoping exercise, where individuals, government, non-government and private organizations were contacted and meetings were held to introduce the SNC project and GHG inventory exercise, and to explain the data requirements for the inventory work. Contacts were made through letters to the various organizations, companies and government departments and were delivered either through fax or hand delivery. Follow-up contacts were made through phone calls and electronic mail (e-mail) messages. To facilitate the provision of relevant data from the individuals and organizations, a checklist based on the IPCC and the UNFCCC GHG Software Worksheets were distributed and discussed during the

[1] A sink is any natural or man-made system that absorbs and stores GHGs, including CO_2 from the atmosphere. To be considered a sink, a system must be absorbing more CO_2 than it is releasing, so the permanent store of Carbon is expanding.
[2] Decision 17/CP.8 is contained in the Report of the UNFCCC and actions adopted at its Eighth Session.

meetings and consultations with relevant stakeholders. The worksheets were then filled with relevant data where available.

2.4 Data Gathering Visits to the Provinces

A number of field visits were conducted to the 12 Provinces[3] by each sectoral team (e.g. Energy, Industrial Processes, Agriculture, Land Use Change and Forestry, Waste). Each of the provincial visits took approximately one week. Each team had with them the checklist of GHG inventory data, which was used to collect additional data. Prior contacts were made to the industries / companies in the respective provinces for the visitation. Letters and electronic mail (e-mail) messages were also sent to Provincial Administrations notifying them of the purpose of the visit. The checklist was also sent for the relevant stakeholders so that they would know what was expected of them with regard to provision of data and other information relating to the preparation of GHG inventory.

2.5 Data Entering

All data collected from the various provinces together with those collected from Port Moresby[4] were sorted into specific categories following the IPCC guidelines. The data was then checked for consistency with the units of measurement and then converted to units of mass for entry in the UNFCCC GHG Software[5]. The Software enabled input of activity data and emission factors which automatically calculated emissions in CO_2 equivalents (Gigagrams). Some of the data was transferred to an excel spreadsheet to create information in graphic form.

2.6 Categories of Emissions by Sources and/or Removals by Sinks

In PNG the main categories of emissions by sources and removals by sinks are Energy, Industrial Processes, Agriculture, Land Use Change and Forestry and Waste. The National GHGI covers these categories of emissions and or removals.

2.7 Energy Sector

The responsibility for energy policies and plans, data collection and analyses, and advice to government on energy issues rests with the Energy Division of the Department of Petroleum and Energy (DPE). So far the Energy Division had concentrated on electric power; however, that responsibility has been taken over by the establishment of PNG Power Ltd (PPL). PPL is a state owned company that is responsible for the generation, transmission, distribution and retailing of electricity through PNG and servicing individual electricity consumers. It has thermal and hydro power stations located in 20 provinces providing power to its customers. DPE itself reports that extremely limited resources have seriously hampered data collection and analysis and for renewable energy, data collection has been non-existent since the mid 1980s (PIREP, 2006).

PNG Power Ltd operates three major systems at Ramu (supplying Lae and Madang provinces), Yonki (supplying 3 highlands provinces of EHP, Simbu and WHP) and Gazelle (East New

[3] PNG has 19 Provinces and 1 National Capital District
[4] Port Moresby is the capital city of Papua New Guinea and by far the largest city in the country.
[5] The UNFCCC GHG Software enables automatic calculation of emissions and/or removals of GHGs, based on default emission factors.

Britain province), which have a generation mix of hydro and diesel. The other 12 provinces are predominantly diesel generated. One of PNG Power's seven key strategic areas is increasing hydro-electricity availability and the amount of hydro-electricity generation by sustainably harnessing the country's water resources. PNG Power is also looking at other renewable energy sources like gas, solar and wind, which are environmentally friendly. In addition, PNG Power is utilizing the generators at the Kanudi private power generation plant in Port Moresby for gas generation. The Kanudi gas power plant, owned by a Korean company, contributes 40% of the use in the Port Moresby grid. It was commissioned in early 2011; however, it is currently non-operational due to technical problems. About a hundred small rural electricity systems called C-centers are operated by local authorities at government administration centers, through diesel generators, small hydro and occasionally solar photovoltaic (PV). Responsibility for financing, managing and planning rests with provincial authorities but many systems are badly managed and not operating. The Independent Consumer and Competition Commission licenses electric power supply, establishes electricity tariffs and controls maximum prices of some petroleum fuels. There is a national power tariff for those served by PNG Power. Fuel prices are the same at the four main ports but are considerably higher, though still controlled, in remote areas.

The Petroleum Division of DPE is responsible for oil and natural gas exploration and development, with the industry controlled by foreign companies. InterOil, Shell, Exxon-Mobil and British Petroleum market most petroleum fuel. A 36,000 barrels per day refinery by InterOil began producing fuel for the local market in 2004, with some exports planned to neighboring countries.

2.7.1 Policies and Laws Regarding Energy

There were several policy-related studies underway in 2004:

a) An Australian Aid funded energy policy review project
b) World Bank (WB) assistance to build the capacity of DPE's Petroleum Division
c) A WB rural electrification policy and strategy; and a review of petroleum product pricing.

The most recent energy policy documents are a draft *National Energy Policy Statement* and accompanying *National Energy Policy Guidelines of 2001* with no formal status. Rural electrification policy guidelines were developed in 1993 to address the low rate of rural electrification, high costs and subsidies to C-centers, high costs of grid connections, and the relative effectiveness of mission station electrification compared to government initiatives. The guidelines advocated decentralized diesel generators, very small hydro and PV. Despite these and more recent policy initiatives, rural electrification remains *ad hoc* and C-centers perform very poorly. A draft Energy Division strategic plan for 2004-2008 called for creation of a Rural Electrification Authority with enabling legislation.

Acts of Parliament that deal with energy issues include: the *Electricity Supply Act* regarding powers of the minister for energy for generation, supply and extension of electricity from power facilities built with government funds; the *Electricity Industry Act* regarding the functions and powers of PNG Power; the *Independent Consumer and Competition Act* regulating electricity, petroleum and their pricing; the *Independent Public Business Corporation Act* under which the government holds all shares of PNG Power; the *Organic Law on Provincial Government and*

Local Level Government which grants authority to 19 provincial and 299 local (district/sub-district) governments to regulate electricity; the *Community Services Trust Act* which could in principle require PNG Power to supply services at subsidized rates to rural or low-income populations; and the *Environmental Act* which can require environmental impact assessments for prescribed energy investments.

2.7.2 Energy Supply

Since 1992, PNG has exported about 340 million barrels of light crude oil, about 100,000 bbl./day on average, from recoverable reserves of roughly 550 million barrels. In 2003 exports were 15 million barrels earning about US$ 520 million. Production will steadily decline over the next decade as the resource is depleted. The natural gas resource is equivalent to about 2700 million barrels of oil (perhaps far more), over ten times PNG's remaining recoverable oil reserves.

Imports of refined petroleum products vary considerably from year-to-year but averaged nearly 7,000 million liters from 1997-2000 with Shell having roughly 40% of the market, Mobil a third and BP a fifth. Wholesale fuel prices in Port Moresby (excluding taxes and import duties) are slightly lower than the Pacific Island Countries (PIC) average for diesel fuel, somewhat cheaper for gasoline and about average for kerosene.

Table 2.Petroleum Fuel Imports to PNG

Petroleum Fuel Imports to Papua New Guinea, 1990-2002 (millions of litres)

Fuel	1993	1994	1995	1996	1997	1998	1999	2000	2001
Motor Spirit					58.854	70.54	50.946	4.91	
Aviation Gasoline					4.753	8.29	5.97	1.69	
Jet fuel (Jet A1)					53.42	53.802	54.49	28.51	
Kerosene					11.67	10.41	4.88	9.49	
Distillate Fuel					275.25	290.17	342.12	672.27	
Heavy fuel oil					37.83	31.71	87.49	50.96	
LP Gas	11.26	9.36	12.49	11.43	14.33	11.9	18.21	11.88	10.56
Other					0.04	0.5	0.02	0.04	
Total (ML)					**456.147**	**477.322**	**564.126**	**779.75**	

Sources: Customs Dept (provided by J.Wilmot, April 2004) except Liquid Petroleum Gas (LPG) is imports from DPE (2004) survey. Totals are rounded off

In 2004, InterOil[6] integrated oil and Gas Company began processing crude oil from its Port Moresby refinery, the first and only refinery in PNG. InterOil is currently processing 32,500 barrels of crude oil per day, which is more than enough to meet PNG's requirements for petrol, diesel and kerosene and aviation fuel for now and well into the future.

[6] InterOil Ltd company profile on pages 75,78,82 of the Papua New Guinea Business Directory (PNGBD) 2012

The major products refined include petrol, diesel, kerosene, aviation fuel, liquid petroleum gas (LPG) and InterOil Power Fuel (IPF). InterOil currently controls 70% of all retail fuel sales in Papua New Guinea.

The Asia-Pacific Economic Cooperation (APEC) prepared an energy balance for PNG in 2000. Net primary energy supply was 573 kilotonnes of oil equivalent (ktoe). Light crude oil and petroleum accounted for 61%, natural gas 25% and hydropower fourteen percent. Seventy nine percent of indigenous commercial energy production (i.e. oil) was exported. In 2001, electric power capacity was reportedly to be 451 MW and the power generation was 2,638 GWh, about double the 2000 output due to dramatic annual variation in mining. Hydropower provided 35% of generation and thermal 65%, (of which gas 26%; and oil 39%).

There are no recent studies of non-commercial energy use but the PIREP mission estimates that about 1000 ktoe of wood are used annually for cooking.

2.7.3 Energy Demand

The end use consumption of commercial energy in 2000 was 364 ktoe. Industry accounted for 60%, transport 17% and agriculture/residential/commercial use for 24%. Petroleum provided 40% of energy consumption and other energy forms (mainly electricity) sixty percent.

In 1996, 2% of all households in PNG were surveyed. 12% had electricity and 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.

The WB estimates that in 2001, about 600 MW of installed electricity capacity (PNG Power and private) generated about 2,600 GWh. PNG Power supplies electricity to only 5.5% of households nationally, accounting for 82% of customers but 11% of sales. It is likely that under 10% of the population is electrified by all means: grid, self-generation, nearby industry, small hydro or solar.

PNG Power sales were expected to grow from 660 GWh in 2003 to 766 GWh in 2012, aggregate peak demand from 152 MW to 173 MW, and customer numbers from 76,000 to 103,000. The utility is under financial distress and has been unable to invest enough for adequate maintenance or expansion, resulting in high system losses, degraded generating plants, and frequent outages. As a commercialized utility, it is reluctant to expand its unprofitable rural electrification.

2.7.4 GHG Emissions

The emissions from the energy sector were estimated for the year 2000, based on the data provided by the Customs and Excise Division of the Internal Revenue Commission (IRC) of Papua New Guinea. The data for years before and after 2000 remain sketchy although some

data is available for 1997-1999 periods (Table 2 above). Based on data from IRC, emissions from both energy (fossil fuel combustion) and liquefied petroleum gas (LPG) dominated accounting for over 80% of emissions of CO_2. This is followed by gas/diesel combustion and to a lesser extent combustion of jet kerosene. Most importantly, it has been very difficult to obtain disaggregate fuel consumption data to undertake a sector approach (i.e. energy industries, manufacturing & construction and transport) emissions estimate for the energy sector in the PNG GHGI, due to the lack of data and disclosure issues by private sector sources, especially the major fuel suppliers/distributors and consumers in the country restricting access to these data. The figures as provided are indicative, as other subcategories of energy combustion have not been adequately covered in this emissions estimate. For example there is very little or no information available for energy generated from biomass combustion in PNG as most rural population burn biomass for their energy needs.

.**Table 3** GHG Emissions from Combustion of Various Fuel Types in 2000

Fuel Type	**Gg CO_2 equivalent**
Gasoline	1,047.4
Jet Kerosene	83.0
Other Kerosene	19.9
Gas/Diesel Oil	143.8
Residual Fuel Oil	83.0
LPG	1059
Total	**2436.2**

No time-series data were provided from known energy users and providers, thus only 2000 data is presented here.

2.7.5 Bunker Fuels

Estimates of GHG emissions (CO_2) from the consumption of fuel by the aviation and marine industries for international operations is for information purposes only and is not added to the national totals. Bunker fuels estimate for year 2000 is 144.5 Gg CO_2.

2.8 Industrial Processes

The data for Industrial Processes were sorted and analyzed under three subcategories: mineral production, metal production and other.

2.8.1 Mineral Production

The data collected were from the sub-category of Cement Production and Limestone and Dolomite Use. Emissions of CO_2 and SO_2 in the Cement production increased almost 28% and 22% respectively since 2000.

Cement Production

Only 2 cement-producing companies provided data on production and estimated CO_2 emissions[7]. The production in 2000 of the companies was 1040 metric tonnes. The estimated GHG emission was 0,52 Gg CO_2 equivalent. The total production of the cement industry in 2000 was 120,000 tonnes. The total GHG emissions for 2000 from cement production thus can be estimated at 60 Gg of CO_2 equivalent.

The production of the cement company increased steadily over the period 2000-2008. The trend in CO_2 emissions is increasing with the corresponding increase in cement production. If it were assumed that the same increase is valid for the sector as a whole, the estimated CO_2 emissions in 2008 would have been around 89 Gg.

The associated SO_2 emissions from the one company are around 0.31 Gg. The estimate for the sector as a whole is about 36 Gg for 2000 and 53 Gg in 2008.

Limestone and Dolomite Use in the cement industry

The use of limestone in 2000 was about 2,516.84 tonnes and of dolomite it was about 326.66 tonnes. The use of Limestone and Dolomite in the cement production and lime industry also shows an increasing trend. Limestone and dolomite use has increased steadily between the periods 2000-2008 except for a peak in 2002 when dolomite use was much greater than limestone due to a high demand for dolomite. Overall limestone use is generally higher than dolomite use.

The associated emissions of GHG can be quantified at 1.25 Gg CO_2 equivalent.

2.8.2 Metal Production Category

Metals such as steel, aluminum, iron and other related metals are imported and therefore are not produced in the country. However, minerals such as gold are produced in the country and were included in the inventory. The emission factor was derived from the electrolysis process, which was multiplied by the total quantity of gold produced (activity data) in a particular year.

Only one mining company, Lihir Gold Mining Limited, provided production data. In total there are 6 Gold, Copper and Silver Mining Companies operating in Papua New Guinea. The production of gold at Lihir commenced in 2004 and shows an increase until 2008 in production and in CO_2 emissions of about 33%. Other greenhouse gases such as oxides of Nitrogen (NO_x), non-methane organic volatile compounds (NMVOCs), carbon monoxide (CO) and Sulphur dioxide ($S0_2$) are also produced in minute quantities from gold production.

[7] Hala and Maipakai Cement companies provided the data

Based on the data from Lihir and extrapolated to the total production of gold in PNG of about 74.5 tonnes, the emissions can be calculated at about 0.12 Gg CO_2 equivalent.

2.8.3 Other category

This category has two sub-categories; paper and pulp production and food and drink production.

Paper Production

The data for paper production were collected from two manufacturing companies of paper; Amalpack and Niugini Paper Corporation. The main gases, emitted from paper production, are NMVOC, NO_x and CO. Their emission factors vary, giving rise to the variation in the trend line as shown in Figure 4. The emissions increased since 2007 when Amalpack Company started its production.

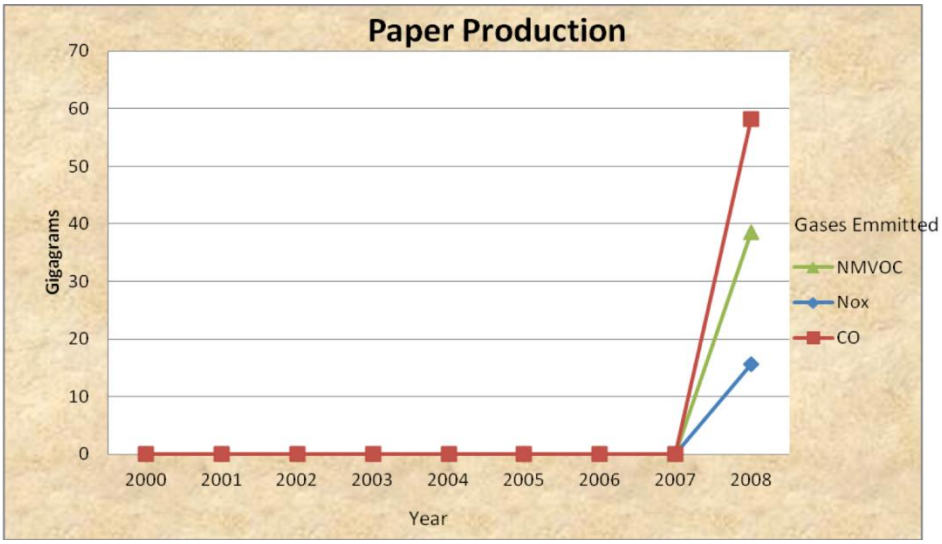


Figure 7 Emissions from Paper production

From the figure it shows that in 2000 the emissions where hardly existing. This increased to about 115 Gg CO_2 equivalent in 2008.

Food and Drink Production

Within this sub-category there is production of bread and other food and alcoholic products. The gases emitted are mainly Non Methane Volatile Organic Compounds (NMVOC). These are organic compounds, other than methane, that contribute to the atmospheric photochemical reactions.

The sub-category food production accounts for all types of food production within the country. The majority of the companies had given data on how much they have been producing since 2000.

Most of the foods processing companies have started their operations in PNG before 2000. However, they do not have proper records of their production, attributed in part by regular changes with their management. Some food processing companies started their operations

after 2000 and therefore do not necessarily have data for the year 2000. Some companies were reluctant to provide data on their production output and in some cases were unwilling to address GHG emissions. However, a total of 12 companies[8] cooperated and provided data on output production upon which GHG emissions estimates were calculated.

The emission levels between 2000-2005 periods remained rather steady, but increased rapidly during and after 2006 due to the operations of RD Tuna and Frabelle Fish Canneries with high production and processing capacities. However, the level of emissions of NMVOCs decreased in 2008 again by 10,000 tonnes with the decline in output production.

For the year 2000 the total emissions from the food and beverages industry have been calculated at 416 Gg CO_2 equivalent, with the bulk (> 90%) coming from the sugar industry.

2.8.4 Summary industrial emissions

The total emissions from the Industrial Sector are estimated at around 615 Gg of CO_2 equivalent. The breakup of the greenhouse gases is as follows:

Table 2.3 Summary table industrial emissions of GHG 2008

GHG Emissions from Industrial Processes (Gg CO_2 equivalent)	
CO2	61.25
CO	86
Nox	16
MNVOC	416
SO2	36
Total GHG Emissions	**615.25**

Non-Methane Volatile Organic Compound (NMVOC) came mainly from the processing and manufacturing of food products with concomitant increase in food manufacturing industries. Thus most emissions from the Industrial Processes came mainly from the Food and Beverage industry

In recent years the production in various sectors has increased substantially, so the emissions will have increased as well. More recent consistent data however are not available.

2.8.5 Uncertainty Analysis

It is estimated that data collection covered less than 50% of data although much of the data provided came from the Food and Beverage Industry (> 80% coverage). For most other categories of industrial processes many of the companies or private sector organizations consulted did not have sufficient relevant data as they are mainly suppliers and distributors and

[8] Nestle PNG, Frabelle PNG Limited; Lae Biscuits Limited; Goodman Fielder; Laga Industries; James Barnes (PNG Limited) RD Tuna Canners; South Seas Tuna; Banz Kofi; Alotau Bakery; Boss Mei Bakery; and Ramu-Agri Industries.

not necessarily manufacturers. For example data for chemical industry, metal industry and production of halocarbons and Sulphur hexafluoride could not be established or recorded as they were considered not applicable in the country. The data on production, which have been provided, have been extrapolated to the total production of the various sectors. There is no verification means on those data in PNG. With this it was assumed that the same emission factors apply. Because most of the companies, which supplied data on emissions, used the IPCC default values, this did not introduce additional uncertainty.

2.9 Agriculture

The emissions estimates were calculated for Domestic Livestock in 2000 (table 2.4), total nitrogen released from sugar cane field burning and field burning from agricultural residues (included in Table 2.5). As indicated in the Table 2.4 below, the total CH_4 emissions from livestock were 42.88 Gg in 2000; more recent detailed information is not available.

Table 2.4: Methane Emissions estimates for Domestic Livestock in 2000

Types of Animals	Number of Animals	Emissions Factor for Enteric Fermentation	Emissions from Enteric Fermentation	Emissions Factor for Manure Management	Emissions from Manure Management	Total Annual Emissions from Domestic Livestock
		(kg/head/yr.)	(t/yr.)	(kg/head/yr.)	(t/yr.)	(Gg/yr.)
	A	B	C = (A x B)/1000	D	E = (A x D)/1000	F =(C + E)/1000
Dairy Cattle			0		0	0
Non-dairy Cattle	80000	53	4,240	7	560	4.80
Buffalo			0		0	0
Sheep	15000	5	75	0.21	3	0.08
Goats	30000	5	150	0.22	7	0.16
Camels			0		0	0
Horses			0		0	0
Mules and Asses			0		0	0
Swine	1,800,000	1	1,800	20	36,000	37.80
Poultry	1,578,000	0	0	0.023	36	0.04
			6,265		36,606	42.88

Emissions not only come from domestic animals. Many animals graze in pastures and paddocks with a resulting large excretion of especially nitrogen. This only partly goes to the atmosphere. The GHG emission resulting from this is highly uncertain for PNG and is not included in the inventory yet.

GHG emissions also come from soils and burning of organic material when savannas are prescribed-burned and when residues are burned in the field (especially with sugar cane).

Table 2.5 summarizes the most important elements contributing to GHG emissions in the agricultural sector (results from table 2.4 are included). More detailed information on these issues is presented in the annex.

Table 2.5: Summary table all emissions of the Agriculture sector

Emission type	Total emissions in Gigagrams (Gg)
Methane emissions from Domestic Live Stock Enteric Fermentation and Manure Management	43.5
Nitrogen Excretion from Animal Waste Management System – Pasture and Paddock	30
Nitrogen Excretion from Animal Waste Management System-Solid storage or dry lot	5.8
Nitrogen Excretion from Animal Waste Management-Daily Spread	0.050
Emissions from Animal Waste Management	0.18
Prescribed Burning of Savannah-Quantity of dead biomass burned	627.8
Prescribed Burning of Savannah-Total carbon released	389.7
Prescribed Burning of Savannah-Emissions from savannah burning	CH_4 :2.1 CO:54.6 N_2O:0.026 NO_x:0.93
Field burning of sugar cane residues; biomass burned	405
Field burning of sugar cane residues; carbon released	165
Field burning of sugar cane residues; nitrogen released	3.3
Field burning of residues: emissions	CH_4:1.1 CO:23.1 N_2O:0.04 NO_x:1.3
Direct nitrous oxide emissions from agricultural fields	0.1
Manure nitrogen Use	6.7
Direct Nitrous Oxide emissions from cultivation	12.45
Direct Nitrous Oxide emissions from Grazing animals	0.9
Indirect Nitrous Oxide emissions from Atmospheric Deposition of NH_3 and NO_x	0.08
Indirect Nitrous Oxide from Leaching	1.3

2.10 Land Use Change and Forestry

2.10.1 Changes in Forest and Other Woody Biomass Stocks

This category focuses on estimating GHG emissions and removals from forest plantations, natural forest, non-forest trees, logging, fuel wood consumption and other wood use. The data for forest plantations were obtained from the Papua New Guinea Forest Authority (PNGFA) website while that of the natural forests were obtained from the University of Papua New Guinea Remote Sensing Centre (UPNGRSC). Data for non-forest trees were obtained from the Oil Palm Research Association (OPRA), Cocoa and Coconut Research Institute (CCRI) and a few other organizations that responded to the questionnaires. Logging data were obtained from the SGS and PNGFA log harvest book and comparisons were made while fuel wood and charcoal consumption data were obtained from the Asia-Pacific Forestry Sector Outlook Study II Report. Information about the cutting of trees for power lines and other infrastructural works is not available.

2.10.2 Forest and Grassland Conversion

Under the Forest & Grassland Conversion category, the main gases emitted are carbon dioxide, methane, oxides of nitrogen and carbon monoxide. These gases are estimated when an area of forest or savannah & grassland is converted annually and in a 10-year average period into cropland or pasture.

The only data received for the clearance of forest annually for the purpose of cropland were from Vidar Coconut Plantation and Mercy Secondary School. For the 10-year average period, the data were obtained from UPNGRSC based on a study on 30-year average converted areas of rainforests in Wildlife Management Areas (WMA), National Protected Areas (NPAs) and Kikori Integrated Conservation and Development (ICAD) area. It is not known for what purpose these areas were converted but it was assumed that conversion of forest and grassland were for the purposes of activities such as alluvial mining, construction of building. However, all data were used in this calculation. An estimated area of 93,101 ha of forested land was cleared in 2002 for Oil Palm Plantation (Phil Shearman et al., 2008). These data were added for that year alone while all the other data were used consistently including data provided by Lihir Gold Limited for the years 2006 to 2008.

Some data on Savannah & Grassland were collected from the National Agriculture Research Institute (NARI) at Kerevat and Vudal University of Natural Resources and Environment (UNRE) and were used for the calculation of emissions/removals from savannah/grassland conversion. The Department of Agriculture and Livestock (DAL) in the East Sepik Province (Maprik) also provided some data on the savannah/grassland conversion area but not in the form that could easily be used in the calculation.[9]

[9] Data were provided in percentage and since the savannah/grassland area of Maprik was not known, it was difficult to estimate the area.

2.10.3 Abandonment of Managed Lands

The abandonment of managed lands category focuses on the removal of carbon dioxide (CO_2) from those plantations or other croplands and pastures that have been abandoned for 20 years and more than 20 years. For the 20-year period, the calculation was done using data from plantations in Madang, ABG, NARI (Kerevat), Mercy Secondary School and Division of Livestock from Yakosa Cattle Ranch. For more than a 20-year period, the data used were obtained from a study conducted by Shearman et.al (2008) which includes the total rainforest, swamp and mangrove forest in Protected Areas and Wildlife Management Areas as well as data from Stettin Bay Lumber Company, Cloudy Bay and Vudal University (Oro).

2.10.4 CO_2 Emissions and Removals from Soil

Emission of CO_2 was estimated in three ways and added together to give the total. Firstly, it was estimated from a 20-year period of net change in soil carbon for mineral soils. This was done by using the Land Use System for PNG obtained from the Department of Lands and Physical Planning (DLPP) and multiplied the soil carbon in agriculturally impacted lands such as Alienated Lands by its land area for the present time period and over a 20 year period. The second set of calculations was from intensively managed organic soils. In this section, the area of plantations, pasture and forest that were under intensive management were used and the data were collected from cocoa and coconut plantations in Madang, ABG, Vudal University (Oro), Tea Plantation from Carpenters Estate (Mt. Hagen), Oil Palm Plantation from OPRA and a few other places. Carbon emissions from liming of agricultural soils was the third set of calculations and this was done using the Internal Revenue Commission (IRC) data on limestone and dolomite imported into the country during the 2000-2008 year period.

2.10.5 Other (Abandonment of Unmanaged Lands)

This category is not part of the IPCC guidelines. However, we are encouraged by the IPCC Guidelines to use national methodologies that reflect our national situation, provided that these methodologies are consistent, transparent and well documented[10]. Hence it was included because of the importance of shifting cultivation agricultural system of this country. The fallow periods are usually between 5 and 15 years or more than 15 years and the fallow regrowth ranges from savannah grassland to short woody regrowth and tall woody regrowth[11]. The estimation done for this category is similar to that of the Abandonment of Managed Lands, however, the time spans are from 5-15 years and more than 15 years.

The UNFCCC Software version 1.3.2 does not allow insertion of any new sheets into the workbook so this calculation was done separately in another spreadsheet and the results were manually entered in Table5s1 (Sectoral Report for Land Use Change and Forestry Sector) in the Overview under the “Other” category.

[10] UNFCCC Guidelines for National Greenhouse Gas Inventories

[11] Mapping Agricultural Systems Programme (MASP)

2.10.6 GHG Emissions Estimates

Carbon dioxide emission was the only GHG estimated in the Initial National Communication (INC) while in the Second National Communication (SNC) the GHG estimates include carbon dioxide, methane, oxides of nitrogen and carbon monoxide (as far as data are available).

Table 2.6: Net Emissions and Removals of GHG in the Land Use and Forestry sector both from INC (1994) and SNC (2000-2008) in TG (= 1000Gg) CO_2 equivalent

GHG (Tg)	1994 (INC)	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO_2	0.413	-181.04	-183.18	-170.48	-181.07	-181.79	-180.66	-179.99	-178.82	-179.03
CH_4	X	0.00013	0.00013	0.05878	0.00013	0.00013	0.00013	0.00018	0.00018	0.00018
NO_x	X	0.00003	0.00003	0.01461	0.00003	0.00003	0.00003	0.00005	0.00005	0.00005
CO	X	0.00115	0.00115	0.51437	0.00115	0.00115	0.00115	0.00160	0.00160	0.00162

2.10.6.1 Emissions

The INC report showed CO_2 emission of 413Gg but that was largely due to underestimation attributed to lack of data. In this SNC, there are emissions of carbon dioxide from Forest and Grassland Conversion and Soils. However, these are small and therefore there is no net emission for carbon dioxide. The emissions of the other three GHGs are also reported in here.

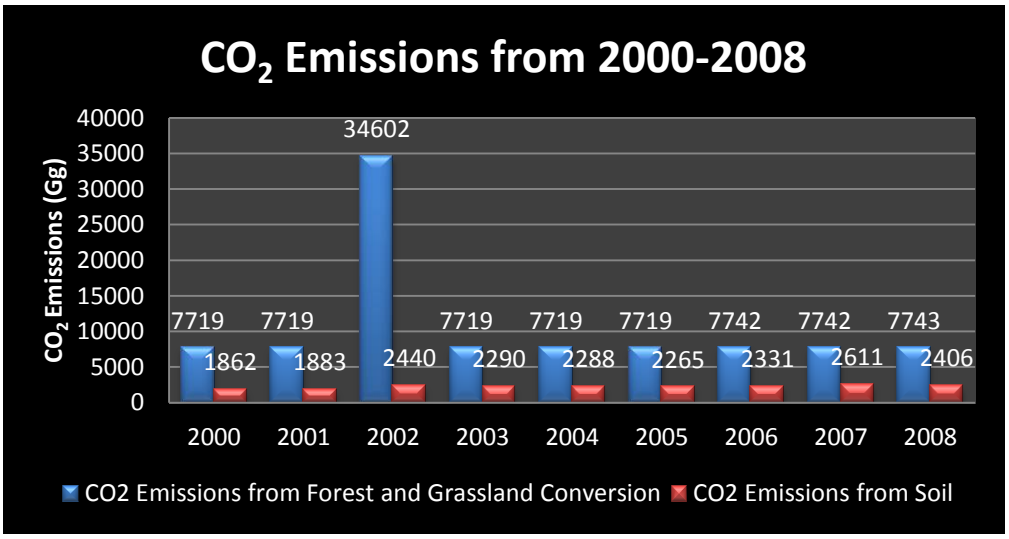


Figure 8 Calculated CO2 Emissions from 2000-2008 as derived from the inventory

CO_2 and CO emissions were estimated for the period 2000-2008 with carbon monoxide the least emitted. CO_2 emissions were largely due to Forest and Grassland Conversion for the purpose of cropland and pasture. Limited data was collected regarding Forest and Grassland Conversion for all the years except 2002, which contain some data that are higher than the other years. As a result, there was an increase in the calculated emissions of all gases in that particular year alone with CO_2 being the largest.

Papua New Guinea has about 26,457,000 ha of moist forest (Phil Shearman et al., 2008) and 3.241 million hectares of savannah/grassland (PNG Forest Authority, 2009). According to the data collected for 2002, about 0.35% of Moist forest was converted (oil palm) while the area of savannah/grassland converted was 0.0003%. It is quite interesting to see the very high emission that resulted from just the very small percentage, actually less than 1%, of the two areas converted for that year alone.

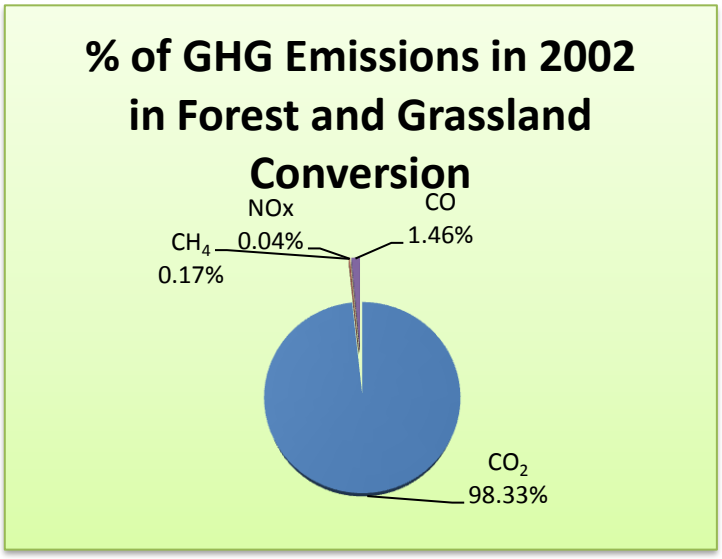


Figure 9 Percentages of GHG Emissions in 2002 from Forest and Grassland Conversion

Year 2002 emission is therefore quite significant as it portrays an almost convincing picture of Papua New Guinea. A lot of land use activities have been going on in the country at that time such as logging, clearing of forests for oil palm plantations and other agricultural activities. Mining is also another major land use activity as well as clearing of vegetation for the purpose of land development to build roads, houses, schools, etc. However, all these activities are not captured in this calculation because the IPCC methodologies only apply to land use change as a result of forestry and agricultural activities.

Moreover, although the areas of the different types of vegetation of PNG are known, there is no data available to show how much of those land areas are converted annually or over a period of 10 years and for what purpose.

Since there are on-going land use activities such as those mentioned above that are not captured for those individual years, it is assumed, based on the 2002 emissions, that there is actually a lot more emissions for all those years than what is presented here as the emissions estimated are constrained by a lack of high quality activity data from the LUCF sector. However, based on these estimates, it appears that the emission of CO_2 for PNG for the years 2000-2008 in the area of Forest and Grassland Conversion is almost the same as the 2002 emissions and probably equal to or greater than 35,000Gg.

2.10.6.2 Removals

There was no record of removal from the LUCF sector in the INC and again that was due to lack of data. In this SNC, the three categories that contribute to the removal of CO_2 are Changes in Forest and Other Woody Biomass Stocks, Abandonment of Managed Lands and Others (Abandonment of Unmanaged Lands).

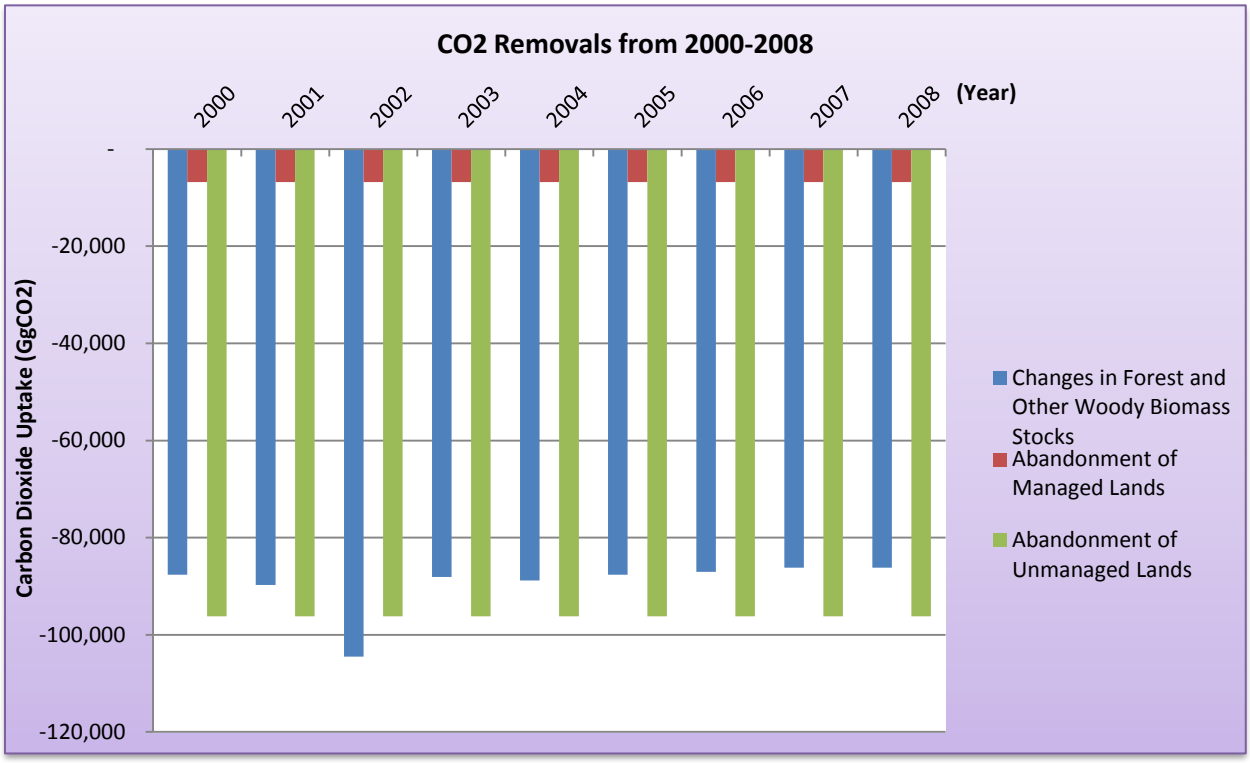


Figure 10 CO2 Removals from 2000-2008

The values of CO_2 removals presented in Figure 2.4 above and Figure 2.5 below result are from the area of forest plantation and the limited number of non-forest trees captured in the GHG inventory data collection. However, it is believed that if data of *Extensively Managed Forest* (Naturally re-growing stands with reduced or minimum human intervention) and all the *Non-Forest* trees in the urban areas, villages, farms and elsewhere around the country were added, the removal of CO_2 would have been larger than what is presented in this report.

Most of the CO_2 removal is estimated from *Abandonment of Unmanaged Lands* (about 50% on average) and *Changes in Forest and Other Woody Biomass Stocks* (about 46% on average). Although carbon dioxide is emitted in this category as a result of logging and fuel wood consumption, the forest plantation and non-forest trees remove most of this. PNG has about 62,277 hectares of forest plantations[12]. These areas remain constant from 2000-2008 in the calculations because there is always replanting going on in forest plantation when they are harvested so the area always remains more or less the same. In natural forests selective logging normally occurs where only those trees with a diameter of 50cm and above are

[12] PNGFA website: http://www.pngfa.gov.pg

harvested (PNGFA, 1996) while the others remain, thus allowing the area to remain constant as well.

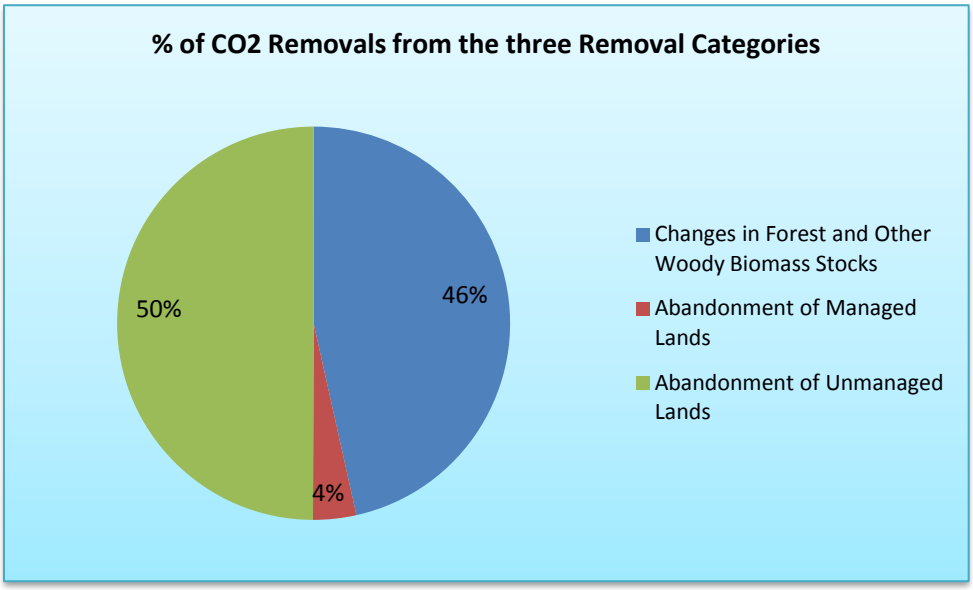


Figure 11 Average Percentage of CO2 Removals from the three Removal Categories

WRI (2008) reported that 94% of CO_2 emission in PNG is derived from the Land Use Change and Forestry Sector. However, according to this estimate, there is no net emission but only net removal in the LUCF sector. In the light of evidence as presented, the country can be considered a carbon sink as is shown by CO_2 removals for the 2000-2008 period. The 2002 figure is less than the other years because of the removal of forested land for oil palm plantation (Shearman et al., 2008). However, if all data for land clearance for all the years were captured, the emissions of CO_2 for those years would be at the same level as that of 2002 thereby reducing their removals down to -170,481 Gg or lower. Even at that level, PNG would still remain a net sink for carbon dioxide gas.

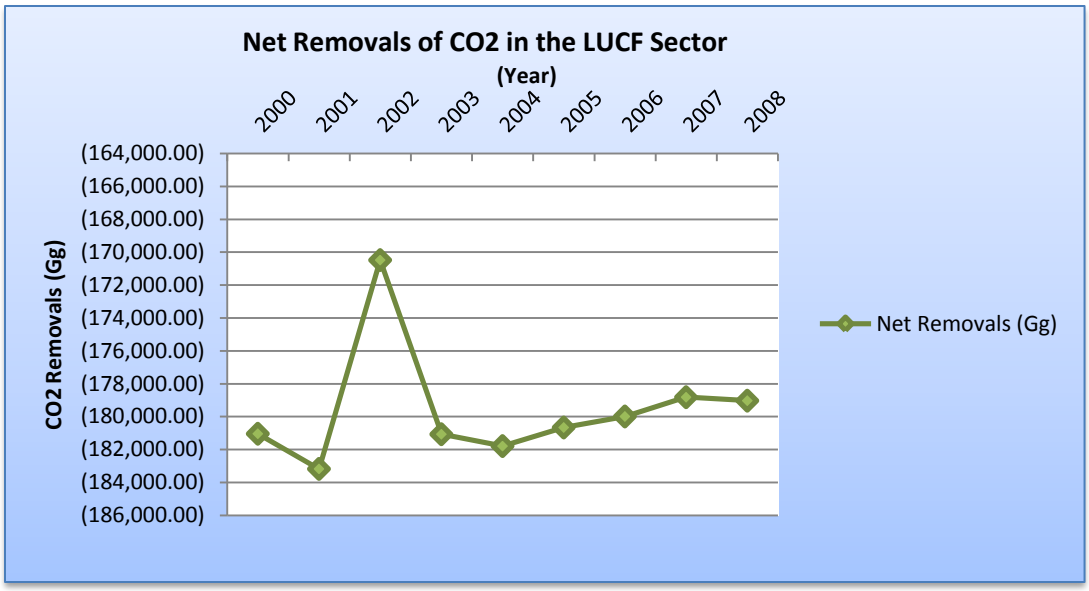


Figure 12 Net Removal of CO2 in the LUCF Sector

2.10.7 Uncertainties

There are however, a lot of uncertainties involved with the estimation of emissions and removals from the LUCF sector.

Firstly, there were not enough data used and therefore the figures presented in this report were based on the limited data received during the data collection. As such, it does not reveal the true picture of Papua New Guinea.

Secondly, the IPCC categories for the activity data do not match most of PNG's country activity data. For example, the IPCC guidelines for the different forest vegetation types do not fit well with national forest categories such as Upper Montane Forest, Lower Montane Forest and so forth. Hence, the calculations for forest clearance were done under Moist, with a short dry season only. Since the IPCC categories have default values; these were used to estimate emissions of GHGs.

Thirdly, to keep the time series' consistency, the Third National Communication could explore to estimate GHGs in forest related sections based on values reported to FAO from PNG historically.

2.11 Waste

Given the paucity of data, emissions estimates from the waste sector comprised only of methane emissions from Solid Waste Disposal sites which accounted for 2.9 Gg of CH_4 and from Domestic and Commercial Wastewater and Sludge which contributed 6.47 Gg. There was no information of data available for sludge so this estimate is only for wastewater for a small number of sources.

Most Solid Wastes from households, commercial and industrial setups within the 20 urban towns and/or cities in Papua New Guinea are disposed in aggregate quantities at open air dump sites

located at the periphery of the town/city through a road side pick-up system. Waste Management in Papua New Guinea remains a poorly managed sector with much improvement needed in the short and long term.

The recently reformed state owned company Water PNG is now set to manage water commercially in towns and cities including wastewater management.

The National Capital District Commission (NCDC) manages solid waste in the capital city of Port Moresby with a population of more than 400,000 people. Solid wastes consist of both organic and inorganic household, commercial and industrial waste, dumped at the 6-mile and Baruni open-air dumpsites. There is currently no proper waste management system to manage solid wastes in the city of Port Moresby and similarly for the other towns and cities in the country.

2.12 Constraints and Recommendation

A major constraint, faced in conducting this inventory, has been the lack of good data for the various categories of the Land Use Change and Forestry sector for the GHGI reporting period (2000-2008). Some data are kept at provincial centers but these are often not made accessible to such activities as the GHG inventory. Furthermore, most data on land use changes due to agricultural activities, kept at the Provincial Headquarters, are often not properly documented and not well managed. Given poorly managed data it would be necessary to develop a reliable data management system for future GHG inventories. Following are recommendations that resulted from the data collection during the GHG inventory exercise:

a) More awareness has to be achieved at all stakeholders regarding the GHG Inventory to enable them to correctly conduct country research and to file and manage the data needed within their area of specificity
b) Policy and structures of DAL, DEC and other government agencies have to link more strongly with the Provincial Administrations, mining companies and NGOs, to enable easy access to data for GHG inventory
c) A reliable database and GHG inventory management system should be developed and maintained within the OCCD
d) Adequate funding is required to enable relevant stakeholders to carry out research on an annual basis for the purpose of providing GHG inventory data to the OCCD
e) A government policy or legislation has to be enacted for all government departments and agencies, NGOs and relevant private sector organizations to actively participate in the GHG inventory process.

The GHG Inventory for the LUCF sector was conducted to show the commitment of the PNG Government to the UNFCCC. For the period 2002 – 2008 data collection was done and calculations were made using the UNFCCC software and other materials such as the IPCC guidelines to guide the inventory along. Estimates for the GHG emissions and removals were done under five (5) categories:

- *Changes in forests and other woody biomass stocks*
- *Forest and grassland conversion*
- *Abandonment of managed lands*

- *CO_2 emissions and removals from soils and*
- *Others (Abandonment of Unmanaged Lands).*

Of these, the Forest and Grassland Conversion and CO_2 Emissions and Removals from Soil became the source categories. The largest amount of CO_2 emissions was in 2002 from the Forest and Grassland Conversion while the emissions of other gases increased during the same period due to large areas of forestland being cleared for oil palm plantation. The other three categories of LUCF remain the sink with huge amounts of CO_2 being removed from the Changes in Forest and Other Woody Biomass Stocks as a result of the huge areas of forest plantation and natural forest, accompanied by the sustainable logging practice and the vast number of non-forest trees in the country.

2.13 Summary and Conclusions

Table 2.8 Summary (as in appendix to 17/CP.8) for 2000

Greenhouse Gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOC's (Gg)	SO_x (Gg)
Total national emissions and removals	**14,251.3**	**-190,620**	**56.2**	**15.01**	**18.2**	**163.2**	**416**	**36**
Energy	**2,436**							
Industrial Processes	**61.3**				**16**	**86**	**416**	**36**
Agriculture	**1903**		**46.7**	**15**	**2.2**	**78**		
Land use Change and Forestry	**9,851**	**-190,620**	**0.13**	**0.01**	**0.03**	**1.15**		
Waste			**9.4**					

GHG emissions from PNG have been estimated based on available data. The results are only indicative for the total emissions and/or removals profile. The energy sector data were provided only from one agency. It is known that other agencies do have some energy data but they did not make these available to the inventory team. The emissions however were calculated for the country as a whole. The data are presented for 2008, but the development over the reporting period 2002-2008 is not very clear for all categories.

3. PROGRAMS CONTAINING MEASURES TO FACILITATE MITIGATION OF CLIMATE CHANGE

3.1 Introduction

Mitigation options in PNG are largely available in the forestry and agriculture sectors where 95 percent of the country's carbon dioxide (CO_2) emissions are derived. Although the energy/energy efficiency sector, transport, industrial, mining, and the oil and gas sector together contribute about 5 percent of the country's emission, there also are options available for mitigation and with them options for the country to reduce its carbon dioxide emissions.

Papua New Guinea's total greenhouse gas (GHG) emission in 2008, compared to the entire global CO2 emissions, is estimated at 0.035% excluding LULUCF (annual emission is 14.65 CO2e) while 0.2% including LULUCF (annual emission is 102.31CO2e) (WRI,2014). Earlier in 2005, the greenhouse gas (GHG) emission was 14CO2e (0.04% of global emissions) excluding LULUCF while 99 CO2e including LULUCF (0.2% of global emissions) (WRI, 2014).

Given the high density of emissions in the forestry and agriculture sector, the option to use forests as a major sink is quite obvious for the country to pursue, in order to reduce emissions in these sectors. Likewise options for mitigation in the energy/energy efficiency, transport, industrial processing, waste, mining and oil and gas sectors are also available for the country to pursue in order to mitigate its greenhouse gas emissions.

Key Developments include:

- Developed a Climate-Compatible Development Strategy (CCDS)
- Established an Office of Climate Change hereafter referred to as OCCD
- Established an Interim PNG Designated National Authority (DNA) Secretariat within the OCCD
- Developed an Interim Action Plan for the CCDS
- Developed a REDD+ Readiness Roadmap for PNG
- Established Technical Working Groups on REDD+ and Low Carbon Growth
- Identified and established REDD+ Pilot Activities
- Encouraged agencies involved in agriculture, and forestry to develop programmes that address deforestation and forest degradation
- Work progress on the development of PNG's National Measuring Reporting And Verification (MRV) System
- Initiated work on PNG's National Forest Inventory (NFI)
- Established a Commission of Inquiry to review all existing Special Agricultural Business Leases (SABLs) in the country
- Explored new opportunities in the use of renewable energy and the efficient use of conventional energy
- Issued DNA Host Country Approval for 10 Clean Development Mechanism (CDM) Projects
- Encouraged lowering of energy consumption through demand-side management energy efficiency and conservation programmes through its participation in the Asian Development Bank Programme on Promoting Energy Efficiency in the Pacific (Phase 1)
- Participated in the Asian Development Bank Promoting Energy Efficiency in the Pacific (Phase 2).

3.2 Measures to Mitigate

In accordance to the United Nations Framework Convention on Climate Change, Papua New Guinea is obliged to prepare and publish steps taken or envisaged toward formulating, implementing and regularly updating national, and where appropriate, regional programmes containing measures to mitigate climate change by addressing anthropogenic emissions by sources and the removal of Greenhouse Gases (GHG) by sinks.

The PNG Climate-Compatible Development Strategy has identified key priority areas in mitigating PNG's GHG emissions. These include Land use, Land-use Change and Forestry (LULUCF) and Low Carbon Growth – covering aspects of energy/energy efficiency, waste transport and industrial processing.

Among these key priority areas, Reducing Emissions from Deforestation and forest Degradation, Conservation, Sustainable Management of Forest and Enhancement of Forest Carbon Stock (or REDD+) has been the major priority area of focus for Papua New Guinea in mitigating the country's GHG emissions.

Even though Papua New Guinea's emission in the power generation sector, transport, buildings, mining, oil and gas and the industry sectors are minimal, it is projected that if the country does not take actions to reduce its greenhouse gas emissions, by year 2030 a considerable increase in the amount of emissions will be escalated from high carbon intensive development activities in the country. With the introduction of Liquefied Natural Gas (LNG), it is projected that by 2030 Papua New Guinea will expect an increase in GHG emissions from its current volume of emissions in the oil and gas sector. Also, a similar increase in GHG emissions will be expected from other sectors of the economy if no immediate actions are taken in adopting a low carbon intensive business development practice.

This increase in GHG emissions comes from the oil palm, power generation, transport and the oil and gas sectors under the Business-As-Usual (BAU) scenario. This is also due to the high population growth. It is expected that GHG emissions will increase over time amounting to a total increase of approximately 11.9-16.6 million tons (or Gg) of carbon dioxide equivalent per year by the year 2030, compared to its year 2010 level of emissions at approximately 3.0-4.2 Gg of carbon dioxide equivalent per year, if no measures are taken to reduce emissions.

The current BAU growth path in PNG is carbon intensive. The GHG emissions continue to grow by up to 40 percent by 2030 under the BAU scenario. The majority of this increase would come from increased deforestation from large-scale agricultural leases, subsistence and smallholder agriculture. Noting that absolute emissions from non-land use sectors are very low compared to LULUCF sectors. However, as projected, the oil and gas emissions would rise further upwards if the natural gas produced by LNG project was retained for domestic consumption, but could be reduced if the liquefaction plant were powered by renewable energy sources.

Greenhouse Gas Emissions from the PNG Liquefied Natural Gas (LNG) Sector

Given this high density of emissions over the projected 30-year life span, there is a great need to reduce emissions in the existing LNG facilities situated at the project sites as well as the LNG Plant. Efforts were made by Oil Search Limited to reduce GHG emissions from the LNG facilities through installation of flare and vent gas conservation facilities in its Iagifu Central Processing Facility, and its Central Processing Facility Refinery. Similar efforts were also made by Oil Search Limited in its Gobe and Agogo facilities respectively.

Renewable energy

The technical potential for renewable energy sources in PNG is enormous. Much of this resource is in remote areas with limited demand and therefore is not readily exploitable. The Geothermal Energy Association estimates PNG's ***geothermal*** potential at 21.92 terawatt hours (TWh). Thus in theory the country could meet all its electricity needs from geothermal sources alone. The total installed geothermal capacity was 56 MW in 2010. ***Hydropower*** has significant potential in PNG, which contains nine large hydrological drainage basins. The largest river basins are Sepik (catchment 78,000 sq. km), Fly (61,000 sq. km) Purari (33,670 sq. km) and Markham (12,000 sq. km). There are other catchments of less than 5,000 sq. km in very steep areas. The mean annual rainfall on the mainland of PNG ranges from less than 2,000 mm to 8,000 mm in some mountainous areas and in the islands mean annual rainfall ranges between 3,000-7,000 mm. Thus the gross theoretical hydropower potential for PNG is 175 TWh per year.

Very little is known about the potential for ***Ocean Thermal Energy Conversion (OTEC)*** in PNG as little is also known about tidal energy and/or wave energy. The tidal range near Port Moresby is 2.7 meters compared to 1.1-1.6 m in most parts of the country. As regards ***wind*** energy there have been no systematic estimates of wind energy potential since the 1970s when the best potentials were assessed in Central, Western, Milne Bay, New Ireland Provinces and Port Moresby area. However, at present only one pilot wind energy project is being installed in the Duke of York Islands, supported jointly by GoPNG and the Government of China.

Solar energy provides the largest potential sources in PNG where average irradiation is between 400-800 W/m^2 with 4.5 to 8 sunshine hours a day. Twenty-three locations in PNG were assessed for solar energy potential; Port Moresby has the largest resource, with 2,478 sunshine hours per year. The lowest is Tambul, Western Highlands, with 1,292 hours. The best locations for solar photovoltaic power production are on the offshore islands and the southern regions of the country. ***Biomass*** provides another potential source of energy in PNG. Although two-thirds of PNG is covered with forest, much of it remains inaccessible or unsuited for energy use. However, much of the rural population depends almost entirely on biomass combustion for their energy needs. The main practical biomass energy potential is in areas such as logging and agricultural production, using either crop output or residues.

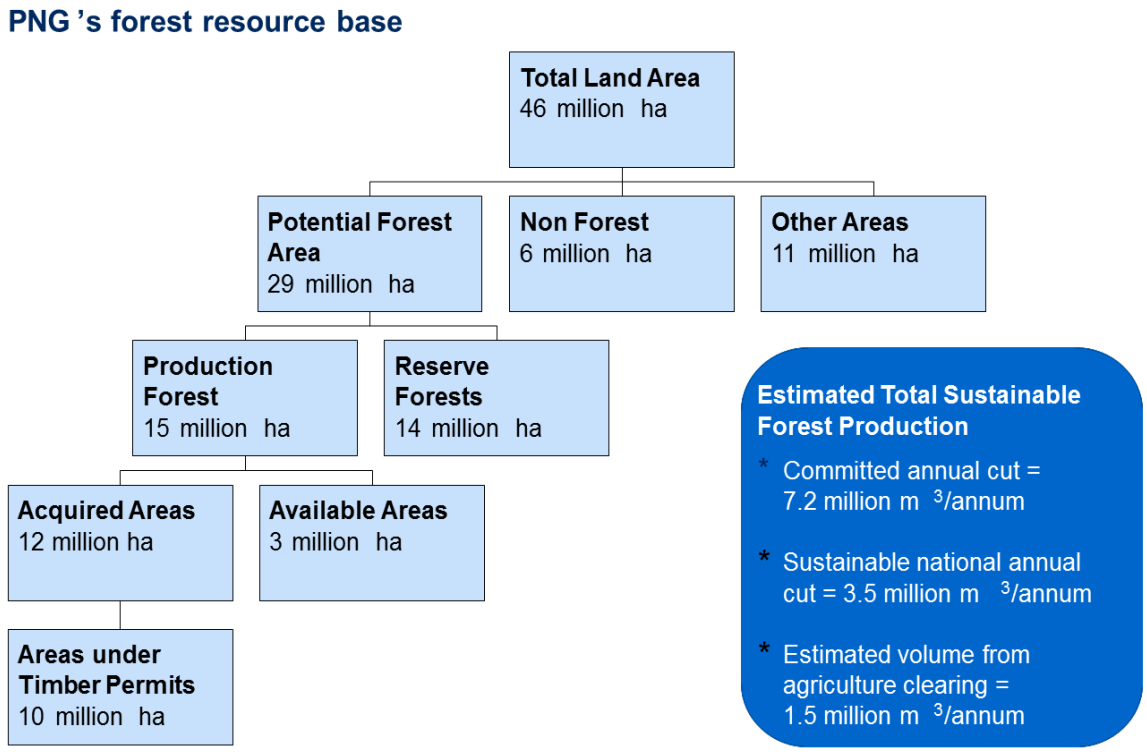
Forestry and Agriculture Sector

During the preparation of the Initial National Communication the option to use forests as a major sink is quite obvious; with large tracts of forests still intact and the potential for establishing reforestation and afforestation, this needs to be explored further. The use of intact forests for

mitigation of GHG emissions would also enhance PNG's approaches to conserving its unique and very rich biological diversity. Similarly, the options for use of biomass, biogas, hydropower, etc., from the available resources in the country, need to be tapped into to realize its potential in mitigation of GHG emissions. Moreover, the Initial National Communication did identify some important mitigation options in the energy, forestry, transport and waste; however, no analysis of these mitigation option measures was done due to lack of data.

The Papua New Guinea Forest Authority (PNGFA) estimates that approximately 60 percent of the total area of the country is covered by natural forests, of which 52 percent are classified as production forests (for exploitation of timber and other products) and 48 percent are for conservation (not for timber extraction due to inaccessibility or ecological constraints).

There is a long history of debate regarding the forestry sector in PNG in numerous reviews, independent audits and studies of the forestry sector, e.g., IIED 1998 Country Study, IIED 2001 Report edited by Colin Hunt, and PNG Forest Industry Association analysis 2006. An official assessment of the Forest Resource Base by PNGFA indicates that about 29 million hectares of land are forested of which 15 million hectares are classified as production forest having potentially high quality hardwoods species suitable for commercial development (PNGFA, 2009). The remaining 14 million hectares are classified as Reserve Forests.



Source: PNGFA, Forest Resource Base

Figure 13 Papua New Guinea's Forest Resource Base

FAO's Global Forest Assessment 2010 in consultation with PNGFA reports lower forest coverage. Based on their report, in 1990 primary forests covered 31.3 million hectares, declining to 26.2 million hectares in 2010. The annual loss of total forest area increased significantly: from -180,000 hectares between 1990-2000, to -427,000 hectares between 2005-2010. This translates into an average annual deforestation rate of 1.55 percent between 2005-2010.

3.3 National Climate Change and Development Strategies

Policies and plans have been developed for sustainable socio-economic growth of Papua New Guinea and for climate change in particular, for both short term and long term developments.

Long term Policy: Vision 2050 and the DSP 2010-2030

Papua New Guinea Vision 2050 (Vision 2050) is the country's unified strategic vision for socioeconomic growth that aims to build a "Smart, Wise, Fair, Healthy and Happy Society." Vision 2050 identifies the main challenge of socioeconomic growth to shift an economy, dominated by the mining and energy sectors, which together represent over 80 percent of PNG's export revenue, towards agriculture, forestry, fisheries, eco-tourism and manufacturing by 2050. Environmental sustainability and climate change represent one of seven pillars of Vision 2050, and many of the targets for achieving environmental sustainability and addressing climate change relate to REDD, including:

- Reduce greenhouse gas emissions by 90 percent to 1990 levels
- Establish a Sustainable Development Policy in all sectors, especially forestry, agriculture, mining, energy and oceans by 2015
- Develop mitigation, adaptation and resettlement measures in all impacted provinces by 2015
- Conserve biodiversity at the current five to seven percent of the world's biodiversity
- Establish a total of 20 national reserves, wilderness areas and national parks.

Systematical hierarchal implementation of any plan derives all actions from a master blue print; such is the Papua New Guinea ***Development Strategic Plan 2010-2030*** (DSP). The DSP is the 20 year long term development blueprint created to achieve Vision 2050 through broad frameworks, targets and strategies.

Medium Term Development Plan: MTDP 2011-2050

The Medium Term Development Plan (MTDP) 2011-2050 basically maps out sector targets for the Papua New Guinea DSP.

Climate Compatible Development Strategy: CCDS

As an enabling environment for the in-country Climate Change Low Carbon-growth Readiness drive, the Climate Change Development Strategy (CCDS) has a strong focus on the REDD+ mechanism with respect to the country's emissions derived from Land use, Land-Use Change and Forestry (LULUCF) as seen in figure 3.3 (Box 1).

Box 1: Main principles, themes and intended actions contained in the Executive Summary of the Report on Climate-Compatible Development

On 22nd March 2010, Council . . . endorsed and supported **as a matter of National priority**, the main principles, themes and intended actions contained in the **Executive Summary of the Report on Climate-Compatible Development** as follows:

(i) That mitigation of and adaptation to climate change are inseparable from economic development and future prosperity of the people;

(ii) That the national strategies and plans on climate-compatible development are to be adopted and incorporated into the other national development strategies and plans, including the **Vision 2050** and the (renewed) **Medium Term Development Plan**;

(iii) That it is necessary to reform (and in some cases to create) institutions and bureaucratic arrangements to facilitate implementation of the National Strategy on Climate-Compatible Development, taking care to ensure that there is no overlap or duplication of activities with other branches of government or the Prime Minister's Department;

(iv) That a review is necessary of all national development policies and plans which impinge upon and are affected by climate change mitigation, adaptation, and low carbon growth, to ensure climate compatibility;

(v) That research and development is commissioned and conducted to support the development of a comprehensive greenhouse gas inventory and a more comprehensive understanding of the impacts of climate change on the Country;

(vi) That collaborative efforts by stakeholder agencies and inputs from development partners must be coordinated and used to improve upon the Government's preliminary policy initiatives;

(vii) That arrangements for Measurement, Reporting and Verification (MRV) and benefit sharing must be developed such that resource owners' rights and interests are protected and that they share in the benefits from greenhouse gas mitigation schemes, including REDD-PLUS;

(viii) That pilot projects, demonstration projects and Programmes are established and managed by relevant departments and agencies, to improve knowledge and technical capacity on mitigation, adaptation and low-carbon growth, with a view to incorporating lessons from them into the policy framework and legislation; and

(ix) That a financial strategy be developed in tandem with the above stated activities, to request assistance from donors in building capacity for REDD-PLUS and other aspects of climate-compatible development.

Figure 14 Themes and intended actions contained in the Executive Summary of the Report on Climate-Compatible Development

Released by the Department of Environment and Conservation (DEC) in March 2010; the main elements of the draft CCDS and the process for multi-stakeholder consultation have been endorsed by the National Executive Council (NEC) hence, the document outlines the overall direction of the country to achieving the vision 2050 goals of 50 percent net emission reduction by 2030 and carbon neutrality by 2050. Box 1 gives the main features of the Climate-Compatible Development Strategy.

Interim Action Plan

As an intermediate mechanism through which Papua New Guinea would be able to achieve its overall climate change mitigating goals, the formulation of an Interim Action Plan (IAP) was executed. PNG's climate change objectives via the IAP have been integrated into the MTDP. The Interim Action Plan basically outlines the immediate actions and priorities to be acted upon with a timeframe of 6 to 12 months.

The National Climate Compatible Development Management Policy

The National Compatible Development Management Policy (NCCDMP) was derived from a highly intensive stakeholder consultation process and has been endorsed by the NEC. The NCCDMP gives impetus to the role of the different stakeholders within the country.

Via the adoption of core elements from the CCDS and the Interim Action Plan, the NCCDMP recognises that climate change mitigation and adaptation measures must be coupled with economic development so as to ensure;

- The Promotion of economic development through low-carbon-growth
- Mitigation of net GHG emissions through participation in a global REDD+ scheme
- Adaptation to climate change related hazards.

The convergences of these three objectives form the core of Papua New Guineas Climate Compatible Strategy, ultimately fostering environmentally sustainable economic growth whilst seizing the carbon mitigation opportunities.

3.4 Priority abatement options

A number of priority abatement actions have been identified under the Climate Compatible Development Strategy to address the drivers of deforestation and forest degradation, all of which are subject to national consultation and have not yet become domestic policy. Translation of these abatement options into policy is dependent upon a piloting and demonstration phase and in some cases reliant on international support. The abatement opportunities identified for the country include the following and are described in Table 3.1.

Table 3.1 A number of priority abatement actions have been identified to address the drivers of deforestation and forest degradation

Opportunities	Description
Reduced Impact Logging	Reduces degradation through sustainable harvesting volumes and reduce collateral damage and by increasing re-growth through replanting and treatment (silviculture practice)
Secondary Forest Management	Refers to increasing carbon stocks in secondary forests through planting, treatment or protection
Afforestation / reforestation	Involves planting of trees on PNG's widespread non-forest lands, e.g. grasslands, pasture land and scrubland

Community REDD+ schemes	Targets forest conservation through local REDD+ schemes at the community level, Implemented with help of civil society organizations
Agriculture leases review	Explores potential alternatives that allow economic developments with lesser impact on loss of forest area / deforestation
Land use planning	Envisages establishing an integrated land use plan (LUP) at the district level using TAP (Transparent, Accountable and Participatory) principle
Agriculture extension program	Aims at improving average yields and fertility over time Will allow longer planting periods and / or reduces fallow periods on the same land, thereby reducing deforestation
Commercial plantation on non-forest land	Shifts new commercial plantations (e.g. palm oil) to non-forest land by revising land use regulations, and offering compensation for loss in timber harvesting profit, assuming there is sufficient suitable non-forest land

Source: Shearman et al. (2008, 2009), Fox (2009)

Multiple abatement options are available for every driver of deforestation, hence emission drivers, such as the complete halting of an activity, to partial abatement from reducing an activity's carbon intensity. For example, complete abatement of emissions from subsistence agriculture would require a total cessation of the activity, which is clearly not a feasible option. Agricultural extension programs can provide viable options for more effective land usage, thereby reducing the stress on forests and provide an alternative means of reducing emissions. Likewise, the maximum abatement potential of the forestry sector could be achieved by a complete halt of logging nationwide. Although such an approach would result in conservation merits, it is not a mandatory requirement for REDD+. The option of Reduced Impact Logging could be a more practical alternative, particularly for existing concessions.

The theoretical cost of abatement measures such as these is estimated at approximately USD 5.6 per tCO2e, amounting to ~USD 5.9 billion through 2030. Naturally, these reductions are conditional on an international agreement that will fund REDD+ so that Papua New Guineans are compensated for the ecosystem services and mitigation benefits they contribute to the world, and for the resulting changes to their incomes and livelihoods.

Figure 3.4 below shows the cost curve for the abatement measures related to LULUCF, with the lowest cost measures on the left side near the axis and the most expensive on the right side[13].

[13] Unit costs per tonne of CO_2 abated are calculated based on cost of programmes, with the exception of agricultural leases and shifting oil palm plantations, which also include opportunity costs in the form of compensations for stakeholders that would lose revenue or income from a change in activities.

Overall, these measures would reduce emissions by approximately 60-80 percent compared with the BAU scenario.

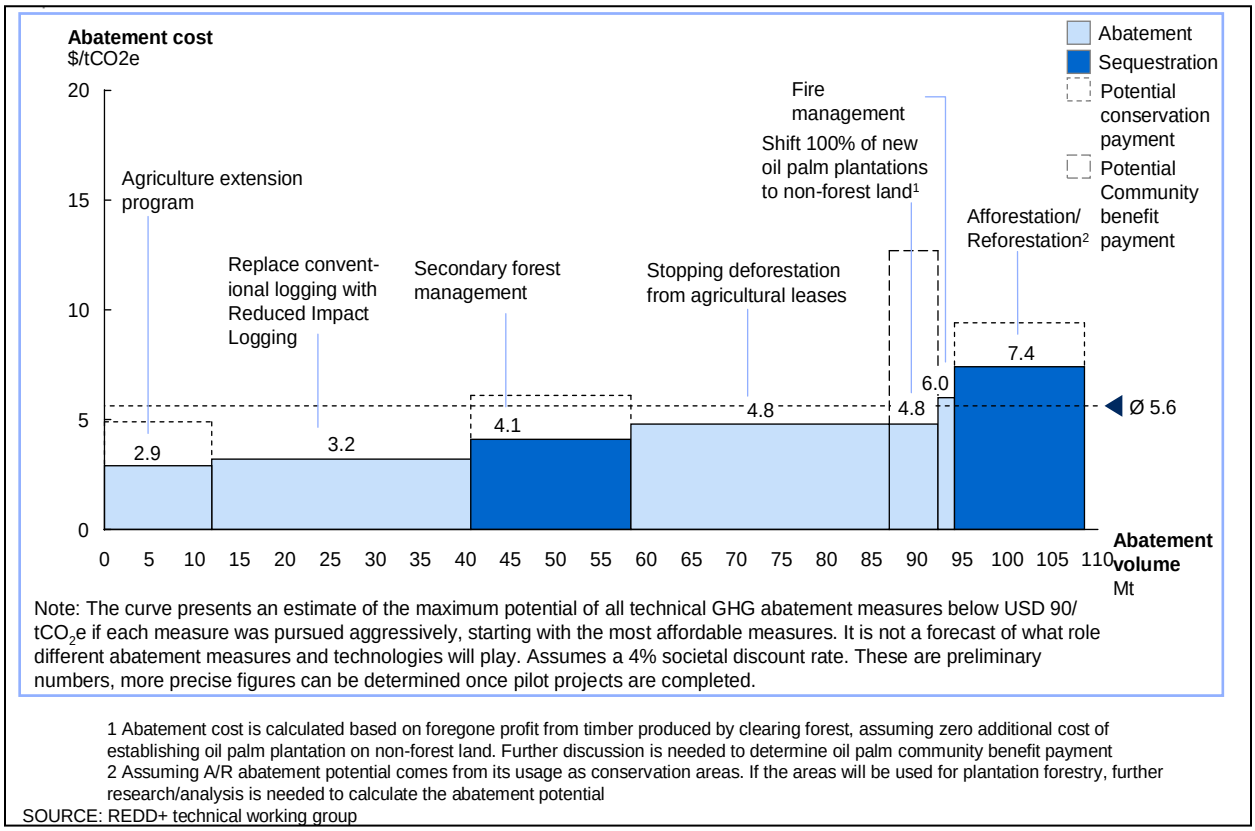


Figure 15 LULUCF abatement potential by 2030

As mentioned earlier, all the potential abatement measures are subject to national consultation and have not yet become domestic policy. Each measure is described below;

3.4.1 Reduced Impact Logging (RIL)

The implementation of Reduced Impact Logging (RIL) practices[14] in all logging concessions could save 21-36 Mt CO_2e per annum by 2030. This is inclusive of the potential to reduce forest degradation by 33-55 percent in carbon stock loss and to reduce the deforested area by ~33 percent within forest concessions. An alternative to RIL would be a moratorium of all new forestry concessions, thus restricting logging to plantation forests and resulting in a reduction of more than double the emissions (~66 Mt CO_2e per annum by 2030), although a higher opportunity cost would be incurred. Application of this initiative could also impact negatively on plans for downstream value adding activities and employment in the forestry sector;

[14] Reduced Impact Logging (RIL) differs from conventional logging in as much as it extracts commercially viable timber at sustainable volumes while minimizing collateral damage. RIL reduces degradation by minimizing logging roads, managing directional timber falling and optimizing cutting methods. RIL can reduce biomass loss to 20-30%from 40-50% through conventional logging practices and reduce the eventual area deforested by 33%, Climate Compatible Development Strategy (CCDS) 2010

nonetheless, forest conservation could create new employment opportunities and offset some job losses.

3.4.2 Secondary Forest Management

The careful selection of replanting and silvicultural practices to enhance re-growth in over-logged forests could save 14-21 Mt CO_2 per annum by 2030.

3.4.3 Afforestation/ Reforestation

The promoting and practicing of afforestation or reforestation on marginal lands; protecting watersheds and in some cases creating "forest plantations" could save ~14 Mt CO_2 per annum by 2030.

3.4.4 Agriculture Lease Review

A halt to the agriculture leases could save 27-30 Mt CO_2e per annum by 2030, that being if 60-80 percent of the ~670,000 ha[15] of the agriculture leases approved in May of 2010 are withdrawn. Approximately 40,000 ha of these have already been logged. Additional agricultural leases that have not yet obtained full approval have not been included in these calculations. A large portion of agricultural leases is awarded to commercial plantations, particularly oil palm plantations.

3.4.5 Commercial Plantation on Non-Forested Land

This abatement option has the potential to save ~2-9 Mt CO2e per annum by 2030. The full abatement potential can be achieved only by shifting 100 percent of all new oil palm plantations to degraded land.

3.4.6 Forest Conservation

The conservation of forests provides critical opportunities by means of carbon stock protection and biodiversity protection from deforestation and forest degradation. Moreover, the implementation of forest conservation measures should create new employment opportunities for local communities. Calculations for this abatement option have not been done, as they are dependent upon prior land allocation; abatement potential will defer among conservation areas formerly allocated to agricultural leases and that of wildlife management areas.

3.4.7 Agriculture Extension Program

On the premise that 25 percent of the farming communities improve their methods and preserve current forest coverage; increased yields in subsistence and smallholder agriculture by investing in agricultural extension and market access could save 9-15 Mt CO_2e per annum by 2030. The abatement effect of these measures is unproven, although they are likely to improve food security and rural income, hence their value supersedes climate change mitigation.

[15] 670,000 ha only include projects with full approval from PNGFA and DEC.

3.4.8 National Fire Management Program

Continued efforts to reduce environmental impact of large-scale mining in addition to a national fire management program could save ~5.4 Mt CO2e per year.

The abatement measures set out above have the potential to put Papua New Guinea onto a low-carbon growth pathway that will have benefits beyond reducing emissions. The number of jobs created in new sectors, such as tourism and forest management, should more than outweigh those lost in the traditional logging sector. Overall, with the right additional inputs, the economy can therefore achieve the same 6-7 percent annual growth rate under a low-carbon growth path as under the BAU scenario, with over 20,000 additional jobs created and a more equitable income distribution. In order to translate the identified initiatives into real action, pilot projects and programs need to be rolled out over the next three years.

The following section has been adapted from the Papua New Guinea Readiness Preparedness Proposal (R-PP) to the Forest Carbon Partnership Facility (FCPF) as the chapter concerned encompasses a graphic description of national programs and measures with respect to the National Circumstances with regard to mitigation activities in REDD+. The full R-PP can be attained on the FCPF.

3.5 Implementation Plans for pilot initiatives and programs

Technical working groups have identified potential mitigation, growth and adaptation initiatives, which are designed to test new concepts as well as programs, which involves scaling up and rolling out solutions that have already been developed elsewhere. Given resource constraints – both human capital and financial – mitigation and adaptation initiatives have been prioritized based upon efficacy in carbon mitigation and protecting people and economy from climate-related hazards.

In PNG, a number of activities by GoPNG, development partners, civil society organizations and the private sector are already under way, aiming at furthering PNG's progress on REDD+ readiness and field-testing. There are two types of pilot initiatives: sectorial and geographical pilot projects.

3.5.1 Sectoral demonstration activities-forestry sector

Sectoral pilot projects aim to solve challenges related to various REDD+ mechanisms, such as MRV, fund disbursement, community engagement, capability building and a benefit sharing mechanism. The REDD+ working group and its sub-working group on forestry have developed a series of initiatives in the forestry sector. These are in line with the Forestry and Climate Change Framework for Action (FCCFA) developed by PNGFA.

PNGFA, for example, is preparing five pilot projects to support the FCCFA. The projects are covering each of PNG's 5 official REDD+ pilot provinces and target Reduced Impact Logging, Afforestation/ Reforestation, Sustainable Forest Management and Conservation. After extensive

stakeholder consultation, GoPNG designated five official pilot provinces: Milne Bay, East Sepik, Eastern Highlands, West New Britain and West Sepik.

Table 3.2 REDD+ related sectoral/regional demonstration activities in PNG

REDD Pilot Province	Vegetation Types	Current REDD+ Activities
Milne Bay (Central Suau)	Mangrove, Swamp Forest, Low Altitude Forest on Plains & Fans, Low Altitude Forest on Uplands	Reduced Impact Logging (RIL)
East Sepik (April Salumei)	Swamp Grasslands, Swamp Forest, Low Altitude Forest on Plains & Fans and Low Altitude Forest on Uplands	Conversion of proposed logging Area to REDD+ Pilot REDD+ activities will be determined after a development option study (DOS)
Eastern Highlands	Grassland Lower Montane Forest	Afforestation of grassland areas Forest conservation
West New Britain	Low Altitude Forest on Plains & Fans, Seral Forest, Littoral Forest, Low Altitude Forest on Uplands	Secondary Forest Management Afforestation / Reforestation Forest conservation Reduced Impact Logging (RIL)
West Sepik	Grassland, Low Altitude Forest on Plains and Fans	Afforestation / Reforestation Forest Conservation Secondary Forest Management? Reduced Impact Logging?

3.5.2 Reduced Impact Logging

Given the large potential abatement from RIL, it is necessary to compare its impact and enforcement costs with current logging practices. PNGFA has identified the provinces of Milne Bay, West New Britain and West Sepik as priority areas for this initiative. Pilots will provide an opportunity to test RIL enforcement, silvicultural practices and MRV methodologies (both field measurements and remote sensing), and were initiated early in 2012.

3.5.3 Secondary forest management

A pilot will identify biomass regeneration rates from post-logging silvicultural practices. PNGFA has identified Eastern Highlands, West New Britain, and West Sepik to trial this initiative, which will also build the capacity of PNGFA and FRI to implement silvicultural practices, in partnership with other organizations.

3.5.4 Afforestation and reforestation

PNG already has considerable expertise and data in this area. Consequently, the scaling-up of afforestation and reforestation could begin immediately and proceed rapidly. The PNGFA has

identified Milne Bay, Eastern Highlands and West New Britain as potential locations. Implementation presents an opportunity to test different approaches (e.g., spacing of 29 trees, mix of species and monoculture) over a range of geographic and climatic conditions to determine the methods that offer optimal growth at minimal costs.

a) Forest conservation

Conservation initiatives present an opportunity to use the REDD+ scheme to maintain biodiversity and critical ecosystem services provided by forests. This initiative can also be linked with the Payment for Ecosystem Services (PES) mechanism. PNGFA has identified West New Britain, Milne Bay and Eastern Highlands as potential locations. Implementation will require strong collaboration between PNGFA and DEC.

b) Sectoral demonstration activities-agriculture sector

Integrated land use planning at the local government level should clarify and rationalize the allocation of land between forestry, commercial agriculture, subsistence agriculture and other uses, such as hunting. Pilot projects are proposed for Madang, West New Britain, Eastern Highlands and Central provinces. In order to realize the full impact, the plans need to be combined with measures to increase agricultural productivity and improve access to markets.

Agricultural extension programs in combination with integrated land use programs should lead to increased yields. A pilot has three purposes: 1) increase productivity 2) improve market information and farmers' access to markets and 3) reduce emissions associated with clearing forest for agriculture by intensifying the use of existing plots. Implementation will require collaboration with research institutions such as NARI.

3.5.5 Commercial oil palm plantations on non-forest lands

Additional research into the feasibility of using non-forest land for new oil palm should be conducted. Data generated will highlight economic differences such as yields and input requirements. Collaboration with the private sector is a key, and there is scope to build on existing projects, such as oil palm plantations that have been established on pasture land (Ramu; Madang Province) and also on anthropogenic grasslands (in Popondetta).

The idea of diverting implementation of commercial oil palm plantations to non-forest lands was also a consensus reached by the REDD+ TWG in 2010, as a recommendation for SABL developers. This was also intended to test the candidness of the Palm Oil projects to be established through the SABL approval process, so as to minimize perverse intentions for timber extraction through the pretext of Palm Oil development in PNG.

3.6 Bilateral and Multilateral support for the progression of REDD+ Implementation in PNG

3.6.1 Papua New Guinea – Australia Forest Carbon Partnership

The Prime Ministers of Australia and Papua New Guinea established the Papua New Guinea-Australia Forest Carbon Partnership on 6 March 2008. Under this Partnership, Papua New Guinea and Australia have agreed to cooperate in three main areas: policy dialogue on national

and international REDD+ policy; increase PNG capacity in forest carbon monitoring and assessment; and cooperation on participation in international carbon markets, including on REDD+ demonstration activities. As announced at the PNG-Australia Madang Ministerial Forum, Australia is contributing up to A$ 3 million in initial funding which will include technical, scientific and analytical support for the design of Papua New Guinea's carbon monitoring and accounting systems. This Partnership represents one of the support windows under the Australian Government's A$ 273m International Forest Carbon Initiative (IFCI).

Australia has worked with the GoPNG to identify an initial package of assistance under the PNG-Australia Forest Carbon Partnership. It aims to:

- Build the capacity of GoPNG institutions to articulate and implement national climate change policies that meet relevant international standards
- Build the capacity of GoPNG and other relevant institutions to develop a robust national carbon monitoring and accounting system
- Support GoPNG to engage in international dialogue on REDD+.

The GoPNG has requested that the Forest Carbon Partnership work plan would be updated; which is under consideration by officials. It is envisaged that the updated work plan would complement the REDD+ readiness efforts covered under the National Programme by lending support to areas that are not comprehensively covered in the NP.

3.6.2 Other International Forest Carbon Initiative-Australia (IFCI) windows of direct relevance to PNG

- An allocation for NGOs to develop concepts for demonstration activities to inform the development of a national REDD+ framework; this work is nearing completion, with four of the five NGO concepts presented to the Government of Papua New Guinea in July 2010;
- The Asia-Pacific Forestry Skills and Capacity Building Program commenced in 2007 to assist countries in the Asia-Pacific region increase their forest management expertise and improve carbon sequestration performance of their forests. Phase II, for which PNG is a priority country, seeks to build regional capacity for delivering sustainable forest management in support of REDD+ efforts. The project activities will address the following objectives:
    - Improving capacity to provide support for sustainable forest management and improved forest governance, law enforcement and regulatory frameworks that assist efforts to REDD;
    - Building the institutional and technical capacity needed to deliver sustainable forest management that supports REDD;
    - Adaptive and effective program, partnership and knowledge management.

A project is currently under negotiation with GoPNG, through the PNGFA, to support the development of a forest management Decision Support System (DSS) to assist PNGFA with forest management and planning of operations in support of sustainable forest management.

a) Australia – PNG Kokoda Initiative

The Australian and PNG governments have signed a Joint Understanding to work together to protect the Kokoda Track and Owen Stanley Ranges and improve the lives of communities living along the Track corridor, through the Kokoda Initiative. While the Kokoda Initiative is not a

REDD+ initiative, it may explore opportunities for 'forest carbon' amongst other income generation and development activities, which it will facilitate for the local landowners of the Kokoda Track and Brown River region. This will involve utilization of GIS and satellite imagery to assess and monitor forest carbon emissions and may therefore support activities aimed at developing an MRV system for REDD+ in PNG under the UN-REDD NP and other support programs. DEC is building capacity to support this activity.

b) European Union

The European Union (EU) is currently funding activities of UPNG aimed at supporting PNGFA in inventory techniques as well as upgrading the forest inventory mapping system. In addition, it is foreseen that two REDD+ related projects are launched in 2011. One will contribute to remote sensing forest degradation. A second project will focus on improving the productivity and quality of Teak plantations in PNG, thereby contributing to afforestation/reforestation efforts.

Moreover, the EU has also been initiating discussions with Papua New Guinea's stakeholders in view of informing them of the possibility for implementing a Forest Law Enforcement, Governance and Trade (FLEGT) mechanism.

Finally, additional funds may further be allocated to the sector depending on identification processes to be carried out beyond 2013.

c) Global Environment Facility (GEF) Support for Sustainable Forest Management

PNG is developing a Forest and Coastal Conservation and Natural Resource Management project with the assistance of UNDP, as an element of the GEF's Pacific Alliance for Sustainability, specifically under the Forestry and Terrestrial Protected Areas component. The objective of the project will be to develop and demonstrate resource management and conservation models for landholding communities that effectively incorporate community conservation areas. The key outcome will be the extent of high conservation value terrestrial and marine area, which is brought under community-based conservation and protected areas at targeted sites. PNG has received an allocation under the GEF STAR program. It is envisaged that a portion of this allocation will be used to strengthen initiatives under the GEF-5. DEC has prepared a Project Initiation Facility proposal.

GEF's support to PNG also includes a project on capacity building for sustainable land management, which will be relevant for aims to strengthen human and institutional capacity at all levels to mainstream Sustainable Land Management into government's development planning. This will be achieved through improving the information basis of characterizing the state of land degradation and its impact, raising awareness at various levels of government agencies, improving individual knowledge and skills, improving institutional structures and processes to maximize coordination, mainstream Sustainable Land Management into government's development planning processes, and incorporating the use of mainstreaming tools in decision making.

d) GIZ

Through the ICI project: "Climate protection through forest conservation in Pacific Island Countries", GIZ supported the development of a Pacific Regional REDD+ Policy Framework. This Policy Framework is designed to provide policy options to guide REDD+ policy processes at a regional and national scale, and to provide a rationale for financial support for the better management and use of forest and tree resources. The National REDD+ Programme of PNG, with its encompassing activities, will feed into this overall programme.

e) ITTO Project Proposal "National Training Program to Promote the Adoption of Reduced Impact Logging (RIL) in Papua New Guinea"

The PNGFA and the Tropical Forest Foundation have submitted a project proposal to the International Tropical Timber Organization (ITTO) for a 2-year program aimed at developing the capacity to understand, implement and regulate the adoption of RIL practices at the government and concession level among the medium to large scale forest operations in PNG. The project seeks to achieve these objectives by establishing a comprehensive training program to be developed and implemented in three pilot forest concessions. The project will also provide refresher training for all field staff of the PNGFA, Field Services Directorate to strengthen their monitoring and reporting capabilities.

f) Japan International Cooperation Agency (JICA) and Government of Japan

With the support of a PGK 20 million (700 million yen) grant from the Japanese government, PNGFA is aiming to improve its forest monitoring and data management system using remote sensing and GIS/database capabilities. The grant comes under the forestry preservation program (FPP), and was signed by the Government of Japan and GoPNG on March 19, 2010. The main objectives of the project, which focuses on software and hardware equipment, but includes training of staff from all relevant collaborators, are:

- Update the forest resource information of the country
- Strengthen institutional and capacity building of the PNGFA and other collaborators in assessing changes in forest cover
- Support PNG's capabilities to report its GHG emissions to UNFCCC.

The funds will be used to procure equipment and soft (non-physical) components, which may include:

- The Japanese Aerospace Exploration Agency (JAXA) remotely sensed data (ALOS Satellite Imagery) and other remote sensing data
- ALOS Satellite Imagery
- Geographical Information System (GIS) related equipment, computer hardware, software/licensing & software upgrading
- Ground truthing instruments
- Training in the use of GIS and Remote Sensing using satellite imagery
- Training PNGFA staff on the Global Positioning System (GPS)
- Training in field data collection and data processing
- Training of all related data management in database manner.

It is envisaged that as much as possible existing facilities (e.g. the UPNG Remote Sensing Center) be strengthened and upgraded to build local capacities in GIS/Remote Sensing interpretation. In addition, JICA is providing capacity building for officers from the collaborating institutions, particularly PNGFA, FRI, UPNG, Unitech and OCCD, amongst others on Forest Resource Monitoring for Addressing Climate Change.
GoPNG and JICA also agreed to set up a Technical Cooperation Project from 25th March 2011 stationed in PNGFA aiming at enhancing capacity of relevant institutions in PNG for monitoring nation-wide forest resource including carbon. A full-time JICA technical adviser on forest management is attached from the outset of this project. This project will be implemented in close coordination and accordance with the grant mentioned above from the Government of Japan.

It is envisaged that the UN-REDD Programme components focusing on MRV and the JICA assistance will be closely coordinated through regular meetings and exchange to ensure efforts are complimentary to each other.

g) UN-REDD Programme

The objective of the UN-REDD Programme in PNG is to ensure that by 2013, PNG has an operational MRV system that enables the country's participation in international REDD+ systems to protect its environmental resources and contribute to the sustainable livelihood practices of rural communities. This objective will be achieved through the following outcomes:

- Readiness management arrangements are in place
- National MRV system is developed
- Support is given to the establishment of RELs and RLs
- Monitoring of abatement concepts is supported
- Stakeholders are engaged in PNG's REDD+ readiness process.

The UN-REDD Programme is primarily supporting activities outlined in Component 3 and 4. This R-PP will further bridge capacity of provinces to bridge gaps with PNGFA.

The PNG National Programme of US$ 6,388,884 was approved by the Policy Board in November 2010 and transfers were made in June 2011. The Programme duration is 36 months. The PNG National Programme Inception Workshop was held in July 2011.

According to the UN-REDD Programme 2011 Annual Report, there have been significant delays in advancing national REDD readiness activities due to a number of factors, including the lack of in-country presence of two of the Participating UN Organizations, the lack of clarity on the mandates of OCCD apart from coordinating climate change initiatives, and external difficulties including political instability. In addition, the national elections in 2012 made it difficult to take on policy issues. OCCD has been asked to reconsider its approach to stakeholder engagement to ensure that solid partnerships among government, development partners and civil society are in place and contribute to achieving strategic and sustainable results for REDD+ readiness.

3.7 Existing and Progressive Community-based REDD+ demonstration activities

Several NGOs have developed concepts that involve the use of REDD+ funds to promote sustainable livelihoods and forest conservation.

These projects currently focus mostly on forest conservation and environmental and biodiversity protection and can provide important lessons learned on community engagement, land tenure issues, and community project management in PNG, among many others. It is envisaged that the experiences and learning from these activities will be incorporated into the REDD+ readiness process and that the existing activities will be leveraged to test and refine concepts for REDD+, e.g., a benefit sharing mechanism. DEC and OCCD have already established links with many of these projects and in many cases, representatives of the implementing organizations are represented on the REDD+ Technical Working Group. A preliminary review included REDD+ initiatives in Manus Island, West New Britain, Sandaun and Madang provinces. Additional on-going activities include, for example, NORAD's support to the Foundation for People and Community Development (FPCD) for REDD+ community-based initiatives, and the Eco-Forestry Forum's (EFF) REDD+ road show to raise community awareness. One road show consultation event was already held jointly between EFF and OCCD.

a) Case Study: WCS Village REDD+ Project

The Wildlife Conservation Society, with support from AusAID and in cooperation with the OCCD, has launched a Village-REDD+ demonstration activity in Manus Province that will operate at two levels: technical activities at the sub-national level, and the organization of social groups at the community level. The process will be managed by local people and their local level governments, and is consistent with local, district and provincial development plans.

Village-REDD+ is an approach to forest management designed to operate at appropriate social scales – which in PNG are often smaller social groups such as clans – and bundling forest and associated carbon into administratively and economically viable units. At the village level, the process of bringing forests or carbon to these units and receiving benefits in return will be integrated into community development that strengthens Local Level Government (LLG) planning systems – or develop them where none exist – and features local Benefit Sharing Agreements that aim to deliver on local development plans.

Manus province, part of the Bismarck Archipelago, is named after the largest island in the group and is surrounded by many smaller islands and atolls, together called the Admiralty Islands. With a total land area of 2,100 km^2, Manus Province saw 45% of its accessible forests cleared or degraded from 1972-2002.

Demonstration of the Village-REDD+ concept will allow landowners to undertake small-scale low-impact activities (which may include REDD+ projects) over their customary land. Although the approach proposed was designed with a REDD+ mechanism in mind, it is equally applicable to general community development and alternative livelihoods.

A significant component of the Village-REDD+ demonstration activity is developing and strengthening social and environmental safeguards in the design and implementation of activities. Safeguards ensure that the rights of indigenous peoples and local communities are respected, and that significant social and environmental co-benefits are delivered. The development of REDD+ safeguards will include field-testing of free, prior, and informed consent (FPIC) and a benefits sharing and distribution system (BSDS), establishing an effective grievance and dispute resolution mechanism, developing a robust and credible measuring, reporting and verification (MRV) system, and linking these to an overall REDD+ implementation framework.

The WCS Village REDD demonstration activity responds to the need for data and on-the-ground learning to inform policy development on REDD+. By designing the proposed project to address a series of critical issues identified by government partners, the outcomes will potentially have a large impact of the development of PNG's REDD+ policy and legislative framework. The OCCD Technical Working Groups (TWGs) including the REDD+ TWG, of which WCS is an active member, are the forum by which WCS will share it experiences and provide technical advice and assistance to OCCD for the development of the REDD+ policy and legislative framework. The proposed activities in this project are in line with needs expressed by OCCD for technical support, data or learning to inform policy development. It is consistent with the policy objectives outlined by the three major national agencies with responsibilities for climate change mitigation and REDD+ in PNG, including the OCCD, PNG Forest Authority (PNGFA) and the Department of Environment and Conservation (DEC).

The Manus Provincial Government and LLGs will be important partners in this project, as REDD+ activities will occur at this scale and require partnerships with local government and possibly the development of enabling legislation. In Manus Province, where the fieldwork for this project will occur, WCS has an MOU with the provincial administration to provide it with technical assistance and capacity building for environmental management, including technical support for climate change adaptation and mitigation initiatives (e.g. REDD+) and sea level rise.

3.8 Public-Private Partnerships to foster a strong REDD+ implementation environment

Although there are currently no national-level public private partnerships on REDD+ in PNG, the draft National Climate Change and Development Policy (NCCP) envisions that the private sector will also play a major role in contributing towards climate compatibility for the country. Their partnership will be vital in terms of ensuring that any economic ventures are consistent with the aspirations of the NCCP.

The NCCP intends to recognize any public-private partnership in the following key areas;

- Climate Change investment in Finance and Technology transfer, Mitigation and Adaption
- Partial implementation measures to address key policy areas alongside other stakeholders where appropriate
- Capacity Building and Development
- Education and Awareness.

4. IMPACT ASSESSMENT AND ADAPTATION TO CLIMATE CHANGE

4.1 Impact Assessment

Papua New Guinea (PNG) is among one of the island nations in the world under enormous threat from the impact of global warming and the effects of changing climatic patterns. The 4th Intergovernmental Panel on Climate Change (IPCC) report (2007) has shown scientific predictions of increased surface temperatures, thus accelerating changes in global and regional climatic patterns[16]. In PNG, climate change will likely exacerbate event-driven hazards such as coastal flooding, inland flooding and landslides, and may also introduce new hazards due to gradual shifts in climatic conditions – most prominently, further malaria penetration into the highlands, changed agricultural yields and damaged coral reefs. The natural environment already poses significant risks to Papua New Guinea today and climate change will make it worse. Hazards like coastal flooding; inland flooding, landslides and droughts take a severe toll on the people and the economy. Throughout the country, natural disasters driven by climatic conditions as well as gradual shifts in climatic conditions will disrupt daily life, damage assets and infrastructure, destroy livelihoods and endanger cultural heritage. Impacts of climate change in PNG could be summarized as follows:

1. **Coastal flooding and sea level rise will affect coastal regions in Papua New Guinea.** In the last 15 years and through four catastrophic flood events, coastal floods have affected some 8,000 people a year. On an annualized basis, the floods cause USD 10-20m of damage, displace 500 people and killed five. Rising sea levels worsen the effect of coastal floods and necessitated the evacuation of people from the Carteret Atolls and Duke of York Islands, as salinization and flooding are damaging fragile communities and cultures, making these areas uninhabitable. Social and cultural issues with the displacement of people and communities have to be addressed.
2. **Malaria severely affects our daily life, with 1.7m people infected every year.** About 60% of the population lives in high-risk malaria regions. In the last 20 years, climatic changes have worsened the effects of malaria; with rising temperatures, the parasite has established itself in the highlands where it was not previously present. Additional rises in temperature over the next 20 years will introduce malaria to previously risk-free regions and could worsen the impact of malaria for those living in low-risk zones.
3. **Inland flooding, driven by heavy irregular rainfalls, regularly affects valleys and wetlands in both lowlands and highlands.** The effects of inland flooding are amplified by steep inclines and deforestation. Based on 19 years of data, 22,000-26,000 people are affected annually by inland floods, displacing 6,000-8,000 and typically resulting in a few deaths each year. Public records estimate annual damage at USD 8-12m, a burden usually shouldered by the poorest people in the country. Changes in climatic conditions – both through increased average precipitation and increased extreme rainfall events – will strongly affect the impact of inland floods.

[16] The recent Fifth Assessment Report (2013) confirms these trends with even more certainty.

4. **Sea temperature increase and acidification may over time destroy Papua New Guinea's coral reefs, the fifth largest in the world.** Between 50,000 and 70,000 coastal inhabitants rely on coral reefs for their food, livelihoods and shelter. Not only do the reefs contribute to economic growth through fisheries and tourism, they protect the coastlines from storms and loss of land.
5. **Landslides, triggered by increased rainfall intensity and land use changes, destroy vital assets in mountainous areas.** In recent decades, landslides have caused considerable damage to road infrastructure and remote communities. The effect of landslides is not well understood given the unpredictability and remote impact. At the same time, landslides have caused significant damage along the Highlands Highway, the sole lifeline for the highland communities and export businesses. Changes in precipitation patterns and land use are likely to increase the number of landslides.
6. **Variability in agricultural yields will affect many agricultural regions.** The highland regions are particularly sensitive to variability in agricultural yields as a result of change in climatic conditions. Sweet potato, coffee and cocoa are examples of climate-sensitive crops that Papua New Guineans are dependent on for food and livelihood. Subsistence farmers will be the most affected by changes in the climatic condition, and may need to look for alternative crops.

4.2 Methodologies

The information generated for the V&A assessment followed two principal approaches: (i) a consultative process involving key stakeholders and/or sectors and (ii) a modeling approach using climate change and sea-level rise projections for different time horizons in the future. These approaches enable the impacts analyses and identification of adaptation options, measures and strategies. The V&A assessment is regarded as a living document; i.e., it will be updated and presented on a regular basis and will depend on the availability of resources and expertise. The periodicity of V&A assessment is considered significant for the Bahamas as the needs and priorities for adaptation to climate change over the long term will more than likely change as with the projected changes in climate change and sea level.

All of the frameworks and approaches are based on and/or are closely aligned with the common methodology of the Intergovernmental Panel on Climate Change (IPCC 1996) and derived methodologies and approaches: United States Country Studies Handbook on Vulnerability and Adaptation Assessments (1996) and the UNEP Handbook on Vulnerability and Adaptation Assessments (1998). Additionally, a number of other approaches were used to collect information and to help characterize future climate change risks. These include focus meetings and consultations to find out past, present and future activities relating to V&A in the various sectors and to ascertain the needs and priorities for V&A within each of the sectors. The process of stakeholder consultations took about one month initially and continued through the cause of the V&A process.

4.3 Vulnerability Assessment

Past experience has shown that some areas in PNG are more vulnerable to food shortages than others. The following summary points can be made about "vulnerable areas" to food shortages:

- The severity of the impact of the 1997 event increased with distance from the Equator. Rainfall deficits were worst below 5 degrees south.
- Areas above around 1800 m altitude can be frosted, but the dangers of frost are greatest in valleys and basins into which cold air can drain and settle. Areas that are regularly frosted are well known locally.
- People with cash savings from marketing of crops or other cash earning activities, or with relatives with cash, were best able to reduce the impact of the drought. People with little or no savings, with few or no relatives in employment, or with no political representation, suffered disproportionately.

The places where these people live have poor access to services and markets. They are commonly located away from roads, along provincial borders, inland between the highlands and the lowlands, or inland on the larger islands and on most of the small islands. Even in normal times living conditions in these places are poor and government services are minimal. Cash incomes are very low and child malnutrition rates are well above the PNG average (ACNARS, 2006).

The largest equatorial island hosts the 3rd largest tract of rain forest on earth, having a large coverage of coral reefs and mangroves. These natural settings constitute the character of the island country and determine the culture and heritage of the community. In fact the life and livelihoods of the majority of the population depend on the sustenance of these natural resource bases. Climate change is threatening these life giving natural resources. The population is increasing at a very high rate of 2.7%. Safe drinking water and sanitation coverage is very low and is going to be more difficult to provide because of climate change. The health system is not at all adequate and is going to suffer further following climate change; for example if the highlands become a malaria epidemic zone, this will be an unbearable burden for PNG. The communicable and non-communicable diseases reduce the work force ability and thus reduce productivity of the country. Disasters in the changing climate are expected to further erode people's assets and reduce livelihood opportunities if appropriate adaptation measures are not taken immediately. Increased stress to the life and livelihoods of the millions of people in the village-based society could impose further abuse against women, children, elderly and people with disability.

Through this analysis of existing situations and in consultation with different levels of stakeholders, the adaptation technical working group prioritized sectors, locations and communities for adaptation measures and options. PNG has prioritized the water sector, the agriculture sector, the health system, and forestry, fisheries, biodiversity and disaster management. The water sector includes the management of coastal zones, inland waters, potable water and sanitation. The fisheries sector includes coral reefs and forestry includes mangroves.

4.3.1 Water Sector

The water sector in PNG is vulnerable to hazards like coastal flooding and inland flooding. The PNG water sector also has a challenge to provide safe drinking water and sanitation to the

communities. Irrigation to agriculture during drought could be an adaptation option, which has to be discussed in the agriculture adaptation section.

4.4 Adaptation Strategies and Measures

4.4.1 Approach and Strategies to initiate the adaptation process

The overall goal of the adaptation is to increase the country's resilience to climate change and reduce its adverse effects on various economic sectors and : and to maximize the use of opportunities which arise from climate change. Addressing climate change involves huge resources both in terms of capacity and funding. It is practical to take a strategic approach for prioritization and action. To achieve this goal PNG is taking strategies, approach and principles to start its journey towards climate compatible development process in PNG. The overarching strategies 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 & local level
- Mainstreaming climate change concerns into national development plans (Sectoral plans for national, provincial, districts and LLG)
- Adaptation Research to fill knowledge gaps and ensure adaptability
- Target selected areas, ecosystems, and infrastructure, areas of special importance, as well as special vulnerable groups and make them resilient.

The following approaches will be used to put appropriate adaptation in place:

- The key elements of the climate compatible development strategic approach are: participation; partnership; targeting; learning by doing and replication
- Address the issues through biophysical as well as socio-economic interventions
- Tackling climate challenges at different levels including community, LLG, district, provincial and national level
- Functional partnership across all levels of governments and across all departments, NGOs, and academic and research institutes (both national, regional and global).

Following are some principles to guide the adaptation process:

- The climate (and variability) change is a development challenge for all stakeholders
- Building community resilience under girding livelihoods and reducing dependence on ecologically fragile sources
- Integrate climate-related concerns in national development planning (climate compatible development at all levels)
- Analysis of global, regional and national impacts form the basis for adaptation.

PNG is vigilant in tracking the challenge of climate change and in taking its preparation to build the resilience of the community. In this regard a comprehensive approach to climate risk management and adaptation has been taken. However, it is not possible to address everything at a time and as such it is necessary to adopt an overarching strategy that will address the immediate concerns, targeting specific locations, communities, sectors and areas of special importance which shall pave the way to address similar concerns in other parts, sectors,

ecosystems, communities etc. PNG has recently prepared a climate sensitive vision 2050 and accordingly CCDSs, MTDPs, ESEG policy and so on. Different sectors are also sensitized and oriented and are taking steps in developing strategies and plans to deal with climate change in their respective sectors. Examples are: drought coping strategies, CC implications and strategies for PNG agriculture, forestry adaptation action plan, water and sanitation plan etc.

4.4.2 Strategic Priority for Mainstreaming Adaptation

Mainstreaming Climate compatible development and adaptation in to the national development process involves large numbers of entities including public bodies like the national planning authority, ministries, departments, provincial, district and local level government bodies, private entrepreneurs, NGOs, civil societies and communities by large. The strategy is to make entry points into priority sectors and levels and then elaborate within those sectors and levels and again into other sectors. Adaptation technical working groups are represented by different sectors and are the entry points in terms of professional engagement for the respective sectors. Mainstreaming will begin with a selected unit of professionals in selected sectors and then gradually expand. On the other hand specific interventions also have to be selected among many potential ones. For example deal with risks of a selected area by establishing a levee and then replicate this in other areas. Similarly, other sectors shall be brought on board gradually. This modality will be followed for private sectors, NGOs, Communities and ecosystems. PNG will achieve this goal by adopting a long-term strategy based on three key pillars:

Pillar 1: Improve the capacity of institutions to:

- Increase awareness and understanding of climate risks in their respective sectors
- Enhance risk assessment, develop screening tools; this is needed for policy adjustment
- Promote research to fill knowledge gaps
- Reduce impact on human health
- Early warning systems, disaster preparedness and improve fast response relief
- Climate Compatible Development Center (CCDC) [established and mentored by OCCD, DEC]
- Special emphasis on LLGs capacity development and local governance.

Pillar 2: Strategic Priorities for Climate change adaptation and compatible development

- Priority sectors (Agriculture, Water, Health, Forestry, Fisheries, Infrastructure, Coastal zone and Disaster management)
- Engage the whole government in dealing with climate change adaptation and climate compatible development. Involve local governments at all levels, right from the planning through to implementation. Ensure functional participation of communities
- Priority communities (e.g. Atolls, subsistence farmers in drought prone areas, communities living at higher altitudes etc.)
- Areas of special importance (commercial/industrial locations, protected areas, biodiversity hot spots etc.).

Pillar 3: Develop financing instrument(s): For example establish and operate a multi donor trust fund for climate change adaptation and compatible development. Harvest from different global funds for climate change adaptation and mitigation. PNG government could devote revenue fund for this purpose.

4.4.3 Improve the Capacity of Institutions

a. Increase awareness and understanding of climate risks into their respective sectors

In PNG the top level officials in DEC and the adaptation technical working group members are sensitized and aware of the climate concern and accordingly championing and proactive in making higher level strategic and policy documents. However, the professionals in the government in different sectors and levels who are operationally functional are yet to be sensitized, oriented, trained and educated in better understanding climate change risks, risk assessment, designing and devising adaptations measures, options and developing climate compatible development programmes for their respective sectors and levels.

b. Enhance risk assessment, develop screening tools; needs for policy adjustment

Data collection, collation and analysis, which are essential to assess risks, are inadequate in all sectors in PNG. Data collection, collation and analysis in a systematic and long-term approach on climate parameters (NWS), water sectors (water branch, DEC) and all other sectors have to be in place. Climate impact prediction modeling has to generate scenarios, which will determine the degree and level of risk depending on the resilience of the community, ecosystems and the infrastructures. It is necessary to enhance capacity in this regard. Current climate change vulnerability and adaptation assessment however had to use regional CC projections and reports on the south pacific including PNG, which were prepared by external experts. The sector professionals should also develop a screening tool (set of indicators) for their respective sectors. Application of these sets of indicators collectively will ensure coherent sectoral development programmes and projects on climate compatibility. The screening tool ultimately will be used at the planning authority level (National Planning Department) as a measuring stick to ensure that development planning is climate compatible. The policy makers and professionals of the sector should also revisit sector policy and make necessary adjustment to create an enabling policy environment conducive to climate compatible development.

c. Promote research to fill knowledge gaps

The impacts of the climate change at different stages of the life cycle of the natural resources are yet to be understood. At the same time the adaptability of the ecosystem, species and the communities are not well known. In real terms we know little in this regard. To answer to the development challenge in the changing climate, it is necessary to generate knowledge to fill the gaps. Examples are: promoting research on drought, flood and saline tolerant varieties of crops; understand health risks and generate options to overcome these; design infrastructure to withstand the impacts of changing climate; and also livelihood options.

d. Reduce impact on human health

Increase knowledge and awareness of the health consequences from climate change within and outside the health sector; prepare mitigation and adaptation plans based on a vulnerability assessment of the national health system; ensure coordination with, and advocate for decisions on climate change in other key sectors that enhance public health.

e. Early warning systems, disaster preparedness and fast response

Improvement of the early warning system to communicate early warnings with increased lead-time to the respective community in a language they understand (e.g. through community radio)

and to all stakeholders will reduce the impacts significantly. Strengthening capacity of the relevant institutions to reduce risks, through preparing the community and all relevant stakeholders, will reduce impacts. Enhanced capacity of the respective institutions for response relief to the remaining impacts is essential.

f. Climate Compatible Development Center (CCDC)

A "Climate Compatible Development Center" shall be the center of excellence to support all stakeholders to mainstream climate risk management towards a climate compatible PNG. The Office for Climate Change and Development (OCCD) shall be hosting such a center and shall provide support for, (but will not be limited to) the following:

- Revisit relevant sectoral and national policies and adjust these to address climate change concerns
- Climate Risk Assessment (prediction modeling, vulnerability, community impacts)
- Adaptation Research (for different sectors, ecosystems, communities)
- Capacity building (both professional & institutional and central &local level)
- Development of tools (screening, indicators, monitoring, evaluation, training modules, ICT materials etc.)
- Community empowerment (social communication)
- Coordination of mainstreaming activities among stakeholders (e.g. ministries, departments, academics and others)
- International & regional communication (negotiation, sharing, exchange)
- Knowledge management (library, website, database, portals, etc.)
- Policy advocacy to ensure policy directives.

4.4.4 Strategic Priorities for Climate Change Adaptation

Climate change impacts all spheres of life and livelihoods directly or indirectly. Every life form is dependent on climate, and the non-living environment is also dependent on the climate system. Some systems are already impacted and will be more profoundly and compounded in future. Impacts on some other systems are not yet visible but the indication is there. It is necessary to understand the broader context of adaptation in PNG to appreciate communities and their needs before prioritizing sectors or locations or communities for adaptation measures and options.

The PNG society is predominantly villages-based and depends on a subsistence economy. About 85% of the 7 million people of PNG, the small farm holders, or fishers living at high mountains or in the islands realize their livelihoods from the natural resource bases. The transition economy of PNG is gradually drifting towards a market economy. The infrastructures are poorly developed. Remoteness is historical due to geographical reasons and topography. Access to health facilities, safe drinking water and sanitation are limited. Education is not up to the mark. Social equity and gender equity are skewed and violence against women is profound. A widely accepted paradox regarding PNG is, that it is resource rich by being a resourceful country yet vulnerable to climate change and other shocks.

Rain fed agriculture, harvesting forest products or collecting resources from the coral bed depends on sustainable natural environment processes. The climatic condition, shocks,

variability and trends dominate natural environment. Any perturbation in the climatic parameters influences the agriculture and resource harvesting. Failure in crop put the village-based society in to food shortages.

Large numbers of rivers bless PNG and the middle reaches of some of the rivers are fast flowing and overtopping and flash-flooding is regular along with normal flooding. Following CC, the rainfall during monsoon will likely increase and floods could be more frequent.

SLR and enhanced wave actions are predicted to increase coastal flooding.

Erratic precipitation, in particular increasing dry days and drought conditions along with ENSO, affects crop production. La Niña following ENSO brings a wetter and warmer situation that increases pest infestation and disease outbreak, damaging crops. Currently, nineteen of the 89 districts have existing and emerging food insecurity based on energy intake per capita. During the 1997 El Niño drought, some 200,000 people were considered to be in a life-threatening situation with little or no food other than that hunted and collected from the bush. Another 980,000 people were estimated to have had inadequate amounts of food available from gardens, sago palm, coconuts or freshwater fisheries. Fires following drought destroyed many sago swamps in the Gulf Province.

Sixty-three percent of calories consumed by rural people are derived from sweet potato and 11.6% from imported and locally produced rice. In PNG, food security for more than one million people in vulnerable parts of the highlands and lowlands is now seriously at risk because of recurrent and strengthening El Niño and La Niña events. More intense El Niño, La Niña conditions are also being experienced (*bringing drought and flood conditions*) - disrupting food production on many islands and threatening food security for some **50,000** rural smallholders. For coastal dwellers in PNG (**20,000**) farm production is also being threatened by rising sea levels, cyclones and tidal waves which are causing saline contamination of farmland and destroying food crops and sago plantings. The most common causes of widespread food shortages in PNG are too much rain, too little rain and, at higher altitudes, very low temperatures.

4.4.5 Coastal Flooding

In order to identify appropriate adaptation measures and assess their feasibility, different types of measures have been considered for coastal flooding. The adaptive measures have been analyzed in the following categories:

- Infrastructure based: measures that require physical changes to existing assets or building of new assets
- Technological/ optimization responses: Any measure that requires adaptation or use of a different technology, process, or input
- Systemic / behavioral responses: Measures that involve behavioral change or a coordinated systemic response at a community level
- Financial responses: Financial risk transfer mechanisms and alternative financial solutions.

The following coastal flooding countermeasures have been considered and after thorough investigation, feasible ones have been taken into cost curve (although there were some feasible ones not included in cost curve).

- Build dikes / complete water retaining defence: permanently and absolutely hold back sea level in high-risk – high-asset value areas using 4m-high coastal dike system (e.g. Wewak city)
- Create offshore breakwaters: Build concrete and rock structures offshore and parallel to the coastline to reduce wave energy reaching the shoreline
- Develop mangrove buffer: Restore and expand natural coastal mangrove buffer to 100m thickness in order to dissipate wave energy and reduce flooding risk
- Build sea walls / retaining walls in strategic locations: Armor coastline with rock revetments in populated areas, to dissipate wave energy and prevent erosion
- Beach nourishment: Import or relocate sand from elsewhere in the islands or offshore to keep beaches at constant width despite erosion
- Elevate all new near-shore structures: Continue to build in hazard zone, but require that all new structures be elevated on 2m stilts, as in parts of SE Asia
- Revive the reef system: Identify and minimize anthropogenic stresses such as pollution on coral reefs and encourage their recovery
- Flood-adapt home usage: Require flood-adapted interior fittings, primarily by moving all electrical connections and panels up (to second story, or to purpose-built platform) for residential and commercial buildings below 4m
- Set all new buildings/infrastructure back from shore: Cease all building below 4m above current sea level; enforce setback law for all new buildings
- Risk transfer at international level: Insurance designed to protect whole of PNG against the sudden impact of rare but extremely severe events (reinsurance, catastrophe bonds like World bank Multi Cat, etc.).

Table 4.1 The team investigated the following measures through a case study in Manus

Infrastructure/Asset based response • Install Gaven baskets • Plant mangroves • Build seawall • Build breaker on reef	Systemic/ behavioral responses • Set up community ownership scheme • Install early-warning system • Integrate climate-proofing in planning • Relocate communities / move back • Discourage removal of reefs • Limit population growth
Technological optimization response • Climate-proof infrastructure • Improve building code	Financial responses • Set up disaster fund • Offer favorable microfinance product • Offer tax-breaks for disaster victims • Make insurance mandatory for commercial assets

The team prioritized the following measures for coastal flood proofing and conducted cost benefit analysis:

- Plant mangroves

- Build seawall
- Build breaker on reef
- Relocate communities / move back

Table 4.2 Cost of measures and people protected

Measure	Total cost million USD	Protected Population (x 1000)	People protected %	Cost/protected Person/year USD
Construct seawalls	120	326	5	18
Plant mangroves	22	750	12	1
Set up EWS	2	2304	35	<1

a) Planting mangroves

A total of 1500 coastal communities without significant infrastructure around islands and the North-East of the mainland have to be targeted for planting 1km of mangrove per community. Mangroves have to be planted over 5 years. Investment required USD 2,000 per km (total 3 m USD) and USD 750 per km p.a. for maintenance (USD 1.1m annually, mangrove matures in 5 years). Total cost for planting mangroves USD 22m between 2010 and 2030.

b) Sea walls

A total of USD 140m has been estimated required in the next 20 years to protect coastal communities and cities against coastal flooding. Implementation of the interventions will be in selected areas. To protect the coastal communities against coastal flooding, two measures have been identified through condition analysis, field visits, expert opinions and community suggestions. Analysis of the flood return period, took the SLR, increased rainfall and the topography of the land mass and the river network into consideration. Building of site specific sea walls of average length: 6km (scaled by population) in 9 coastal cities with more than 15,000 inhabitants will require an investment of USD 95m and maintenance cost of USD 1.4m annually totaling USD 120m between 2010 and 2030.

USD 105m is required to fund both measures in the first five years. Total investment cost for seawalls will be USD 94million, maintenance cost: USD 26million (no discounting). For planting mangrove the total investment cost is: USD 3m, maintenance cost: USD 19m (no discounting).

c) Early warning for coastal flooding

In order to initiate and maintain an early warning system for coastal flooding it is assumes that installation and operationalization of 25 offshore sea level gauges will be necessary. The following costs have been assumed:

- Total hardware cost: USD 175k (Gauge: USD 1,000, Communication: USD 4,000/gauge, central processing: USD 50,000)
- Requires 5 FTE's to install a USD 25k salary
- Logistics cost of 500 USD per FTE per day

- 2 permanent FTEs staffed for repairs
- 5-year replacement of gauges

Total cost: USD 3m between 2010 and 2030, Investment: USD 1m, Maintenance: USD 100k annually

Table 4.3 Cost benefit and loss averted by different measures identified and estimated on Manus Island

Adaptation measures	benefit	cost	CB ratio	Loss averted
Mangrove planting	1.1	0.4	0.3	8%
Building sea wall	3.1	2.1	0.7	31%
Moving inland	1.2	2.3	1.8	41%
Building breaker on reef	0.2	3.3	6.3	44%

Planting mangroves and constructing sea walls are cost effective and are recommended as adaptation measures and establishing an early warning system has been recommended as well.

Planting mangrove and sea walls are recommended for all LLGs in Manus. The adaptation technical working group under the leadership of DEC has proposed interventions by locations and identified responsible institution and indicative budget for implementation.

Table 4.4 Adaptation initiatives – Coastal flooding

Interventions	Objective	Responsible institution	Proposed location	Proposed budget	Timing and next step
Mangrove protection	Involve coastal communities in planting and maintaining mangroves	MRIC / UPNG DEC TNC WWF WCS	North/Islands Finschafen Morobe Madang New Ireland Manus	2010:USD 0.6m 2011:USD 0.8m 2012:USD 1.0m 2013:USD 1.3m 2014:USD 1.5m	Consultation with villages Hire/train field staff
Sea Wall protection	Build seawalls around top 5 high risk cities	DoW (national + provincial Town Authorities SMEC	1. Wewak 2. Lae 3. Madang 4. Buka 5. Vanimo	2010: USD 8m 2011: USD 8m 2012: USD 8m	Contact provincial works manager / city manager
Early warning system	Set up coastal flooding warnings system	NWS NDC SEAFRAME Dept: of Minerals	Bismarck Sea	2010:USD 0.5m 2011:USD 0.6m 2012:USD	Set up NWS, NDC, private partnerships

	and expand monitoring	and GeoHazards_ Prov. authorities Media Private sector		0.1m 2013:USD 0.1m 2014:USD 0.1m	

4.4.6 Inland Flooding

The following broad range of adaptation measures has been considered by the Adaptation Working Group:

Infrastructure/asset based:

- Levee: Increase height of river bank by small structure
- Dike: Water retention structure, several meters away from riverbank and several meters high
- Flood storage (or basin): Underground tank that stores excess water
- River training: Increase width of river
- River diversion: Shortcut meanders which reduce flow for part
- Drainage: Spillway for excess water (upon levee/dike breach).

Technological/ optimization responses:

- Flood monitoring network: Series of towers with measurement gauges and communication around flood prone river systems; connect to flood warning system
- Interface with private monitoring stations: Ensure institutional arrangements are in place to interface with private sector monitoring capabilities (e.g. PPP)
- Extend monitoring network to informal locations: Use public facilities for gathering data (e.g. schools, government buildings).

Systemic / behavioral responses Measures:

- Flood warning: Signal population around river; 3 levels of warning; work together with network providers or radio stations (local languages)
- Flood awareness program: Educate flood vulnerable communities on actions during flooding
- Local flood reporting: Reporting system for flood vulnerable communities to warn other communities
- Monitoring of buffer zones: Monitor buffer zones around river (e.g. land cover, existing barriers)
- Develop current capacity in monitoring and warning.

Financial Responses:

- Build government capability to mobilize aid / rebuilding: Transition from status quo (mainly aid/donors) to government
- Flood insurance: Offer attractive micro-finance for flood-hit areas: Offer micro-finance credit at preferential rates for flood-hit communities.

Table 4.5 Examples of adaptation measures practiced world wide

Infrastructure/ asset based responses • Maintain existing defenses to 1:100 yr event • Flood warning • Sea wall • Drainage/irrigation system for agricultural lands • Drainage in urban area • Build dam or dike to protect agricultural lands • Bunding/small scale drainage solutions • Mangrove protection	Technological/ optimization responses • Contingency design • Divert water through new & exiting water courses • Regulatory power • Flow monitoring • Drainage improvement • Electrical system hardening • Outflow capacity increase • Flood resistant seeds (rice and sugar case) • Change building code for new construction • Change crop mix (diversity agriculture) • Early warning monitoring system
Systemic/ behavioral responses • Public performance data • Emergency planning • Independent drainage board • Mandatory minimum drainage performance • Appointment of "Principal Drainage Engineer" • Monitor ground water level • Early pumping • Good repair guide • Education in self help • Online flooding A to Z • Change zoning policy/land use • Emergency response plan	Financial responses • Drainage charging • Compulsory flood insurance • Polluter pays principle • Individual flood insurance (index or indemnity based) • Multi-National-Pooling solution • Governmental insurance solution (e.., weather derivatives) • Contingent capital • Forgivable debt • Cash reserves

Building levees, drainage levees and an early warning system have been prioritized as adaptation measures for inland flooding. Lae is the prioritized location for inland flood protection. The cost benefit ratio for protection from inland flooding is 45% recovery of loss. USD 170m is required in the next 20 years to protect medium-sized towns around PNG's major rivers.

a) Building levees

Levees of 2km long need to be built in 25 medium-sized river towns (about the size of Ambunti) over a 5 year time period, which will require an investment of USD 1,500k per km and USD 25k per km p.a. for maintenance. Total cost will be USD 88m between 2010 and 2030 including investment of USD 69m and maintenance cost of USD 1.2m annually.

Draining the towns within levees will require a 4 km drainage network of 2x3m concrete lined channels. Investment of USD 1,400k per km and USD 75k per town for maintenance will be required. Building drainage channels will take over 5 years and will involve a total cost of USD 61m between 2010 and 2030 including an investment of USD 33m and USD 1.7m annually for maintenance (Source: CCDS, Adaptation TWG, web searches, team analysis).

USD 100m is required to fund both measures in the first five years. For building a levee total investment cost is estimated at USD 69m, with maintenance cost of USD 19m, (no discounting). For draining the town the total investment cost will be USD 33m, maintenance cost: USD 29m (no discounting).

b) Early flood warning system

An inland early flood warning system will cost USD 7m over 20 years. This includes investment of 1m USD and maintenance cost USD 300k annually. A coastal early warning system will cost about 1m USD on investment and 1m USD in maintenance (5 years). About USD 4.5m is required to get both warning systems (inland and coastal) up and running in the next five years.

Some more detailed costs:
Central processing:
- Cost for material: USD 50k
- Monitoring: 2 FTEs p.a. at USD 35k.

Rain gauges:
- 100 wireless rainfall gauges on wireless telecom towers
- Total gauges cost: USD 50k at USD 500 per gauges
- Requires 2 FTEs to install at USD 15k salary for 2 years
- Logistics cost of 200 USD per FTE per day.

River flow gauges:
- 40 wireless river discharge gauges
- Installation cost of USD 15k per gauge.

General maintenance:
- 5 permanent FTEs staffed for repairs at USD 15k salary
- 5-year replacement of gauges.

Table 4.6 Cost of measures and people protected

Measure	Total cost USD million	Protected Population (x1000)	People protected %	Cost/protected Person/year USD
Build levees	88	69	1	64
Construct drainage	61	69	1	44
Set up early warning system	6	133	2	2

Building Levees, construct drainage and early warning are cost effective and are recommended for protection of Lae. The adaptation technical working group under the leadership of DEC has

proposed interventions by locations and identified responsible institution and indicative budget for implementation.

Table 4.7 Adaptation initiatives – Inland flooding

Interventions	Objective	Responsible institution	Proposed location	Proposed budget	Timing and next step
Lae flood protection	Implement range of measures along Bumbu river to protect Lae	DoW (Lae) Lae City Authority Prov. Administrator NDC SMEC	Lae	TBD	Refine/present proposal to Lae prov. Admin.
Flood warning system	Build extensive meteorological measurement network in partnership with private sector	NWS NDC Dept. of Minerals and GeoHazards Provincial authorities Media (e.g. radio) Private sector (e.g. mobile telecom)	Along flood prone rivers (e.g. Sepik, Bumbu)	2010: USD 0.4m 2011: USD 0.6m 2012: USD 0.3m 2013: USD 0.3m 2014: USD 0.3m	Set up partnership _ Select equipment

(OCCD; CCDS, 2010)

4.4.7 Safe drinking water and Sanitation

PNG water development board, the responsible government agency for providing safe drinking water and sanitation has developed "Strategic Water Supply and Sanitation Development Plan 2006 – 2015" and also strategic and medium term corporate plans. The Water board identified the vulnerabilities of safe drinking water and sanitation in the changing climate. The agency acknowledged that unsafe drinking water and lack of proper sanitation increases the health vulnerability of the population. Accordingly they have taken the strategic approach to ensure the provision of potable water to 100% of all the urban population whilst ensuring service affordability to mainly the periurban and low-income-earning population. And to ensure all provincial urban towns have in place adequate sanitation services that cover maximal population including the urban fringe population.

PNG Water board under its Core Business Focus in ensuring the provision of safe, reliable and sustainable water and sanitation access throughout PNG, will adopt a Three Pronged Approach.

These Three Approaches are (I) Provincial Towns, (2) Rural District Towns and (3) Rural Communities Water and Sanitation Development.

a) Provincial Towns

PNG Water board will ensure the upgrade / development of all Provincial Towns' Water & Sanitation Services to meet current and future demands and expectations by 2015, all the 19 Provincial Towns must have in place sustainable, reliable and environmentally friendly water and sanitation services to meet the current and future demands of the population, industries and institutions. Currently the Water board services 12 Provincial Towns where *pre-active upgrading* will be done to enhance operational capacity, securing the systems, improving environmental friendliness and ensure real access increase of these urban population and industries to potable drinking water and safe sanitation services. PNG Water board will also take a proactive stance to develop other provincial towns' water supply and sanitation services.

b) Rural District Towns

PNG Water board will *lead* in developing rural district water and sanitation services to improve access to safe water and proper sanitation services compliant to public health and environmental standards. The system will be efficient, easy to operate and maintain and technologically sustainable and secured against environmental, geophysical hazards and meets current and future demand. However ownership of new or upgraded assets will remain with the Local Level Government including operational and management responsibilities.

PNG Water board's position is that by 2015, 65% plus (85%+ in 2020) of all district towns must have access to potable drinking water and 50% plus (70%+ in 2020) have access to safe sanitation services – facilities.

c) Rural Communities

PNG Water board will support the development of rural communities' water and sanitation access in partnership with government lead agency(s) and other stakeholders. The Water board will assume a *supportive role* to lead government agency(s) and other stakeholders in ensuring safe rural water and sanitation access to rural communities introducing a system efficient and easy to operate and maintain and technologically sustainable, secured against drought, floods and other natural disasters including land use degradations. However, Water board's supportive involvement will be confined to research and development of appropriate rural technologies – approaches, compliance and licensing, basic operators training, community based management of water and sanitation systems and technical support through upgraded skilled manpower based in district centers (SMTCP, 2005).

4.4.8 Agriculture

The climate change vulnerabilities of PNG's agriculture are largely because of ENSO-associated drought. Erratic precipitation following climate change may bring more pronounced and prolonged drought spreading over time and space for PNG, making ENSO events more

frequent. Though linkage between ENSO and CC are yet to be established; IPCC 5th Assessment report will devote a report on this. Temperature variation may also influence the pattern of cropping. Following the ENSO there is La Niña that is a wetter and warm situation that invites pest infestation and disease outbreak.

The adaptation measures and options have been drawn from the community good practice through survey and fine-tuned by NARI. Communities at different provinces of high and low lands, during 1997 and 1998 drought used indigenous knowledge and experience to withstand the challenge. NARI has conducted surveys in 6 districts at three different altitudes and having different level of access in terms of communication. NARI also conducted trials on the findings from the communities to reconfirm the options and to fine- tune. NARI has developed a drought-coping strategy and suggested a number of drought tolerant crop varieties, water management strategies and pest and disease control measures. NARI also developed "Climate change Implications and strategies for PNG agriculture".

In order to cope and adapt with the drought, disease infestation and excessive rain following short term and long term measures and options have been identified by NARI with the participation of the local communities and revealed through trial. The following measures have been largely taken from drought coping strategies in line with climate change implications for PNG agriculture.

Short Term Coping Strategies

It is important that farmers grow a wide variety of crops like sweet potato, inclusive of drought tolerant varieties at all times. It will almost always be too late to plant drought tolerant crops after a drought has begun. The main insurance against food shortages is to plant as many varieties as possible and to plant a number of gardens in different places. A further insurance is to save cash from the sale of fresh foods, cash crops or firewood in good years and to use it to buy imported food during a food shortage. The following adaptive and coping measures have been identified:

1. Pre-drought

1. Mulch gardens to protect soil moisture
2. Reserves of planting material of the important crops
    - Store mature and fully dry seed in containers with tight fitting lids. Dry seed out of sun with air movement
    - For vegetative propagated crop, like yam, taro, sweet potato and English potato reserve cuttings with an eye on the tube and reduce size of piece if drought has reduced yield and prepare soil better and managed cultivation shall protect yield
    - Reserve of the best varieties of Sweet potato, cassava, sugar cane, aibika and pitpit vegetative cuttings in a damp area near a river or creek, near the edge of a swamp, or near the house where water can be applied to keep them growing even in very dry periods
    - Never plant all material at one time because all of them may get lost if there will be not enough rain. If there is not enough planting material to plant the whole garden, always keep some seed tubers in reserve to replant again.

3. Indigenous coping strategies under drought and frosts.

A survey was held in six of the worst affected districts following the 1997 drought (and frosts) from three altitude ranges and with good or poor accessibility to markets. Sixteen randomly selected families were surveyed in each district. The following indigenous practice has been recorded:

Table 4.8 Gardening practices adopted under drought conditions

Practice	Description
Cultivation under canopy of trees	Crops under canopy were productive. This is probably due to reduced evapo-transpiration of crops under shade.
Cultivation on riverside plains	Families, who had land near the river, planted the main crops like taro, sweet potato, banana and vegetables there. The gardens were also watered and planting materials were successfully maintained.
Gardening in wind sheltered areas/ pockets	Gardens were planted in gullies and at the foot of hills where soil was seen to be moist enough to support plant growth. Planting materials were also maintained.
Cultivate in the swamp or marsh areas	Families in areas where there are swamps cultivated food crops and preserved planting materials.

Table 4.9 Gardening practices adopted to minimize frost damage in Kandep and Tambul

Practice	Description
Smoke smudges	Making fire near the garden or in the hut and directing the smoke through bamboo to the gardens nearby. The warm smoke disturbs cold air setting on the garden. However it has minimal impact and is seen to be effective only in small gardens.
Covering crops with dry grass or leaves	Crops growing in the field are covered with leaves and dry grasses to avoid direct contact with frost.
Cultivation on slopes	Frost moves down slopes to settle on the flat.
Plant trees across the slope	Trees disturb the flow of cold air down the slope.

Table 4.10 Methods used to preserve planting materials during drought

Method	Description	Districts where it is practiced
Stored sun dried seeds	Seeds of annual crops like corn, bean, peanut, cucumber, watermelon, and pumpkin were sun-dried and stored in airtight containers.	Kandep, Tambul, Bena, Gumine, Raikos and North Coast
Under-ground preservation	The corms of true taro and xanthosoma taro were buried in the ground as food and planting materials.	Raikos & North Coast
Planted in swamps or marsh areas	Crops were cultivated in swamp and marsh areas as food and for planting	Kandep, Tambul, Bena, Gumine, Raikos

	materials.	and North Coast
Stored seeds over fire places	Seeds of annual crops such as corn, bean, peanut, cucumber, watermelon and pumpkin were dried over the fire and then stored in airtight bamboo containers and kept over the fireplace.	Kandep, Tambul, Bena, Gumine, Raikos, North Coast
Vegetative plant parts grown and watered in riverside gardens	Cuttings, vines, suckers and tubers of clonally propagated crops like aibika, sweet potato, pitpit, sugarcane and banana etc. were planted in wet areas or at riversides and watered.	Bena, Gumine, Raikos & North Coast.
Sourced from low- lying areas post drought (& frost)	Low lying areas like the Waghi Valley or Wapenamanda areas were less affected by drought, so provided planting materials to severely affected areas	Kandep, Tambul and Gumine

a) Reducing damage caused by frost

- Local experience over a number of years should show areas where frost tends to be worse, and where it tends to be less severe. Steps should be taken to minimize damage by making sure susceptible areas are marked out.
- Some gardens should always be planted in the areas marked out as less subject to frost damages.
- Traditional practices of planting gardens in different areas of available land help to ensure some gardens will not be affected by frost.
- Gardens on good soil on the bottom of hills tend to produce more crops under normal conditions, but can be more subject to frost.
- Gardens at the top of hills near the bush may not produce as well normally, but are less likely to be affected by frost.
- Gardens on hillsides tend to be less affected than those at the bottom of the hill. Though they do not produce as well as those at the foot of hills, they may be better than those near the bush.
- Trees should be planted near gardens at the bottom of hills to help reduce the effect of frost.
- A row of trees planted across the hill above the garden can stop cold air coming down. Trees planted across the hill but below the garden will trap cold air causing more severe frost damage.
- Trees planted on a hillside should have plenty of space between them to increase air movement and circulation. This means the cold air flowing down will mix with warmer air and reduce frost occurrence
- Thin layers of pitpit should be laid on top of sweet potato mounds and kept there until the frost season ends for plant protection. A thick layer would be better though it will need to be removed during the day to allow the leaves exposure to the sun. The pitpit can be used in mounds for new gardens.
- Old corn stalks and bean stakes should be left in gardens to help protect sweet potato vines from being damaged by frost.

- Few small fires should be lit in gardens to help reduce frost damage. When smoke rises, air around the fire is drawn in, causing air movement that disturbs the mass of cold air in the gardens.
- Any fires lit will need to be managed very carefully, as frost and drought and extreme fire hazard go hand in hand.

Such steps should be undertaken in preparation for frost occurrence once a drought warning is issued. Frosts are associated with droughts due to the fact that there is less cloud cover both day and night with temperature that are high during the day and very low during the night. Long term considerations would include planting trees round gardens at the foot of hills and above gardens on hillsides. Work on frost tolerant crops is being started at the National Agricultural Research Institute's High Altitude Programme in Tambul, which should identify certain crops for cultivation. Research will also be directed towards improving farming practices in existence today.

2. Mid-drought

The following measures have been suggested by NARI during the mid drought period:

- *Sweet Potato Tuber could be stored for a month controlling weevil*
- True taro, Colocasia, and Singapore taro, Xanthosoma can be stored in pits lined with coconut fiber or banana leaves, then covered with the same material and then sealed with a layer of soil. This enables unpeeled tubers to be stored for 2 – 3 months and peeled tubers for a month
- Giant taro, A. macrorrhiza, and Giant Swamp taro, C. chamissonis may be stored in special houses with yams. Submerging tubers in water or covering them with wet sand may help store giant swamp taro. Storage using methods similar to that of taro in lined pits covered with soil or stones is reported to allow storage of giant swamp taro for 2 – 3 months
- *Yams can be stored for longer period in yam houses or any dry shelter. Shoots can be removed a number of times to extend the dormancy*
- Store cassava in the growing ground, prune branches, reduce root exposure to moisture and air
- Manage livestock properly during droughts. Keeping at least a healthy reproducing male and female in a fenced area use other to eat or sale
- Collect fenced animal manures and use in the garden.

a) Water management

- Dug wells in the middle of the dry bed and collect water
- In cases where water is still running protect from contamination and wisely use
- Use underground water source for well
- Collect water from wet marsh or swamp areas
- *Treat drinking water and cooking water settling in clean containers*
- Make small drains around plants to deep watered once a week
- Slowly introduce water a bit at a time for maximum soaking and preventing run off
- Instead of using sprinkles, place hoses at the base of each plant

- Kitchen gardens with recycling of water
- Harvest rainwater before drought and dew during drought
- Be aware that fire breakout during drought and take preparation to prevent fire breakout.

b) Ready Access to Sago

- Identify accessible sago and water to clean
- Make sure there are always sago trees near the permanent water (if necessary plant) and accessible areas for very dry times
- Protect sago tree from fire
- Wash, strain and sundry sago and store and keep above fire
- Roast pieces of the sago in the fire straight from the tree to use when there is no water to clean.

c) Sweet potato weevil management

During a drought or after a frost, sweet potato tubers still in the soil are commonly attacked by a small weevil (Cylas formicarius). The weevil bores holes in the tubers, causes them to taste bad and to rot quickly. The following measures help to protect sweet potato and reduce risks:

- Rotate sweet potato with other unrelated crops to reduce weevil population build up
- In highly infested areas, select deep rooting and early maturing varieties
- Always select clean planting material from weevil-free plants or a weevil-free field
- Always cover the exposed tubers and soil cracks to prevent weevil entry
- Always remove and destroy all crop residues and other host plants like kangkong to prevent weevil infestation
- Cover the soil with mulch (e.g. grass) as it helps to keep the soil moist and prevent soil cracks.Allow bush to grow in the weevil-infested field and return later. This helps to break the life cycle and reduce weevil population.

3. Post-drought

After a drought when normal rains return, food production must begin again as soon as possible. Planting of quick maturing crops after the drought is the obvious solution. The use of early maturing varieties to provide food in the post-drought period is recommended. In order to do this planting material must be available and should have been preserved throughout the drought period. Important crops other than sweet potato that will produce rapidly after drought are maize, beans, peanuts and potato. Drought, salinity and excess moisture tolerance, early maturing characteristics, food quality and performance under ‘normal’ conditions (varieties that perform well under normal conditions will be retained by farmers in their gardens), of previously selected highlands and lowlands sweet potato and cassava varieties, re-tested and verified both on-station in Aiyura and Laloki, and at pilot locations in regions prone to moisture stress conditions.

During a drought, nitrogen levels rise in the soil, partly through death and decay of plants, animals and microorganisms, so it is suggested to include few other crops like maize and beans with sweet potato following drought. Quick growing leafy vegetable crops can use the extra nitrogen to grow quickly and yield well, but sweet potato tends to grow lots of leaves, while tuber production is disappointing. It is better to plant a crop of maize first, followed by a crop of early maturing sweet potato. Following are adaptive varieties of sweet potato.

Early maturing sweet potato for the PNG lowlands: Three early maturing sweet potato varieties (B11 PT, NUG 5 and SI 278) have been listed. These have also shown tolerance to drought. One other variety, SI 85, is an excellent variety for early harvest, but lacks the drought tolerance as the other three varieties. All these varieties yielded from 113 to 209% of mean yield when harvested 13 weeks after planting in a Sogeri trial.

Table 4.11 Recommended early maturing sweet potato varieties for the lowlands

NARI name				
English	**Tok Pisin**	**Variety**	**Origin**	**Characteristics**
NLSP 1	NARI nambis kaukau 1	B11 PT	Bubia, Morobe	Tuber skin & flesh are white
NLSP 2	NARI nambis kaukau 2	SI 278	Solomon Islands	Tuber skin & flesh are white
NLSP 3	NARI nambis kaukau 3	NUG 5	Nuguria Islands, Bougainville, PNG	Tuber skin & flesh are white
NLSP 5	NARI nambis kaukau 5	SI 85	Solomon Islands	Tuber skin & flesh are white

These sweet potato varieties must be planted as soon as normal rains return after a drought. Supply should be available by the third month. Requests for foundation planting materials should be addressed to NARI Laloki.

Early maturing sweet potato for the highlands: The National Agricultural Research Institute's Main Highlands Programme at Aiyura has selected 9 Sweet potato varieties, which have produced acceptable yields at 4 and 5 months after planting. The selection was based on results from 2 trials. The selected varieties yielded between 4 and 7 tonnes/ha at 4 months after planting. The varieties are 469, WBS 010, SSYK 026, WHCK 007, 123, SKK 010, 559, 714 and WHCK 005. Five of these varieties (WHCK 005, SKK 010, PRAP 469, WBS 010 & PRAP 714) are also tolerant to drought conditions.

Table 4.12 Mean yields of early maturing highlands sweet potato varieties at 4 months after planting

Variety	**Yield at 4 Months (t/ha)**	**Remarks**
PRAP 469	6.98	Drought tolerant and Early Maturing. Good yield. Acceptable tuber shape and taste
WBS 010	6.69	Drought tolerant and Early Maturing. Yields well with acceptable tuber shape and taste

SSYK 026	6.42	Early Maturing only. Popular in Simbu Province
WHCK 007	5.77	Very early maturing
PRAP 123	5.73	Early Maturing only
SKK 010	5.70	Drought tolerant and Early Maturing. Yields well, good tuber shape and taste
PRAP 559	5.51	Early Maturing only
WHCK 005	5.33	Drought tolerant and Early Maturing. Good yield with good tuber shape, size and taste
PRAP 714	4.86	Drought tolerant and Early Maturing. Good yield, acceptable tuber shape and taste

Long-term strategies

The following long-term strategies have been recommended for adaptation to climate change for the crop agriculture of PNG:

- Drought tolerant crop: The National Agricultural Research Institute (NARI) through trial suggested varieties of sweet potato, cassava, banana for high land and low lands after trial recommended followings
- Drought tolerant sweet potato varieties B 11 PT, SI 278, NUG 5 and K 9 for the lowlands of PNG
- Drought tolerant sweet potato varieties WHCK 005, SKK 010, WBS 010, PRAP 469, PRAP 714 for the highlands of PNG
- Drought tolerant banana: The banana varieties that survived the 1997 drought were mainly from the Kalapua, Yawa and Cavendish groups. The performance of these varieties held at the Papua New Guinea Banana Germplasm Collection site in Laloki NARI revealed their hardy nature of surviving during drought
- Recommended lowlands cassava varieties are l 86, L51, L6 and L92 for lowland and for highlands EHS 010, EHK 012, WBS 007, WBD 011, EDK 007
- Storage and preparation of parboiled rice, maize, beans, corn and some legumes are also recommended to face the challenging drought time
- Innovative water management & conservation strategies/systems (including soil moisture conservation, crop irrigation options and strategies to cope with excess rainfall conditions) to support agriculture under precipitation excess or deficit conditions, developed and piloted in regions prone to drought or excess moisture conditions. The adaptation of intermediate technology pumps like shallow wells and tapping surface flows without relying on engine-powered pumps for smallholder farmers. Of the systems available, two water lifting and one water distribution system have been selected for on-farm demonstration. These are the Rope and Washer Pump, the Treadle Pump and Micro Tube Drip Irrigation system. The Gravity Flow System as both a water lifting and distribution system is recommended where feasible.
- Other crops (vegetables, grain crops) and crop varieties suitable for cultivation under moisture stress, salinity or excess moisture conditions, identified, evaluated on station in Aiyura, Bubia, Laloki and Keravat and piloted in regions prone to drought or excess moisture rainfall.
- Methods of processing, preserving and storing locally grown foods (cassava, sweet potato, banana, taro, small grains etc.) to provide a nutrition buffer during periods of drought or excess rainfall conditions when fresh food is difficult to maintain in gardens, evaluated and trialled in pilot communities.

- A rationale for food preservation and storage developed and trialled in pilot communities indicating how and why this practice could beneficially co-exist with the current practice of fresh food production and utilization (will involve cost-benefit and feasibility analyses, and assessments of land and labour division for fresh food production and for production of other food destined for preservation, storage, subsequent consumption or sale).

4.4.9 Extension services and information dissemination

The following actions will be necessary to effectively communicate and disseminate required knowledge, information and extension services to support the adaptation process:

- Establishment of Resource Centres at existing NGO/CBO/CO/DAL stations or bases & schools in drought-vulnerable districts throughout the PNG highlands, lowlands and islands regions
- Drought-coping strategies need to be made accessible to all vulnerable communities through the establishment of a network of IRC's – ideally one in each drought-vulnerable district – on existing NGO, CBO, CO and DAL stations or bases
- Effective IRCs that deliver the outputs and generate impacts and are self replicable and sustainable
- Functional horizontal and vertical coordination from National through to the LLGs and with among agencies like NARI, DAL, NWS, DEC, water branch etc.

4.4.10 Health Sector

The health system in PNG has a long list of inadequacy. New Guineans are already burdened with various communicable, water and vector borne diseases. Health care awareness and literacy are largely lacking. To improve the situation, overall improvement of socio economic conditions and investment in the health sector are necessary. Overall literacy and social awareness as well as civic norms are to be practiced by large. However, climate change will directly influence existing inadequate safe drinking water, sanitation infrastructures and food security that in turn will make the health of the community vulnerable. As such, the adaptation for water and sanitation system and food security are the most important to maintain health; they have been discussed in the water and agriculture sector adaptation section respectively. This section shall concentrate on the adaptation measures for malaria, which will also support population to improve general health care awareness and first hand access to health care.

Assessment of adaptation measures

The adaptation technical working group under the leadership of DEC and with participation of different sectoral professionals, considered a long list of malaria countermeasures under different categories of response: Infrastructure/ asset based responses, Technological/ optimization responses, Systemic/ behavioral responses and Financial measures.

a) Infrastructure/ asset based responses

- Drain swamps or river banks to reduces ponds and other sources of water that the mosquitoes use to breed
- Install more healthcare facilities: ensure malaria treatment so that each person get one in 5km vicinity

- Build wells for high risk malaria communities that people do not need to go close to mosquito areas, such as rivers and ponds, for water collection.

b) Technological/ optimization responses

- Constantly adapt treatment to resistances: Monitor malaria drug resistances and adapt local treatment guidelines regularly (not included in Cost curve)
- Invest in local malaria research and find out which countermeasures work best for the local conditions
- Introduce bio-pesticides (Plants): Grow plants that repel mosquitoes to reduce mosquito abundance near places where people live and work
- Introduce bio-pesticides (Fish): Introduce the gambusia fish, that feeds on mosquito larvae and so reduces mosquito population.

c) Systemic/ behavioral responses included for the cost curve

- Conduct Indoor Residual Spraying (IRS): Spray walls and roofs of houses with a long lasting insecticide to kill mosquitoes inside the house
- Introduce long lasting insecticide treated bed nets (LLINs): Distribute free LLINs and make sure that population sleeps in beds that are secured by one, to prevent mosquito bites at night
- Ensure availability of ACT (Artemisinin based Combination Therapy): Provide the population with access to ACT. ACT describes different combinations of drugs that the WHO recommends for anti malarial drug therapy in developing countries, having positive effect on stratification and long-term health damage
- Establish malaria prevention for pregnant women: Introduce standardized malaria prevention, including anti malaria drugs, for pregnant woman in high risk areas, to prevent severe damage to the unborn child
- Build shadow communities by planting trees: Increase shadowy areas in communities by planting trees, as mosquitoes develop slower in the shadow
- Conduct malaria education & mosquito habitat clearance campaigns: Teach communities about malaria and start campaigns to reduce mosquito breeding sites Spray ponds and other sources of water near villages with insecticides to reduce the mosquito population
- Control larval breeding sites with insecticides: Increase shadowy areas in communities by planting trees, as mosquitoes develop slower in the shadow
- Improve building standards: mosquito mesh on windows/ doors and gapless walls: Install screens for windows and doors to ensure that mosquitoes cannot get into houses
- Medicate with Chloroquine drug. Effectiveness low; outperformed by ACT treatment method
- Spray riverbanks, ponds, lakes, rice fields and other sources of water
- Conduct outdoor spraying with DDT.

d) Financial measures

- Introduce micro insurance against Malaria: Offer population a micro healthcare insurance for free anti malarial medication and treatment fees in case of illness. Stratification and severity of infection could go down, because: No delay in medication for financial reasons, less self-medication. Theoretical studies from Ghana exist, but it has not been implemented. (*SOURCE: Team analysis; WHO; Roll Back Malaria; AAAS, PNG's High Commission to Australia).*

The adaptation technical working group considered the following broad range of adaptation measures of different response types for cost benefit ratio through the cost curve analysis. The list of adaptation measures has been screened to protect the maximum amount of people if there is no program/funding in place.

- Insecticide-treated bed net distribution (LLIN)
- ACT as first-line treatment
- Indoor Residual Spraying (IRS)
- Malaria prevention for pregnant women
- Introduce mosquito-larvae eating fish
- Build wells and reduce breeding grounds
- Build more healthcare centers
- Introduce bio-pesticides (plants)
- Monitor mosquito resistance to treatment
- Plant trees to provide shade.

Cost curves have been developed for malaria, considering Insecticide-treated bed net distribution (LLIN), ACT as first-line treatment, Indoor Residual Spraying (IRS), Malaria prevention for pregnant women, Introduce mosquito-larvae eating fish, Build wells and reduce breeding grounds, Build more healthcare centers, Introduce bio-pesticides (plants), Monitor mosquito resistance to treatment and Plant trees to provide shadow.

Cost curve analysis results in a top three as feasible (CB<1). Benefits include the loss averted. Costs include capital and operating expenses. Costs and benefits calculated using estimates from global experience, supplemented with input from NDoH / WHO interview, Cost per unit of benefit is calculated as an NPV discounted at 10% Cost curve calculated for ‘High climate change scenario’ given small difference from low scenario.

In order to provide adequate LLIN bed nets, perform IRS and to ensure ACT availability and use over 400 million USD has been estimated. However, funding in a timely manner would reduce cumulated expected loss by USD 300 million. The measures are expected to protect over 3 million people, which is slightly less than 50% of the total population.

Table 4.14 Cost of the proposed measures and people protected

Hazards	Measure	Total cost USD million	Protected Population (x 1000)	Total/People protected	Cost/protected Person/year USD
Malaria	- Provide LLIN bed nets - Perform IRS - Ensure ACT availability	412	3100	48	7

If no action is taken, costing of malaria counter measures could amount to USD 10 million annually by 2030 due to climate change only. Additional funding will be required to avert loss due to climate change. Assuming 70% loss aversion with cost effective measures (avg. CB = 30%), funds required are as follows:

Table 4.14 Expected costs and required funding

	Climate Change related expected loss (million USD)	Annual funding required (million USD)
2015	7	1
2020	16	3
2025	32	6
2030	52	11

Immediate funding planned under Roll Back Malaria program would reduce expected loss in 2030 by USD 60 million and a cumulative loss of USD 300 million, assuming 25% loss reduction remains constant after 5 year program.(SOURCE: team analysis).

e) Install more healthcare facilities

To put in place the adaptation measures, as discussed, will require the installation and operationalization of health care facilities around the PNG malaria affected areas. The objective is to provide easy access to health services by ensuring that every person has a healthcare post in 5 km vicinity. To do so a total of 300 new healthcare posts will be necessary. Assuming annual operational cost and benefit only after 3 years and discounted with a discount factor of 10%, implementation by two years and a life time of 20 years the team came up with a cost benefit ratio of 1.2. Following is the cost benefit matrix for analysis of that ratio.

Table 4.15 Cost-benefit matrix

	Benefit	Cost
Qualitative	*Reduces cost of a malaria case by* • Ensured quick treatment • Reduces opportunity cost of individuals by reducing • long lasting sickness and long	*Cost can be split into Investment cost* • Investment cost: Buildings, infrastructure, equipment, administration • Operational cost: Inventory (medical products), logistics, personnel,

	term health damage • Reduces opportunity cost for society reducing severity and stratification of malaria	maintenance • Minus benefits from other treatments
Quantitative	*Present value of benefits USD 33.9 m* • Annual benefit USD 5.0 m • Benefit per successfully treated malaria case: USD 37 • Number of treated people 0.15 m • Success rate per treatment: 90%	*Present value of costs USD 40.0 m* Investments: 4.8 m (buildings, infrastructure, equipment and admin) Present value of operational cost: USD 72.8 m Annual operational costs: USD 10.7 m (1 doctor, maintenance, medical products, administration) Minus present value of additional benefits USD 37.6 m Annual value of additional benefits: USD 5.6 m (benefits from other treatments)

f) Malaria control program

In line with PNG National Malaria Control Strategic Plan, PNG government has taken a malaria control programme with support from the GFATM (USD 6 m over 2 years) and in partnership with the Rotarians Against Malaria and other partners to:

- Strengthen political commitment for malaria control in PNG
- Produce low-literacy instructions for the packaging of the government's new first-line malaria treatment to facilitate treatment compliance (particularly among children younger than age 5)
- Develop a network of partners (government offices, faith-based organizations and non-governmental organizations) in order to facilitate consistent messaging for behavior change communications around malaria prevention and treatment in communities
- Develop a communications strategy to include interpersonal communications and mass media
- Deploy outreach officers to conduct health education sessions in communities to increase consistent and correct use of mosquito nets, and to ensure those with fever report immediately to a health care facility.

The programme is to control the spread of malaria. The strategy is to improve diagnosis, anti-malarial treatment, mosquito control and education on malaria with a target of ensuring that 80% of the population in endemic areas sleeps under a bed net, 70% of malaria cases are laboratory confirmed, annual spraying is carried out in the highlands and the mortality rate is reduced. *(SOURCE: WHO; Roll Back Malaria).*

4.4.11 Forestry

Forests are likely to face an increased risk of forest fires, more intense droughts and more frequent floods associated with El Niño, and a greater threat from diseases and insects following the global warming and climate change. Forest relevance to climate change has

different dimensions. Forests are expected to suffer from climate change. On the other hand the forests play a key role in regulating local and global climates and are a vital frontline defense against climate change. Deforestation is one of the main causes of climate change accounting for about a fifth of all greenhouse gas emissions. This makes it third after the energy and industry sectors. Papua New Guinea (PNG) hosts some of the world's largest and last remaining intact forest landscapes. While these forests have always been a haven for biodiversity and provided a livelihood for the millions of people who live in them, it is only in recent years that their importance for carbon storage has come to be fully appreciated. PNG's forests are estimated to store around 5 gigatonnes of carbon (GtC), or 18.3 gigatonnes of carbon dioxide (Gt CO2), equivalent to almost 1.5 times the greenhouse gas (GHG) emissions from energy production worldwide in 2004.

PNG has some of the largest and most biologically diverse ancient forests left in the world. Most of PNG's over 7 million people live a subsistence life, relying on forest resources. It is their home, supermarket, hospital and church. For many, the forest is the inheritance they will pass on to their children. That inheritance includes more than five per cent of the world's species of animals and plants.

In PNG, 58 of the 260 known mammal species and 33 of the 720 known bird species are threatened with extinction. Of PNG's 29.4 million ha of forests, 57% are made up of tropical lowland rainforest. By 2002, as a consequence of logging activities, 2.9 million hectares (or more than 15%) of these were recently classified as degraded secondary forest and are considered to be at high risk of conversion to non-forest cover. Only 55% of PNG's forests today are in large blocks (>500 km2) of minimally disturbed forest ecosystems known as Intact Forest Landscapes (IFLs).

The protection of IFLs prevents forest fragmentation and biodiversity loss, and is vital to the long-term health of any forest ecosystem. IFLs are also important from a climate point of view because:

- They facilitate adaptation to climate change, e.g. species migration
- Fragmented forest landscapes are more vulnerable to drought and fire (edge effects)
- Intact forest landscapes are more resilient to the predicted effects of climate change and hence more likely to retain
- Carbon stocks, preventing further climate change
- They are less accessible, which protects against industrial logging (Preserving Paradise, 2008).

Forest conservation

Nature reserves or protected areas have been formally designated in Papua New Guinea under the National Parks Act or the Fauna (Protection & Control) Act. To date, Wildlife Management Areas (WMAs), established under the later Act, have been the only type of protected area that has proved to be widely relevant to PNG (Hunnam,1992). The current national system comprises a total of 34 terrestrial WMAs and NPs covering just 1.29 million hectares or 2.8% of

PNG's total land area. Over a third of existing protected areas were gazette in the first four years of independence (1975-1979). In the subsequent 23 years, only 15 were declared. All the forest types are not represented in the current WMAs and contain no upper montane forest. The WMAs are also underrepresented in East Papua, South East Papua, Oro and Owen Stanley region. There are inadequacies in the WMAs in PNG, despite that they are needed and asked for. On the other hand over a period of 30 years a total of 38,926 ha of forests within the WMAs were cleared for subsistence activities and an additional 11,951 ha were cleared by logging. Overall, 8.8% of forest change within WMAs is relatively less compared to the country context, which has been estimated at 24%.

Adaptation measures

PNG forestry policy's main objective is 'Management and protection of the nation's forest resources as a renewable natural asset' and to implement the policy. PNG developed a **"Forestry and climate change framework for action 2009-2015"** that takes several principles and expected numbers of outcomes. Two of the seven principles are adaption to climate change and mitigation of GHG. Adaptation for the forestry sector will mainly be to protect the forests from deforestation, pest and disease and from forest fires; to do so, the following points are required:

- Declare montane WMA's, mangrove WMA's, Swamp WMA's: the Wild life management area shall be declared in montane forest so that it shall ensure protection of montane forest and montane biodiversity
- Declare one fourth of IFLs as protected areas: This has to be in concurrence with the communities (owners) and must provide tangible returns to them, may be carbon price (CER, VER) through government mediation
- Community based forest conservation and management: communities are the owners of the forests in PNG. As such they have to be fully onboard in conservation efforts. To do so, massive sensitization, orientation and capacity building for the community will be necessary
- With technical backstopping from the forestry department, the community shall remain vigilant against forest fire before and during drought
- The forestry department and forest research Institute shall be vigilant against pest and disease and, in collaboration with the community, shall take appropriate measures to protect forests from disease.

4.4.12 Fisheries

Our oceans are being systematically degraded and are in a dangerous spiral of decline. Battered by the impacts of overfishing, destructive fishing techniques and pollution, marine ecosystems are finding it harder and harder to adapt to the largest overarching threat facing our oceans, and in fact our planet – climate change. The resilience of the oceans and their ability to adapt to change from rising temperatures, increasing acidification, changing currents, receding sea ice and rising sea levels, is according to scientists vital if the oceans are to survive the onslaught of global climate change.

With regards to the fisheries sector, the changes that will ensue from climate change, in productivity, distribution, species composition and habitats will require major changes in how we manage fisheries and aquaculture operations. A recently published study by William Cheung and colleagues sets out some of the likely changes. These include:

- There will be a large-scale re-distribution of species, with most moving towards the Poles
- On average, fish are likely to shift their distribution by more than 40km per decade and there will be an increasing abundance of more southern species
- Developing countries in the tropics will suffer the biggest loss in catch
- The invasion and local extinction of species may disrupt marine ecosystems and biodiversity.

These disturbing changes will all have significant impacts on resource availability, stability, access as well as utilization. The experts warn that we have eroded the ocean's ability to cope with and mitigate the consequences of climate change. They recommend that we reduce all the pressures exerted on the oceans in order to give them the best possible chance of withstanding the impacts of climate change, because the Earth cannot survive without the services that the oceans provide. Therefore, the introduction of strong conservation measures to protect and maintain biodiversity as well as promoting a paradigm shift in current fisheries management practices will play a key role in governments' responses to climate change, along with efforts to achieve a peak in global greenhouse gases by 2015 and reducing emissions by more than half by 2050.

An ecosystem approach

The growing understanding that conventional fisheries management is failing and climate change impacts are growing has prompted widespread agreement on the need to adopt an approach to the management of fisheries and other human activities, which addresses the whole ecosystem. Scientists and politicians agree that it is necessary to move away from conventional, single-stock management towards what is called the 'ecosystem-based approach' and this is reflected in a series of political commitments at national, regional and international level. This is possible with a twofold approach whereby human activities are managed sustainably and areas of the oceans are set aside as marine reserves. These marine reserves should form the cornerstone of ecosystem-based management. To implement an ecosystem approach requires a management strategy that:

- Goes beyond a single or multi-species approach by considering the ecosystem as a whole
- Is aimed at protecting biodiversity and recovering ecosystems, not the least with the aim to improve their resilience to global climate change
- Avoids over-harvesting and ecosystem modifications
- Is based on the precautionary principle – i.e. conservation measures are taken even in the absence of full knowledge of the activities, impacts and ecological responses to these impacts

- Focuses on the ‘upstream’ control of human activities rather than on the control of impacts or ecosystems
- Is robust even in the light of uncertainties and management oversight
- And can be applied with immediate effect.

Marine reserve

A marine reserve is an area closed to all extractive uses, such as fishing and mining, as well as disposal activities. Marine reserves can protect near-pristine ecosystems and offer respite to heavily depleted stretches of ocean, allowing areas to recuperate, recover and ultimately regain some level of natural resilience. They are pockets of protection, scientifically selected and determined, which boost the overall health of the ocean, not just in the immediate area by buffering against the impacts of climate change. In addition for more mobile species sensitive to changes in ocean temperature, creating networks of marine reserves can provide stepping-stones that allow fish and other marine species to move north or south to find their preferred conditions as climate change shifts oceans' temperature and salinity. In effect creating networks of marine reserves is a means of 'spreading risk'. It is partly with this in mind that networks of marine reserves are proposed that stretch across the globe. There is increasing evidence that such networks will be more effective at buffering environmental variability and providing greater protection for marine communities than single ones.

The World Parks Congress recommended in 2003 that at least 20-30% of marine habitats be included in networks of marine reserves. In 2005, the United Nations Millennium Project called for 10% of the oceans to be covered by marine reserves in the short to medium term, with a long-term goal of 30%. A review of 40 studies into the coverage that is necessary to achieve conservation and fisheries management goals concludes that 20-50% of the ocean should be protected. Greenpeace advocates that some 40% of marine areas globally should be designated as fully protected marine reserves. Given the level of uncertainty in determining the effectiveness of individual ecosystem-based management measures, the establishment of permanent, legally defined and fully protected reserves will be a vital component of implementing the ecosystem approach while providing immediate respite and recovery. In particular, the protection of critical habitats, such as coastal wetlands, mangroves, coastal lagoons from the threat of destructive fishing practices, unsustainable aquaculture, coastal developments, should be prioritized in order to build resilience into the marine system.

Financial mechanisms to implement the network

As noted by the authors of the 2008 UNEP report '*In Dead Water*', substantial resources need to be allocated to reducing climate and non-climate pressures with priority being given to protecting substantial areas of continental shelves in order to build resilience and ensure that further collapses in fish stocks are avoided in coming decades. Progress in implementing marine reserves has been slow with the consequence that there is a paucity of figures relating to the economic costs and benefits that come with establishing marine reserves. However one

study by a team of UK scientists came up with a cost for establishing a global network of marine reserves to protect threatened ocean ecosystems. For a network covering 30% of the world's oceans the figure they derived was between $12 and $14 billion dollars per year, a relatively small cost when compared to the benefits and ecosystem services that would be provided by such a network and the costs of failing to take action.

Further proof of the economic benefits of establishing marine reserves can be found in an in-depth study conducted in four countries in the Asia-Pacific region. The study showed that well-managed, locally supported marine reserves in that region could significantly help reduce poverty and enhance the quality of life for residents of local communities. The study's authors found that restoration of local resources - be they fisheries or coral reefs - increased fish catch and economic opportunities, improved community health, and directly enhanced the lives of local residents (FAO, 2009).

4.4.13 Biodiversity

Adaptation measures to maintain biodiversity in the real sense would mean adaptation by plant and animal species communities to the changing condition, which is happening from the evolution of the species autonomously. However, human induced climate change and its impact are happening faster than the species biologically could possibly adapt to. The aquatic species may adapt by shifting their position and having new habitats and niches. The same is true for the terrestrial species, even the plants may move upward in the hills, or the mangroves for example may shift to the bank. How the genetic diversity responds to CC, we don't know yet. However, it is necessary to take appropriate measures to facilitate species creating an enabling environment for them to adapt with. It is now well accepted among the scientific communities that to assist the species, it is necessary to support the ecosystems, i.e. the ecosystem based adaptation approach. For PNG, to protect biodiversity adaptive measures has to be taken for

- Forests (high montane, island etc.) ecosystems
- Fisheries, Coral reefs and marine ecosystem
- Mangroves and fresh water Swamp ecosystem
- Sand dunes/sandy beaches (supporting sea turtle reproduction and other species in the ecotone)

Forest ecosystem

Adaptation measures and options to adapt to climate change for forest ecosystem have been discussed in the forest adaptation section.

Fishery and marine ecosystem

An ecosystem-based approach has been considered for adaptation to climate change for the fisheries sector and discussed in previous section.

Coral reefs

Restoration and preservation of existing coral reefs are the best adaptation options for coral reef ecosystems. The marine protected areas proposed for fishery should include coral reefs in PNG as well as the rest of the ocean. The North coast region with reef that is currently dead (20% of total reef: 2,500 km2) has been identified as coral reef protection sites. Anthropogenic stresses such as pollution and overfishing will be managed through community based coastal area management approaches. In these sites beneficial organisms will be released into reefs to speed cleanup. The adaptation measure requires 10 years to implement and shall provide benefit through the centuries (as long as efforts are sustained). The following costs factors are involved:

- Coral reefs are most effective when they are living, and the diverse communities provide a very rough surface exerting drag force on incoming waves
- 50% of PNG's reef is in healthy shape, while 40% is at medium risk of deterioration and 10% is at high risk. It can be assumed that medium risk reefs can be revived
- Requires cultural shift as well as infrastructure investment poor sanitation (e.g. factory dumping) and harmful fishing practices (e.g., dynamite fishing) are causes of coral death.

USD1 m will be required as initial investment including USD 250k for a complete survey of current reef health and ecosystem, and the remainder for subsequent 'planting' of sea urchins throughout dead areas to clear away algae and accelerate reef recovery. Annually USD 40k for monitoring of reef health will also be required. Coral reefs shall reduce damage from storm surges by more than 50% and help natural restoration and habitat rebuilding and will attract ecotourism. Living coral reef can reduce storm surge run-up on land by up to 50% more than dead coral reef (Kunkel *et al.* 2006) and reduce damage to the assets at risk.

Coastal site planning and mangroves management

Mangrove rehabilitation, the restoration of areas where mangroves previously existed, enhancing degraded mangroves by removing stresses that caused their decline, and creating new mangrove habitat, will contribute to offsetting anticipated reductions in mangrove area and health, and increase resilience to climate change effects. Determining the stress or stresses that caused a mangrove to decline is necessary to identify the restoration or enhancement method to remove these stresses. Site-specific assessment of mangrove vulnerability to climate change effects is necessary to incorporate into coastal land use policy. To minimize losses of valued coastal habitats, and maximize available options community-based approaches to managing natural resources, managing mangrove and other coastal ecosystem responses to climate change effects have to be included. Mangrove plantation to protect the shoreline will enhance the mangrove coverage. Mangrove protected areas have been proposed as adaptation options in the forest section. A network of protected areas in the marine ecosystem has been proposed under the adaptation section for fishery. Networks of protected areas are needed to achieve ecological connectivity to permit the movement of species and exchange of genes. Protected areas established and managed through community-based approaches are more likely to be

successful. Reducing and eliminating non-climate-related stresses that are affecting mangroves will increase mangrove resistance and resilience to sea level rise and other climate change effects. Outreach and education activities for the local communities can help develop or augment a conservation ethic. The following technical and institutional capacity building is necessary to manage mangrove responses to Climate Change Effects:

- Strengthen management frameworks regulating coastal activities to develop a plan for adaptation to mangrove responses to climate change effects. This will require developing local capacity to (i) conduct site-specific mangrove vulnerability assessments and incorporate this information into land use and master planning; and (ii) reduce and eliminate stresses adversely affecting mangroves and other coastal ecosystems, in part, to increase resistance and resilience to climate change effects
- Determine projections of trends in mean relative sea level and frequency and elevation of extreme high water events, and incorporate this information into land-use planning processes
- Measure trends in changes in the elevation of mangrove surfaces to determine how mean sea level is changing relative to the elevation of mangrove surfaces, and use this information to assess site specific mangrove vulnerability to projected relative sea level rise;
- Assess how the position of mangrove margins have changed over the past decades through observations of a time series of historical remotely sensed imagery and use this information to predict the future mangrove position and assess site-specific mangrove vulnerability to projected relative sea level rise
- PNG staff with training, experience, and motivation is needed to conduct monitoring and assessment of relevant mangrove parameters, in part, to facilitate adaptive management. Improved staff training and information-sharing is also needed to increase regional capacity to restore and enhance mangrove wetlands
- Establish mangrove baselines and monitor gradual changes through regional networks using standardized techniques. This is needed to distinguish local and climate change effects on mangroves
- Produce maps showing mangrove boundaries, topographic information, and locations of coastal roads and development, and use these products to assess site-specific mangrove vulnerability to projected sea level rise. (UNEP 2006).

Sand Dunes/sandy beaches

There are large numbers of aquatic species that frequently visit beaches for various purposes. For example: sea turtles lay eggs in sandy beaches. Sea beaches are the confluence of two different ecosystems, the marine and terrestrial ecosystems. The confluence is known as ecotone and is a place where comparatively high species diversity is found. As such it is a common norm to allow a stretch of such ecotone for the species to move, graze, and reproduce freely. Sand dunes are the natural flexible formation that has bearing on the characteristics of the specific habitat. The free zone however could be under the surveillance and authority of the local community and non-structural activities could be allowed. PNG beaches host sea turtles to lay eggs. All six species of turtles are found in PNG beaches. Loggerheads, leatherbacks, greens and olive ridleys are currently listed as endangered and the flat back is listed as

vulnerable. The hawksbill turtle now meets the criteria as a critically endangered species, based on global population declines of 80% or more over the last three generations and projected declines over the next three (Meylan and Donnelly, 1999). In PNG, turtles are protected under the Fauna (Protection and Control) Act, which can declare any fauna to be protected. Listing animals as protected turns them into State property and killing, purchasing or possessing a protected animal may incur fines of PNG K 500 per animal. The leatherback turtle is the only sea turtle on the protected species list at present in PNG (DEC, 1996). The Department of Conservation and Environment (DEC) are now currently reviewing the protection status of turtle in PNG (Vagi Rei, pers. comm.).

Since turtle stocks are considered endangered on a global basis there is a need to development monitoring programs and community level education in the PNG so that they can be managed for sustained utilization. Therefore, there is a need to support and empower the island communities so that they can take a greater role in monitoring, caretaking, regulating harvest and post harvest use of turtles. This is deemed necessary because where exploitation and other activities that affect the turtles and their habitats are traditionally involved, there will be a need for profound modifications to established practices.

5. OTHER INFORMATION CONSIDERED RELEVANT FOR ACHIEVEMENT OF THE OBJECTIVES OF THE CONVENTION

5.1 Research and Systematic Observation

Research in support of climate change (or more in general, sustainable development) has to be carried out at all scientific institutions in Papua New Guinea. It includes research on and observation of climate related phenomena (mainly NWS), but also research into mitigation and adaptation options (various institutions like NARI, IMR, PNGFA and NRI). In this section mainly the work of the NWS is highlighted. Results of NARI are incorporated in the chapter on agriculture; that from PNGFA in the forestry and REDD+ chapters.

A more comprehensive approach to the research, necessary to support the further development of sustainable and low-carbon growth in PNG will require a systematic assessment of gaps and the potential of the research organizations to fill those gaps. Fortunately foreign research institutes carry out much research and the dissemination of results is most of the time good. An intensified cooperation with renowned institutes abroad would benefit PNG and helps in strengthening the capacity in the research institutes.

5.1.1 Rainfall

The temperature of the ocean surrounding Papua New Guinea has a strong influence on average monthly air temperatures. Changes in the temperature from season to season are small but more marked around Port Moresby than further to the north[17].

Papua New Guinea has a wet season from November to April and a dry season from May to October but these seasons are only noticeably different in Port Moresby, where about 78% of the yearly average rainfall comes in the wet season. Due to their location in the West Pacific warm pool, islands in the north of PNG experience rain throughout the year. Rainfall in the north of Papua New Guinea is also affected by the Intertropical Convergence Zone and, to a lesser extent, the South Pacific Convergence Zone. These bands of heavy rainfall are caused by air rising over warm water where winds converge, resulting in thunderstorm activity.

[17] Pacific Climate Change Science Program

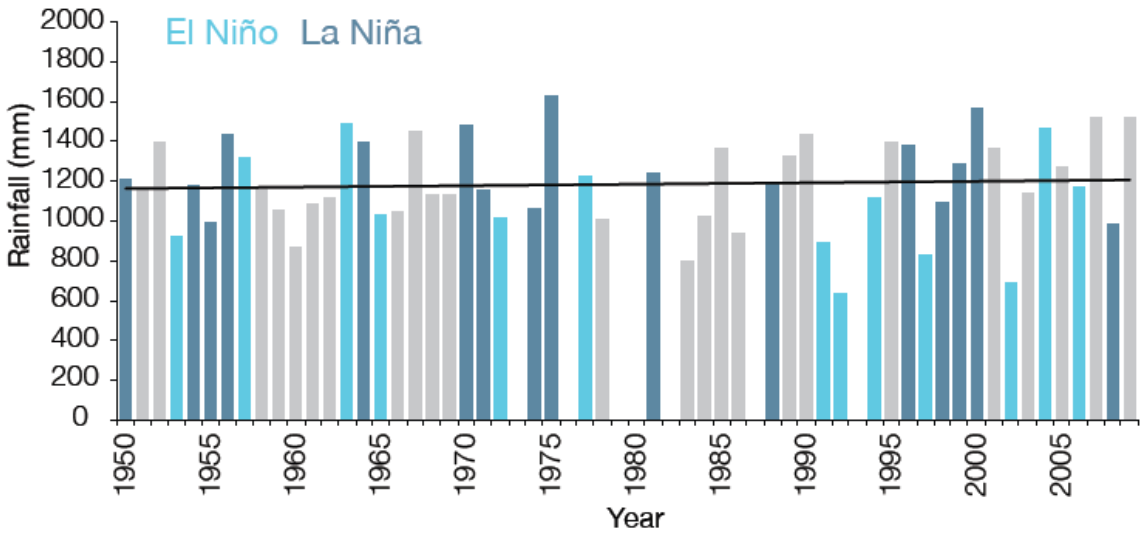


Figure 16 Annual Average rainfall for Port Moresby

Light blue bars indicate El Niño and dark blue indicates La Niña years and grey bars indicate neutral years.

5.1.2 Temperature

Annual minimum and maximum temperatures have increased in Port Moresby since 1950. Maximum temperatures have increased at a rate of 0.11 °C per decade since 1950. These temperature increases are consistent with the global pattern of warming.

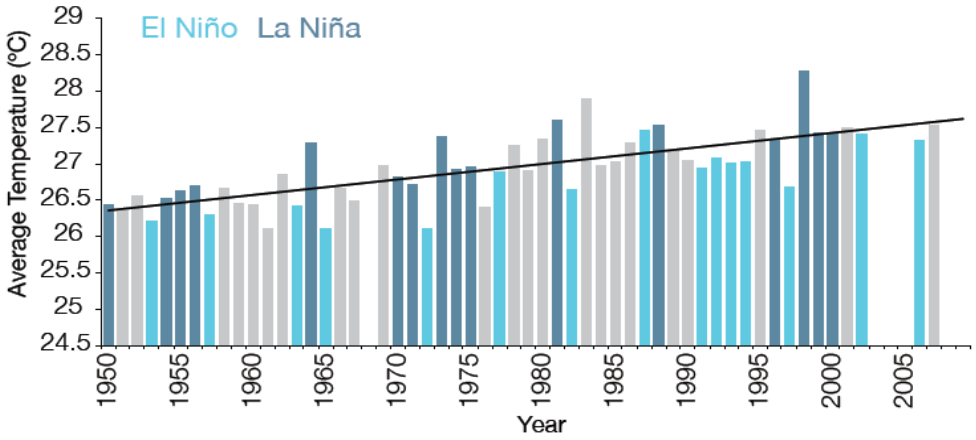
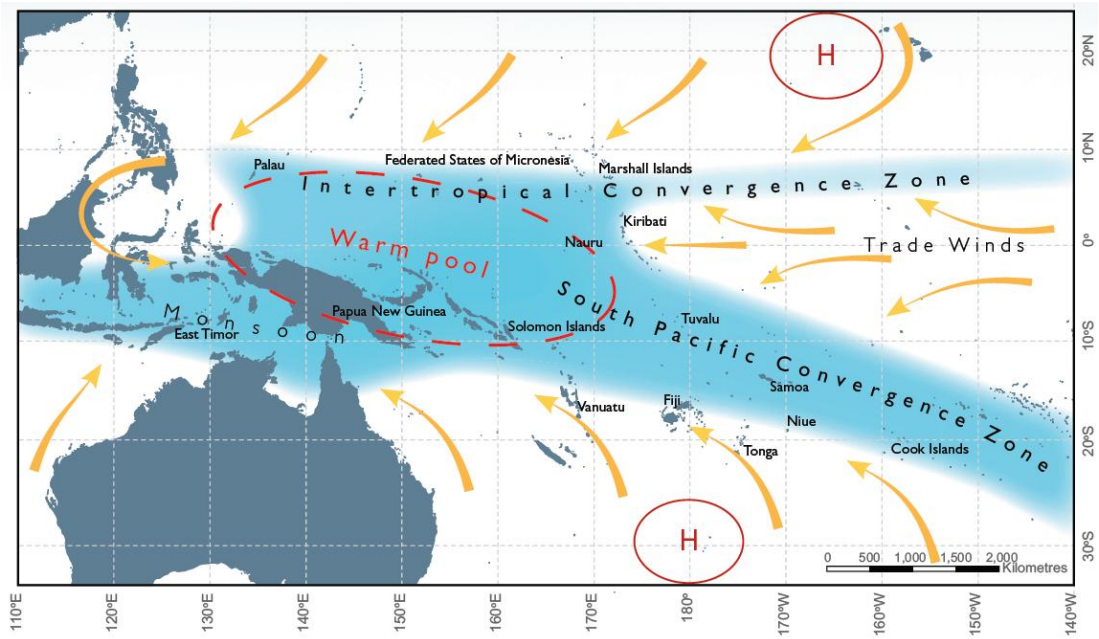


Figure 17 ENSO data since 1950 up to 2010 against the ever-increasing temperature

5.1.3 El Niño Southern Oscillation (ENSO)

PNG's climate varies considerably from year to year due to El Niño- Southern Oscillation. This is a natural climate pattern that occurs across Tropical Pacific Ocean and that affects weather

around the world. El Niño and La Niña are the two phases in the ENSO. In PNG El Niño events are usually drier than the normal; la Niña events are usually wetter. La Niña-associated with prolonged rainfall has led to flooding and landslides whilst El Niño associated droughts have also taken their toll in PNG.

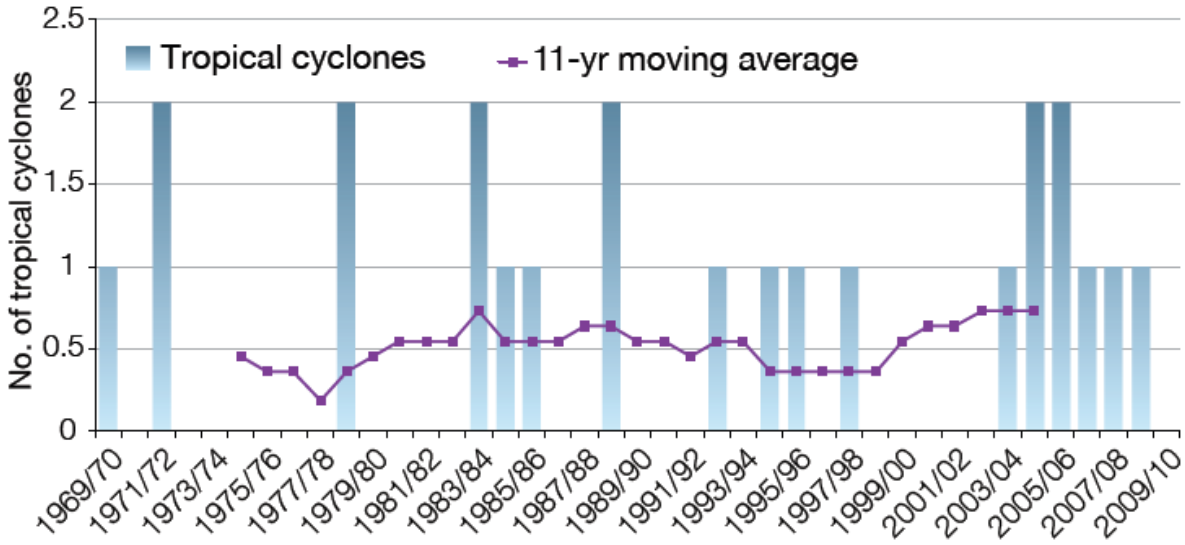


The arrows show near surface winds, the blue represents the bands of rainfall convergence zones, the dashed oval shows the West Pacific Warm pool and H represents typical position.

Figure 18 The average position of the major climate features in November to April

5.1.4 Tropical Cyclones

Tropical cyclones affect southern PNG between November and April. In the 41-year period between 1969 and 2012, 23 tropical cyclones passed within 400 km of Port Moresby, an average of less than one cyclone per season. Over this 1969-2010 period, cyclones occurred more frequent in neutral phases of the El Niño Southern Oscillation



Eleven year moving in purple

Figure 19 Number of tropical cyclones passing within 400 km of Port Moresby

5.1.5 Sea Level rise

As ocean water warms it expands causing the seal level to rise. The melting of glaciers and ice sheets also contribute to sea level rise. Sea level has risen near PNG by about 7 mm per year since 1993. The observed sea-level records are indicated in dark blue (relative tide-gauge observations) and light blue (the satellite record since 1993). Reconstructed estimates of sea level Papua New Guinea (since 1950) are shown in purple. The projections for the A1B (medium) emissions scenario (representing 90% of the range of models) are shown by the shaded green region from 1990 to 2100. The dashed lines are an estimate of 90% of the range of natural year to- year variability in sea level

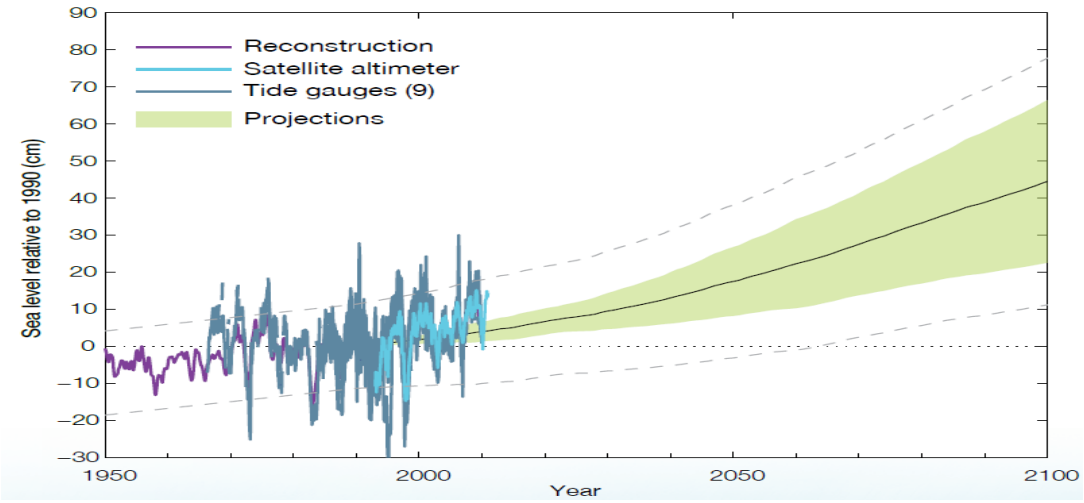


Figure 20 Observed and projected relative sea-level change near Papua New Guinea

5.1.6 Summary

Temperatures will continue to warm with more very hot days in future. Rainfall shows no clear trend since 1950 at Port Moresby but decrease in wet season rainfall in the northern area of the country. Rainfall is generally predicted to increase over this century with more extreme rainfall days.

Sea level near PNG has risen and will continue to rise throughout the century. Ocean acidification has been increasing in Papua New Guinea's waters. It will continue to increase and threaten coral reef ecosystems.

5.1.7 National Weather Service

The National Weather Service was in operation since 1975. The climate and special services department is responsible for investigating the trend in the climate in PNG and produce climate summaries for stakeholders. Its main functions are:

a) Conducting research in meteorology (climate/agromet)

b) Producing of climate summaries/information and

c) Providing improved forecasting aids as a result of effective processing and analysis of climate data.

There are different types of systematic observation:

- National Weather Service Surface Network (GCOS)
- National Weather Service upper Air Network (GUAN)
- Climate Network Volunteer
- Radar Network
- Rainfall Network- GCOS- Global Climate observation System and GUAN- Global Upper Air Network.

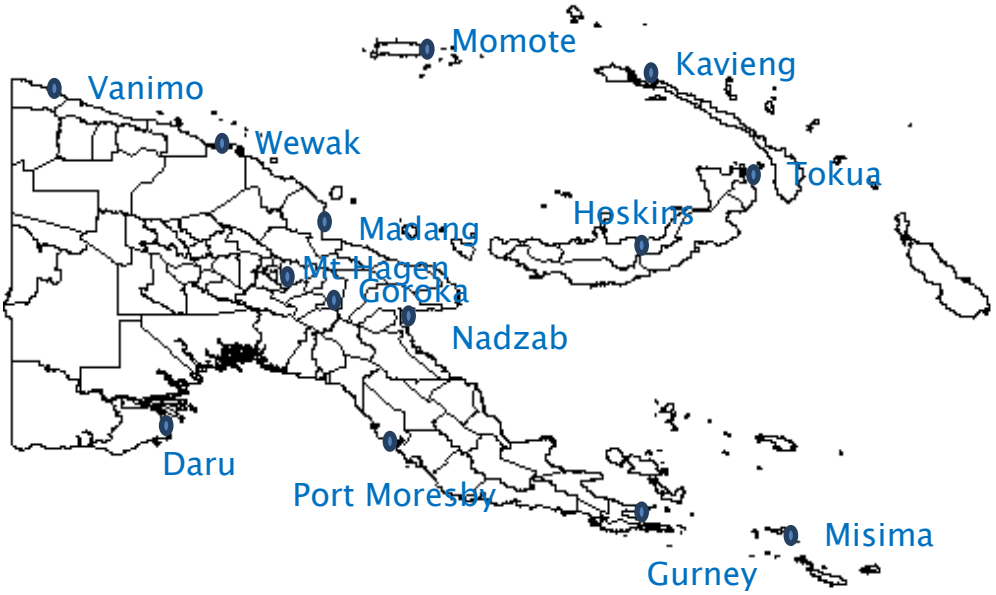


Figure 21 The NWS Surface Network

There are in 2011 the following;

- 14 Surface Observation Stations (3 GCOS Standard)
- 2 Upper Air Stations
- 4 (3) Automatic Weather Stations (AWS)- 6 (14) (UPNG) – (4) (World Bank) = 31 AWS
- 13 Marine stations

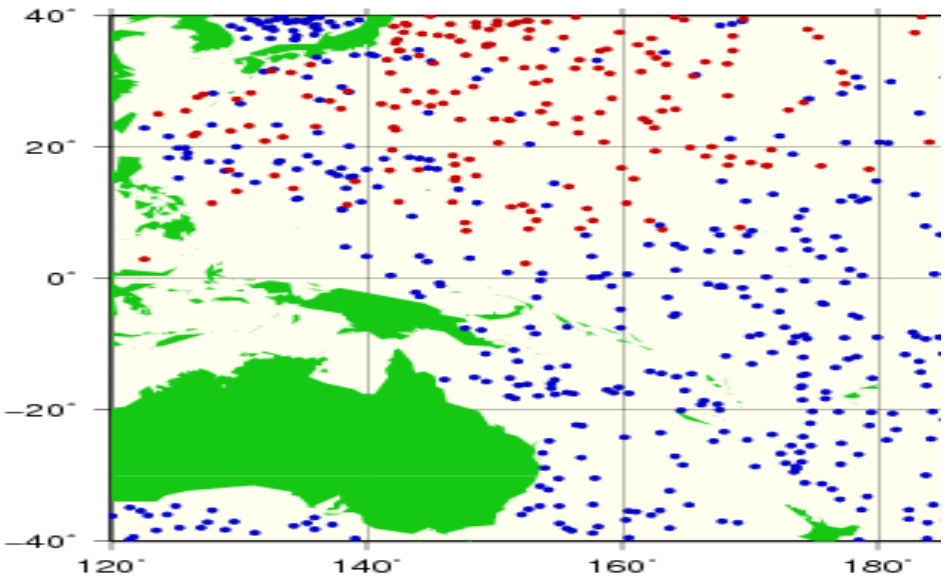


Figure 22 Current Locations of Argo Buoys in PNG Waters

The NWS in collaboration with the international community (Japan & Australia) has access to eleven marine observing triton buoys within the country's area of responsibility

5.2 Technology Transfer

The Framework Convention on Climate Change urges parties to promote and cooperate in developing, applying and diffusing technologies, practices and processes for mitigation of GHG emissions in relevant sectors (Article 4.1 (c)). In Article 4.5 the developed countries and Annex II parties are requested to promote, facilitate and finance the transfer of environmentally sound technologies and know-how to developing countries. It is recognized that developing countries can only implement their obligations under the Convention with this support from the developed countries.

In Marrakesh at the COP 7 a Technology Transfer Framework was adopted. At COP 13 this framework was enhanced. This includes Technology Needs Assessment (TNA) and Capacity Building (see also chapter 5.3) as activities in developing countries; next to creating Enabling Environments, the provision of Technology Information and the creation of Mechanisms for Technology Transfer which have to be undertaken at international level.

At COP 16 it was acknowledged that TT should be accelerated. At that meeting also technology for adaptation was explicitly mentioned next to mitigation technologies.

The acceleration is now supported by a Technology Executive Committee (TEC) and the Climate technology Centre and Network (CTCN). In these the cooperation with other institutions will be realized (like the Adaptation Committee, the Board of the Green Climate Fund, the Registry for NAMAs, the Least Developed Countries Expert Group, the Consultative Group of Experts on NCs from non-Annex I parties, the Standing Committee on Finance and the Adaptation Fund Board).

In order to coordinate the relations from a developing country with the UNFCCC and its institutions on the issue of Technology Transfer, the TEC urges that each developing country nominates a National Designated Entity (NDE). Establishment of a NDE is a necessary step for participation by a Party in the CTCN process[18]. The NDEs in developing countries will play a fundamental role in ensuring that requests submitted to the CTCN reflect national circumstances and priorities. NDEs will also ensure that support provided by the CTCN is well coordinated at the national level with other processes that address climate change, including ensuring engagement of relevant ministries, focal points for other UNFCCC mechanisms, the private sector, civil society, and academia as relevant.

The NDE facilitates the support to their countries from the CTCN by:

- Serving as National Focal Point on CTCN activities
- Supporting the articulation and prioritization of requests and proposals
- Managing the national submission process of technical assistance requests to the CTCN.

[18] http://www.unep.org/climatechange/ctcn/Portals/50212/NDEs_Roles&Responsabilities.pdf

UNEP has produced guidance for developing countries in assistance to set up an NDE. This might help to shape the requests of the country to maximize the effectiveness of efforts to get access to the opportunities that the TT-mechanism has for developing countries.

UNEP, on behalf of the GEF, is now implementing a new round of TNAs. These will go beyond the narrow definition of technology needs. The TNA will lead to a Technology Action Plan (TAP) that prioritizes technologies and facilitates good technology transfer projects. Linked to financial resources.

Papua New Guinea has no policy yet on the issue of technology transfer for mitigation on and adaptation to climate change. There's no Technology Action Plan for PNG as yet. However, OCCD is moving to address this issue with its adaptation initiatives. PNG has not yet performed a Technology Needs Assessment.

However some mechanisms and elements are in place whereby technology transfer and training for skills as well as peer exchange programs are run internationally, nationally, regionally and locally.

In the area of mitigation some projects are important to recognize:

- Divune Hydropower CDM Project Activity (PNG Power Limited)
- Ramazon Hydropower CDM Project Activity (PNG Power Limited)
- New Britain Palm Oil CDM project- Methane avoidance and Biogas Energy project:
    - Hagitha Methane Avoidance Project
    - Sangagra Methane Avoidance Project
- Oil Search Limited CDM Project-Flare and Gas Vent Conservation Project.

Also some activities in the area of MRV for both the National Greenhouse Gas Inventory and the REDD+ mechanism are worth mentioning in this context:

- Establishment of an operational wall to wall satellite monitoring system that allows PNG to report LULUCF activity data
- Establishment of a multi-purpose national Carbon Forest inventory in line with the UNFCCC reporting requirements
- Development of a National Greenhouse Gas Inventory
- Readiness Preparation Proposal (R-PP); Forest Carbon Partnership Facility (FCPF) through World Bank
- Continued support of the National MRV system under the UN-REDD program
- Establishment of the National MRV system for PNG with full coordinated support from the UNREDD program.

In the area of adaptation a number of relevant activities can be recognized too:

- LiDAR- Light detection and ranging. A tool to identify vulnerable areas
- CCAP- Coastal Communities Adaptation Project

- GFDRR- Global Fund for Disaster Risk Reduction
- PACCSAP– Pacific -Australian Climate Change Science and Adaptation Planning Program
- PPCR- Pilot Program on Climate Resilience
- AF- Adaptation Fund
- MARSH project by USAID – Mangrove Rehabilitation for Sustainably Managed Healthy Forest.

Instead of the present scattered activities with individual sources of funding, a more coordinated approach will be developed. For this the following priority actions are necessary:

- Designate an NDE
- Perform a TNA with support from UNEP
- Prepare a TAP with priority actions.

5.3 Capacity Building

5.3.1 Background

Capacity building under the Convention is still under development. It has mainly been defined in the context of implementation of the Technology Transfer Framework (see 5.2). It is defined as the process to build, develop, strengthen, enhance and improve existing scientific and technical skills, capabilities and institutions, particularly in developing countries, to enable them to assess, adapt, manage and develop technologies (UNFCCC-web site). Since the scope of TT has been widened to also include adaptation, capacity development also includes both areas of work.

Capacity building must be country-driven, based on specified needs and conditions of developing countries. It must reflect national development strategies, priorities, plans and projects. The implementation must primarily be by and in the country itself.

By its nature, capacity building is a crosscutting issue. Many activities in this area are conducted as integrated activities in other working areas under the Convention (UNFCCC-web site).

5.3.2 Present situation in Papua New Guinea

Within the OCCD's MRV, REDD+ and Adaptation divisions several activities are already taken place. Under the Clean Development Mechanism (CDM):

– NBPOL CDM Project,
– Hagitha Methane Avoidance Project (Milne Bay)
– Sangara Methane Avoidance Project (Oro Province).

Currently the Adaptation division at the OCCD has a number of projects going on. They include:

– Thousands of Mangroves Initiative
– Mangrove Foundation
– Mangrove Planting Handbook

- Pacific CC Canoe Voyaging
- Dry Stone-walling
- Ice Making Project, and more.

The OCCD is effectively and efficiently carrying out projects and consulting stakeholders, schools, universities, NGO's and other private companies within PNG to easily disseminate information and awareness on climate change.

Specific needs for such capacity building programs would primarily be with funding, the need for relevant policies and guidelines to be in place before carrying out relevant projects to do with technology transfer for better adherence to climate change roles and responsibilities, also an outline of ideal/relevant partners for consultation to help with new students or visitors on site.

Provincial Consultation Workshops: in PNG 18 provinces have been covered; it is the intention to cover the three remaining provinces by 2013. The objective is to build the capacity of officers in the Provincial Governments to be Climate Change Focal Points in the provinces and for the provincial governments to have a Provincial Climate Change Plan. OCCD has been working closely with provinces that have been consulted to address their priority hazards and also NGOs on the ground through the Technical Working Group. Papua New Guinea has a very diverse culture and so education and awareness really needs to be delivered right down to the village level and to their own understanding. So it is necessary to build the capacity of the Provincial Government on Climate Change so that they bring the necessary knowledge and skills to village councilors and ward leaders and educate/train them to educate their own people on adaptation and mitigation measures.

5.3.3 Capacity Needs Assessments

Effective implementation of climate mitigation and adaptation strategies and plans will require sufficient capacity (both in terms of quantity and quality) at all levels and with all stakeholders. For mitigation the focus might be on the national level and on implementing stakeholders (agriculture, fisheries, forestry, industry, mining). Here the focus might be on the most important sectors for GHG inventories and for mitigation. For adaptation next to the national government, also provincial and local government have to be targeted as well as stakeholders like common people, NGO's and (e.g.) extension officers for agriculture and/or forestry. Every group or organization plays its own role in the implementation of CC-policy. For adaptation a focus might be on vulnerable areas to start capacity development.

But CC-policy should not be a separate area of interest. As indicated by the UNFCCC it must reflect development policy, strategy and plans. Mainstreaming climate change into development planning is one of the best options to really implement climate compatible development management policy. This means that at the national and provincial level not just the capacity at the Ministry for Forests& Climate Change needs to be in place, but also at the Ministries of (e.g.) Agriculture and Livestock, Education, Fisheries and Marine Resources, Environment and Conservation, Lands & Physical Planning, National Planning, Mining, Petroleum & Energy etc.

A capacity needs assessment will be necessary to focus on the most important gaps in capacity when compared to the role in the planning and implementation process for climate change mitigation and adaptation. This assessment can only be performed properly when an approved compatible development management policy and strategy are available as reference for the needed capacity. It needs to be carried out with full support of the parties involved in implementing the climate change strategy of PNG (which is still to be finalized).

Additional needs assessments might be useful for various important public and private stakeholders and for local level institutions.

5.3.4 Capacity Building (or better Capacity Development) programme

As stated earlier, effective implementation of the obligations under the Convention will need sufficient capacity (in quantity and quality) with all partners and at all levels. At the moment in Papua New Guinea the capacity at national level is mainly available at the Office of Climate Change and Development. This central office for the Convention has only recently been established and is still building its own capacity. At the same time OCCD is carrying out various projects on capacity building, but not yet based on a programmatic approach. When a capacity needs assessment has been carried out, the necessary activities can be formulated and put in order of priority. In developing countries typically 4-year programmes are defined to achieve progress and to keep it manageable. Establishing focal points / units for climate related issues at the various ministries, with frequent contact between those and OCCD will certainly help in building both capacity and awareness. The same might be considered for the provinces.

A programme can consist of the following elements:

- Preparing manuals or guidance documents for:
    - Writing CC-strategies and preparing CC-plans
    - Mainstreaming CC into development planning
    - Preparing CC-scenarios and applying them at national and provincial level
- Trainings for staff at relevant institutions (ministries, provinces) in using the guidance documents
- Training on technical issues and the use of models in developing CC-plans
- Developing course material and educational programmes at different levels (primary, secondary, high school, university)
- Training of trainers
- Making available relevant background material, models and data
- Creating enabling environments for research and policy advice on climate change (including hardware and software and the institutional arrangements).

Of course it is not necessary to have all components put into one programme but it helps when at least a close cooperation between institutions carrying out parts of this list is guaranteed.

Many elements of such a programme have already been developed in programmes in other developing countries. Much is also available through UNFCCC, UNDP and other international institutions. A thorough literature search at the start of a programme will help in focusing on the

issues that need additional and special attention in Papua New Guinea. The cultural and natural diversity of the country will probably mean that these will lead to a larger variety of approaches than in most other developing countries.

Financing a capacity development programme will probably not be possible with only internal money. Several potential sources for funding can be found within the existing programmes of the Convention and e.g. UNDP.

5.4 Information and Networking

ICT tools and networking are crosscutting issues, essential in reaching the objectives of climate inclusive development and the necessary capacity development. The access to and use of computers is already high and increasing, with almost every person in organizations having fulltime access during working hours. Therefore information processing, storage and transfer happen already on a daily basis.

Scientists and information professionals have email accounts either through the domain name of the organization or privately. Search-based webmail services are widely available, such as Gmail and Yahoo. Access to Internet varies across institutions, as many use modems and lease line systems, while NARI is the only institute that has broadband connection across all its research centres. ARD organizations have their own fully functional websites with web links to other partners and collaborators. There is a cell phone SMS project on market information for vegetables with the mobile company Digicel; this is a collaborative initiative involving the private sector. Facilitated by email and Internet services, electronic resources such as electronic newsletters, blogs and social networking have become timely and speedy media of Information / data sharing, which a lot of research organizations have adopted.

So for scientists and professionals the boundary conditions are rather good, especially in the agricultural sector. But that is only one factor in the system of data and information processing. The data and information themselves must be available. In many cases this is still a challenge in Papua New Guinea.

A possible way forward is to *centralize the present Centres of Excellence* to create a single entity to coordinate it. Currently environmental and/or climate change information in PNG is scattered throughout various institutions including organizations, government agencies, NGO's, and Universities. Hence there is a need to develop a centre for compiling and disseminating information, in our case relating to climate change. Encouraging the exchange of information among institutions is also a necessary approach. This would raise environmental and climate change awareness, minimize social conflict and tensions and assist developers with compliance checking with regulations and standards. At the moment much information in private or public institutions is not accessible, as was encountered when compiling this Second National Communication. To enhance this, a registry might be kept updated with all major organizations and individuals, which are important for national programmes on climate change and development and for the national obligations/reporting towards the international community.

A good example is the Papua New Guinea Resource Information System or PNGRIS, which deals with environmental appraisals for the PNG tropical forestry action plan.

It will be necessary not only to collect, compile and store information on climate relevant issues, but also to make the information available and retrievable. Data must be available for multiple uses and stored in such a way that they can be retrieved for future use. Thus, there is a need to *establish in-house databases* within DEC, NPO and OCCD. This is not a trivial issue. Before data can be stored in a central database, it will be necessary to establish the quality of the data (accuracy, uncertainty) and not only to store the data, but also the necessary metadata (who collected the data, how has it been done, measurement methods etc.) to be able to trace data to the origin. Such databases must be public. Either the data or compilations from the data must be publicly accessible; sometimes there is a restriction necessary for commercial use: then payment for information might be considered. The methods used in this process have to be reported both at the national and international level.

The use of traditional media is still common in sharing scientific information in Papua New Guinea. Such media include *newspapers;* these give prominence to agriculture news and features in their daily issues, because it is important for many people in Papua New Guinea. Of particular importance are the weekly columns, which are provided for free to the agriculture community. Occasionally *television* is used as a medium to relay climate change information (with PNG's two television stations), especially in the news and feature programs. News and agriculture programs are also common with *radio* stations, which have a much wider coverage including the rural areas. As many people in PNG still rely upon verbal and visual tool, the further production and distribution of videos about climate change related issues might be considered.

The various *Resource Centres* will have to become one-stop-centres in which scientific information can be distributed to stakeholders. This arrangement can also take advantage of ICT interventions. A national policy on availability of data and information (especially on public data and information) might help in making this a success.

Next to traditional media, the use of social media has to be considered. A strategy how to use these to the advantage of awareness raising about climate change, still has to be developed.

5.4.1 Constraints in the process of collecting data and information

The lack of information about many climate-relevant issues is perhaps the major constraint to effective monitoring and enforcement in climate change (and the environment sector in general). In large parts of the country it is still extremely difficult to collect the necessary data.

Funding is a major constraint, as most ARD organizations rely on Government funding and the Government has its priorities and budget allocation limits, which not always are tuned to the needs from the climate change perspective.

The rugged geographical terrain and social issues, such as vandalism, also pose major challenges.

While PNG development partners are keen in adopting changes in technology, resources for ICT are limited. This is a challenge at hand that requires input from all actors.

Due to the constraints in technology as mentioned earlier, the access to information systems and databases for scientists and information processors is limited; not many of them are fully aware of the pool of useful knowledge that is available in the public domain.

5.5 Climate Change Education, Training and Public Awareness

(References: National Department of Education (NDOE), 2003 Environmental Studies Syllabus)

5.5.1 Education

It is in the best interest of the country through the national government, to see that all Papua New Guineans, both young and old are educated about climate change. However, for the country to achieve its target and objective of becoming carbon neutral and climate resilient by 2030, it has to have an educated population that will be able to ensure that society lives in a climate sustainable and resilient manner.

Current education syllabi for Primary and Secondary school students in PNG include:

Lower primary (grade 3-5)

Table 5.1 Grade 3 Syllabus

Subject	Strand	Substrand	Learning Outcome
Environmental Studies	What is in my environment?	Changes in my environment	**3.1.2.** Identify natural and built changes and their impact on the environment

Table 5.2 Content of Grade 3 Syllabus

Subjects and Outcomes	Knowledge	Skills	Attitudes
Environmental Studies: 3.1.2	natural and built changes, impact on the environment	identify, discuss, compare, list, collect, read simple tables and graph/charts record, describe, explain evaluate, classify	caring conserving protecting appreciating accepting

Table 5.3 Content of Grade 4 Syllabus

Subject	Strand	Sub strand	Learning Outcome
Environmental Studies	Caring for my environment	Managing Waste	**4.2.2** Investigate the consequences of waste and apply ways to minimize environmental damage

Table 5.4 Content of Grade 4 Syllabus

Knowledge	Skills	Attitudes
Types of wastes (suggestion: To include Waste gas from burning of fossil fuels and biomass called carbon dioxide – its impact on the earth's greenhouse should be included here? solid/liquid/gas wastes should be explain here) Ways of minimizing or controlling environmental damage (suggestion: to include how to control Carbon dioxide and other greenhouse gases emissions into the earth's atmosphere?) Consequences of waste – impact on environment (suggestion: to include consequences of the enhanced greenhouse effect?) Effects of chemical waste Traditional ways of managing waste	Write questions Ask questions Gather information Explain and identify List types of waste Design a model Plan Analyze Classify group Reading skills Survey to observe, collect data	Responsible behavior Positive attitudes

Table 5.5 Content of Grade 5 Syllabus

Subject	Strand	Substrand	Learning Outcomes
Environmental Studies	Caring for my environment	Managing Waste	**5.2.2** Develop and implement action plans to manage waste production and disposal

Table 5.6 Upper Primary (grade 6-8)

Strand	Grade 6	Grade 7	Grade 8
Living things	Nature of Living things Ecology, relationships and interactions	Nature of Living things Ecology, relationships and interaction	Nature of Living things Ecology, relationships and interactions
Science in the home	Learning about substances Using energy at home	Learning about substances Using energy at home	Learning about substances Using energy at home
Earth and Beyond	Our earth and its origin Space exploration	Our earth and its origin Space exploration	Our earth and its origin Space exploration

Lower Secondary (grade 9-10)

Grade 9

9.7 Earth and Atmosphere

Topic 1 – Structure of the Earth

Topic 2 – Rock cycle and rock formation

Topic 3 – Structure of the atmosphere

Topic 4 – Active atmosphere (Investigate, identify, describe and explain)

The components of air
The importance of these components

Topic 5 – Weather.

Upper Secondary (grade 11-12)

Geography for Grades 11 and 12, with topics on the water, carbon cycles, ocean-atmospheric cycles.

In general it is recommended that teachers have access to climate change related resources and are encouraged to use these.

At he moment the emphasis in the curricula is on theory. It might greatly help to include also practical lessons to this. Examples from other countries about these are available (e.g. climate field schools).

5.5.2 Training

The Office of Climate Change & Development (OCCD) coordinates interagency trainings whereby sector professionals from Agriculture, Forestry, Fisheries, Health, and others participate in climate mitigation and adaptation trainings, which are related to their sectors such as climate adaptation in Agriculture sector by NARI and DAL. In addition, various projects such as PACC[19] in Agriculture and others provide for hands-on training in addressing climate change.

Other projects are:

- JICA forest monitoring project with PNG Forest authority to monitor forest in REDD+ related programs
- The National Agriculture Research Institute (NARI) has climate change initiatives in their programs because of the highly climate sensitive nature of the agricultural sector
- Coral Triangle Initiative (CTI) co-coordinated by NFA and DEC is providing training on climate change Adaptation for stakeholders from all levels in the fisheries sector
- ADB and World Bank now supporting GoPNG on the PASSAP Project
- AusAid with UNDP and the EU on climate mitigation for the forestry and energy sectors and Adaptation Programs
- The Construction Industry is moving ahead with climate friendly designs and energy efficient buildings.

At the moment training activities focus on the national/general level and on specific sectors. A provincial and local programme might also be considered, but this will require a lot of trainers. These have to be trained first (training of trainer programme).

5.5.3 Public Awareness

The OCCD has a Consultation Program under National Communications in its structure to conduct stakeholder consultations and awareness programs with provincial and local government, private sector, academia, civil society, and NGOs on climate change mitigation and adaptation programs and projects.

Papua New Guinea's National Constitution reflects the aspiration to promote sustainable development and to be effective custodians of the natural capital. The fourth goal of the constitution articulates; 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 for us all, and to be replenished for the benefit of future generations.

[19] Pacific Adaptation on Climate Change Project

Based on the fourth Goal, Papua New Guinea has evolved its various national legislation and national action plans to promote the objectives of the 4th Constitutional Goal. In doing so PNG has partnered with the global community through various multi-lateral environmental agreements. Since the 1990s PNG has signed and ratified several important global agreements including, the UN Conference on Environment and Development or the Rio Declarations Agenda 21,UN Conference Rio +5, the UN Framework Convention on Climate Change and the UN Convention on Biodiversity, and most recently UN Convention on Sustainable Development – Rio +20, in 2012. These various conferences although emerging with their specific objectives have been consolidated to address sustainable and climate compatible development focusing on the reduction of poverty and the overall betterment of humanity.

All existing government mechanisms guides decentralization of the translated Vision 2050, Pillar 5 Climate Change and environment Sustainability Key Priority activities with the clear demarcation between national and sub-national programs as stipulated under the key result areas of climate change within the Medium Term Development Plan (MTDP) 2011-2015.

The Office of Climate Change and Development (OCCD) is undertaking an intensive period of consultation with a broad range of stakeholders, including government, civil society, private sector and local communities. So far, the OCCD team has already visited 19 of the 22 provinces in the country. This has been an over whelming achievement for the organization who still has a mammoth task ahead in reaching the local people in the remote areas of the country.

Apart from the national consultation programme in the country, OCCD also took lead in hosting events and workshops to create awareness and promote Climate Change and Environmental Sustainability with the key messages on the focus of developing our economy but at the same time, this has to be done sustainably by combining economic development imperatives with climate change mitigation and adaptation measures. This will require substantial change patterns of land use (especially in agriculture and forestry), a paradigm shift from the structure of the economy, and new sectoral policies. In turn, this will also require a shift in the mindsets of actors in the government, private sector, non-profit sector and landowners, from short to long terms, from exploitation to sustainable use and from seeing the natural environment as a constraint to seeing it as an enabler.

- We conducted 19 provincial consultations with reports produced. Where few have access to TV or Internet, the OCCD has begun consultation with some creative solutions to the broader public, especially in remote communities.
- Radio Drama- a 10-episode radio drama in *Tok Pisin*, which addresses climate change topics in a format that is easier to understand.

Cartoon: The OCCD ran a cartoon competition for UPNG students in order to select a cartoonist to draw a series of cartoons on climate change. The cartoons would be used in communication materials as a simple and entertaining way to communicate climate change messages to a broader audience.

Student-led awareness: The OCCD conducted a briefing workshop on climate change with over 50 interested University of Papua New Guinea (UPNG) students from both science and non-science backgrounds prior to the school holidays. The aim is to empower the students returning to their villages across different provinces in PNG to spread awareness on climate change and to help their own family and communities to be climate-resilient and carbon-neutral.

Other awareness activities: Besides the use of different media formats, the OCCD also participated in other events held by other organizations to highlight the issue of climate change. We also conducted first Media Workshop for all Climate Change and Environment journalists in the country and hosted a Climate Change Open Day for the general public. OCCD also continuous its awareness through the use of the Media (local Radio, TV and newspapers) whereby regular Media Releases from the OCCD Management and the Ministry of Forest and Climate Change are circulated to the mainstream media for the general public to have access to. The OCCD also a website and is also on facebook.

5.6 Recommendations and Way Forward

OCCD should initiate a dialogue with the Education Department by writing to have a MoU and funding support to develop a climate change resource book for primary and high schools and if possible include climate change learning outcomes (e.g. climate science, carbon dioxide and other greenhouse gases emissions-impact on earth's greenhouse, impacts & threats, mitigation and adaptation) in the education syllabus for all schools in Papua New Guinea. (Letter from OCCD Executive Director to Secretary for Education requesting MoU on curriculum development and work on climate change resource book for school teachers and students). At present, a few NGOs such as WWF have been working with the Curriculum and Assessment Division of the Department of Education to develop a mangrove conservation resource book for primary schools in PNG.

OCCD in collaboration with Research Conservation Foundation are in the process of developing resource material for teachers in schools.

6. CONSTRAINTS, GAPS AND RELATED CAPACITY GAPS

Papua New Guinea has still a long way to go on the path towards full implementation of the obligations under the Convention. Several limitations and constraints will have to be overcome.

6.1 The Reporting process

The SNC report was mainly written on a project basis. Consultants were hired to collect data and compile most of the report. Due to inconsistencies with the consultants, hired to conduct surveys and compile reports, the process took more time than anticipated. The basic capacity in Papua New Guinea to monitor climate relevant processes, to collect and process the data and to prepare reports to the UNFCCC is still insufficient. Also for the process of Biennial Update Reporting it will be necessary to substantially upgrade this capacity at all relevant places and institutions. The establishment of the intended Climate Compatible Development Center at the OCCD will certainly help in coordinating many efforts in this respect.

6.2 National Greenhouse Gas Inventory

The information on activities, necessary to calculate the emissions, is still inadequate or not accessible; information on the accuracy or uncertainty in the available data is insufficient. The coherence in the data set and data management need improvement.

The processes of collecting data, and to verify and validate them, are not continuous and are not embedded in a standing organization. The collection system is also not complete. Information on several sectors is missing. It will be necessary to designate a focal agency for these tasks. This agency can maintain a database on activity data and emission factors in support of the inventory. It also has to coordinate between data holders in the public and private sectors.

For a more adequate inventory of emissions, country-specific emission factors will be needed. At present the research into, and the assessment and verification of such factors is clearly insufficient. The pool of technical experts on greenhouse gases at research institutions, agencies and ministries is poorly filled.

6.3 Climate Change Impact and Adaptation

A coherent assessment of impacts of climate change on Papua New Guinea is only available at a rather abstract level. A more detailed assessment still has to be carried out. Because of the huge variety in landscapes in the country and the inaccessibility of large parts of the country, this is a major challenge.

For a more detailed assessment it will also be necessary to develop regionalized climate change scenarios. This is again a major challenge because of the lack of detailed climate related data in the country.

Systematic observation and research on climate and related phenomena certainly needs strengthening in PNG. With the 14 surface stations, 2 upper air stations, 31 automatic weather stations and 13 marine stations the coverage of the country is limited. Most of the stations are

located in the coastal region. This means that only very few data are available of the situation in the mountainous areas inland. In view of the natural circumstances, a more widespread application of remote sensing techniques, like LIDAR, and the application of satellite data in combination with modeling techniques might be the way forward on this. But the research capacity and available funding for this are still very limited.

6.4 Mitigation measures

As mentioned in chapter 3, the country has taken important steps in programming mitigation of greenhouse gas emissions. Since the Initial National Communication the focus has been on the most important sector in PNG: forestry. Under the REDD+ programme much progress has been made. This process is now in the pilot phase with several sites established. Both bilateral support and international funding have led to several demonstration projects. Large-scale application of the lessons from pilots and demonstrations is still lacking. For this the intended PPP for REDD+ implementation will be necessary. To achieve this a lot of capacity building and awareness raising has to be done. Programmes for this are still to be developed.

For all other sectors no clear programme of measures is available yet. As the Climate Compatible Development Strategy will evolve into concrete and comprehensive mitigation planning, plans and projects for agriculture, energy, industry and other sectors can be defined and started (provided that funding can be found). The cost-curve approach, as carried out for the LULUCF-sector, can be used to prioritize between potential measures. For this sufficient information about costs of measures will be necessary. At the moment this information is not available.

Important barriers for the implementation of mitigation measures are the lack of available technology, low human resource capacities in operating such technologies, the limited available government budget, and lack of information access (from public and private parties). There are however various opportunities to overcome these issues. Papua New Guinea has an abundance of resources for renewable energy. Government has started with efforts, such as programmes and policies for the implementation of renewable energy. This might accelerate the implementation of mitigation activities. In addition, the emergence of the carbon market may also accelerate the adoption and implementation of mitigation technologies that are not fully economically feasible for Papua New Guinea. Nevertheless, because it will be necessary to upscale the implementation of climate change programmes, additional financial and capacity support will be necessary.

6.5 Technology development and transfer

It is necessary to assess the level of technological needs, including endogenous demand, in mitigation and adaptation at the ministerial, agency and provincial levels. Technical experts and professionals need to be trained in order to facilitate the prompt and successful adoption of new technologies. It is important to seize opportunities to steer development towards a low-carbon economy through the implementation of climate change projects, particularly CDM projects.

Technology transfers originating from abroad and destined for priority areas will have to be climate-friendly and compatible with PNGs sustainable development.

6.6 Capacity building, education, training and awareness raising

The OCCD is working with other agencies and ministries to conduct trainings on climate change mitigation and adaptation. The government and international organizations support most of the projects on this. A clear programme on capacity development however is still missing. For this a capacity needs assessment will have to be carried out. Based on this a focused programme can be developed. This has to include essential knowledge and skills, but also instrumentation for research, monitoring and reporting (including hard- and software). Discussions about such a programme with international organizations like UNDP or the ADB are advisable in order to find adequate funding.

Some elements of teaching on climate change issues are available in present primary and secondary education. Especially for the development of enough knowledge capacity for the tasks ahead, it will be necessary to also create an educational programme at higher education and university level, supported by resource material (both theoretical and with examples form national pilots and from abroad). This has to be set-up and carried out in close cooperation with the Education Department.

Awareness of the natural environment is part of the national culture in PNG. It even is embedded in the National Constitution. In the Vision 2050 climate change and environmental sustainability are key priority areas for actions. The OCCD already embarked upon a process with a broad range of stakeholders. It will need however substantial budget and capacity to continue in this direction.

6.7 Finances

Lack of funding is the main issue with almost all necessary actions. The institutions involved in climate change activities need support staff to carry out surveys, establish enough expert capacity and participate in the processes. E.g. GEF was the only funding source for writing the SNC. Participating in the international and regional activities on climate change issues requires substantial budget, which only partly can come from the limited government budget.
Access to international funds for the support of processes and for projects on climate change mitigation and adaptation requires a solid climate change action plan with estimated financial implications.

6.8 Enabling environment

Climate compatible development management policy as a separate issue is not a viable way forward. To really achieve PNGs obligations under the Framework Convention and to arrive at a climate change resilient and sustainable PNG, it will be necessary to integrate climate change issues and the Climate Compatible Development Management Policy Framework into development planning: i.e. the Vision 2050, the Development Strategic Plan, and the Medium Term Plan.

Implementation of climate compatible development management policy and the Framework Convention is not just a matter of money. It also requires a legal and regulatory framework. Especially when it comes to monitor, reporting, verification, compliance checking and, when necessary, enforcing, at present the basis is still very narrow. The present sectoral legal instruments will need to be geared more specifically towards climate change mitigation and adaptation. This will also require coordination between the national government and provincial (and maybe even local) institutions. Capacity enhancement is necessary for all levels to achieve this.

6.9 Conclusions

The situation in Papua New Guinea with respect to the implementation of the obligations under the Framework Convention on Climate Change and the National Climate Change Strategy shows substantial gaps. PNG is confronted with many constraints due to its development status and its natural situation.

The most important gaps stem from the lack of sufficient capacity (both in quantity and in quality) at all levels of government, in research, and with the relevant stakeholders. Capacity is not only knowledge, but also instrumentation for research, monitoring and reporting on climate change. To solve this, the second most important gap is finances. Being a developing country means that PNG can only afford to spend limited budget to capacity development and to climate change projects in general. Access to international funds is crucial to achieve progress.

ANNEX

Table A1 Bunker fuels estimate for the year 2000 is 144.5 Gg CO2

This spreadsheet contains sheet 4 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

This spreadsheet contains sheet 5 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**	**ENERGY**
SUBMODULE	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**
WORKSHEET	**1-1**	**1-1**
SHEETS	**4 OF 5 EMISSIONS FROM INTERNATIONAL BUNKERS (INTERNATIONAL MARINE AND AIR TRANSPORT)**	**5 of 5 EMISSIONS FROM INTERNATIONAL BUNKERS (INTERNATIONAL MARINE AND AIR TRANSPORT)**
COUNTRY	**Papua New Guinea**	Papua New Guinea
YEAR	**2000**	2000

		A	B	C	D	E	F	G	H	I	J	K	L
		Quantities Delivered[a]	Conversion Factor (TJ/Unit)	Quantities Delivered (TJ)	Carbon Emission Factor (t C/TJ)	Carbon Content (t C)	Carbon Content (Gg C)	Fraction of Carbon Stored	Carbon Stored (Gg C)	Net Carbon Emissions (Gg C)	Fraction of Carbon Oxidised	Actual Carbon Emissions (Gg C)	Actual CO_2 Emissions (Gg CO_2)
FUEL TYPES				C=(AxB)		E=(CxD)	F=(E/1000)		H=(FxG)	I=(F-H)		K=(IxJ)	L=(Kx[44/12])
Solid Fossil	Other Bituminous Coal	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00
	Sub-Bituminous Coal	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00		0.00	0.00
Liquid Fossil	Gasoline	0.00	44.80	0.00	18.90	0.00	0.00		0.00	0.00		0.00	0.00
	Jet Kerosene	15.03	44.59	670.19	19.50	13,068.66	13.07		0.00	13.07	0.99	12.94	47.44
	Gas / Diesel Oil	25.90	43.33	1,122.25	20.20	22,669.39	22.67		0.00	22.67	0.99	22.44	82.29
	Residual Fuel Oil	4.80	40.19	192.91	21.10	4,070.44	4.07		0.00	4.07	0.99	4.03	14.78
	Lubricants	0.00	0.00	0.00	0.00	0.00	0.00	0.5	0.00	0.00		0.00	0.00
			Total	**1,985.35**								**Total[a]**	**144.50**

(a) Quantities taken from column "International Bunkers" from Worksheet 1-1, Sheet 1 of 5.

(a) The bunkers emissions are not to be added to national totals.

Documentation on box:

Parties are encouraged to provide relevant information used in the calculation and on data sources in this documentation box.

Data on fuel and petroleum products were obtained from IRC (ASYCUDA):Total fuel imports for the year 2000 are as follows, Gasoline = 933,653,946.27L; Jet Kerosene=94,529,518L; Other Kerosene = 15,809,999L; Gas Diesel Oil=153,911,391.914 L; Residue Fuel Oil=25,770,213.78 L

Liquefied Petroleum Gas (LPG) consumption= 775,377.58 Stock Change is estimated to be 40% (working group expert judgment) in order to maintain fuel supply to the economy

Table A2: Methane emissions from Domestic Live Stock Enteric Fermentation and Manure Management

This spreadsheet contains sheet 1 of Worksheet 4-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	AGRICULTURE					
SUBMODULE	METHANE AND NITROUS OXIDE EMISSIONS FROM DOMESTIC LIVESTOCK					
	ENTERIC FERMENTATION AND MANURE MANAGEMENT					
WORKSHEET	4-1					
SHEET	1 OF 2 METHANE EMISSIONS FROM DOMESTIC LIVESTOCK ENTERIC					
	FERMENTATION AND MANURE MANAGEMENT					
SESSION	PNG SNC					
YEAR	2000					
	STEP 1			STEP 2		STEP 3
Livestock Type	A Number of Animals	B Emissions Factor for Enteric Fermentation (kg/head/yr)	C Emissions from Enteric Fermentation (t/yr)	D Emissions Factor for Manure Management (kg/head/yr)	E Emissions from Manure Management (t/yr)	F Total Annual Emissions from Domestic Livestock (Gg)
			C = (A x B)/1000		E = (A x D)/1000	F = (C + E)/1000
Dairy Cows	0	0	0	0	0	0
Non-Dairy Cattle	80000	53	4240	7	560	4.8
Buffalo	4000	55	220	3	12	0.232
Sheep	15000	5	75	0.21	3.15	0.07815
Goats	20000	5	100	0.22	4.4	0.1044
Camels	0	0	0	0	0	0
Horses	0	0	0	0	0	0
Mules & Asses	0	0	0	0	0	0
Swine	1823500	1	1823.5	20	36470	38.2935
Poultry	1680020	0	0	0.023	38.64046	0.03864046
Totals			6458.5		37088.19046	43.54669046

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

Table A3 Nitrogen Excretion from Animal Waste Management System-Pasture and Paddock

This spreadsheet contains Worksheet 4-1 (supplemental), in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	AGRICULTURE			
SUBMODULE	METHANE AND NITROUS OXIDE EMISSIONS FROM DOMESTIC LIVESTOCK			
	ENTERIC FERMENTATION AND MANURE MANAGEMENT			
WORKSHEET	4-1(SUPPLEMENTAL)			
SPECIFY AWMS	PASTURE RANGE AND PADDOCK			
SHEET	NITROGEN EXCRETION FOR ANIMAL WASTE MANAGEMENT SYSTEM			
SESSION	PNG SNC			
YEAR	2000			
Livestock Type	A Number of Animals	B Nitrogen Excretion Nex (kg/head/yr)	C Fraction of Manure Nitrogen per AWMS (%/100) (fraction)	D Nitrogen Excretion per AWMS, Nex (kg N/yr)
				D = (A x B x C)
Non-Dairy Cattle	80000	60	1	4800000
Dairy Cows	0	0	0	0
Poultry	1680020	0.6	0.95	957611.4
Sheep	15000	20	1	300000
Swine	1823500	16	0.8	23340800
Others	24000	25	1	600000
TOTAL				29998411.4

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

Table A4 Nitrogen Excretion from Animal Waste Management System-Solid storage or dry lot

This spreadsheet contains Worksheet 4-1 (supplemental), in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**AGRICULTURE**			
SUBMODULE	**METHANE AND NITROUS OXIDE EMISSIONS FROM DOMESTIC LIVESTOCK**			
	ENTERIC FERMENTATION AND MANURE MANAGEMENT			
WORKSHEET	**4-1(SUPPLEMENTAL)**			
SPECIFY AWMS	**SOLID STORAGE OR DRYLOT**			
SHEET	**NITROGEN EXCRETION FOR ANIMAL WASTE MANAGEMENT SYSTEM**			
SESSION	**PNG SNC**			
YEAR	**2000**			

Livestock Type	A Number of Animals	B Nitrogen Excretion Nex (kg/head/yr)	C Fraction of Manure Nitrogen per AWMS (%/100) (fraction)	D Nitrogen Excretion per AWMS, Nex (kg N/yr)
				D = (A x B x C)
Non-Dairy Cattle	0	0	0	0
Dairy Cows	0	0	0	0
Poultry	0	0	0	0
Sheep	0	0	0	0
Swine	1823500	16	0.2	5835200
Others	0	0	0	0
TOTAL				5835200

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

Table A5 Nitrogen Excretion from Animal Waste Management System-Daily Spread

This spreadsheet contains Worksheet 4-1 (supplemental), in accordance with the
Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**AGRICULTURE**			
SUBMODULE	**METHANE AND NITROUS OXIDE EMISSIONS FROM DOMESTIC LIVESTOCK**			
	ENTERIC FERMENTATION AND MANURE MANAGEMENT			
WORKSHEET	**4-1(SUPPLEMENTAL)**			
SPECIFY AWMS	**DAILY SPREAD**			
SHEET	**NITROGEN EXCRETION FOR ANIMAL WASTE MANAGEMENT SYSTEM**			
SESSION	**PNG SNC**			
YEAR	**2000**			

Livestock Type	A Number of Animals	B Nitrogen Excretion Nex (kg/head/yr)	C Fraction of Manure Nitrogen per AWMS (%/100) (fraction)	D Nitrogen Excretion per AWMS, Nex (kg N/yr)
				D = (A x B x C)
Non-Dairy Cattle	0	0	0	0
Dairy Cows	0	0	0	0
Poultry	1680020	0.6	0.05	50400.6
Sheep	0	0	0	0
Swine	0	0	0	0
Others	0	0	0	0
TOTAL				50400.6

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

Table A6 Emissions from Animal Waste Management

This spreadsheet contains sheet 2 of Worksheet 4-1, in accordance with the
Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**AGRICULTURE**		
SUBMODULE	**METHANE AND NITROUS OXIDE EMISSIONS FROM DOMESTIC LIVESTOCK**		
	ENTERIC FERMENTATION AND MANURE MANAGEMENT		
WORKSHEET	**4-1**		
SHEET	**2 OF 2 NITROUS OXIDE EMISSIONS FROM ANIMAL PRODUCTION**		
	EMISSIONS FROM ANIMAL WASTE MANAGEMENT SYSTEMS(AWMS)		
SESSION	**PNG SNC**		
YEAR	**2000**		
	STEP 4		

Animal Waste Management System (AWMS)	A Nitrogen Excretion Nex(AWMS) (kg N/yr)	B Emission Factor For AWMS EF3 (kg N2O-N/kg N)	C Total Annual Emissions of N2O (Gg)
			C=(AxB)[44/28]/1 000 000
Anaerobic lagoons	0	0	0
Liquid systems	0	0	0
Daily spread	50400.602		
Solid storage & drylot	5835200	0.02	0.183392
Pasture range and paddock	29998411.43		
Other	0	0	0
Totals	35884012.03		0.183392

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

Table A7 Prescribed Burning of Savannah-Quantity of dead biomass burned

This spreadsheet contains sheet 1 of Worksheet 4-3, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	AGRICULTURE						
SUBMODULE	PRESCRIBED BURNING OF SAVANNAS						
WORKSHEET	4-3						
SHEET	1 OF 3						
SESSION	PNG SNC						
YEAR	2000						
STEP 1					STEP 2		
A Area Burned by Category (specify) (k ha)	B Biomass Density of Savanna (t dm/ha)	C Total Biomass Exposed to Burning (Gg dm)	D Fraction Actually Burned	E Quantity Actually Burned (Gg dm)	F Fraction of Living Biomass Burned	G Quantity of Living Biomass Burned (Gg dm)	H Quantity of Dead Biomass Burned (Gg dm)
		C = (A x B)		E = (C x D)		G = (E x F)	H = (E - G)
248.994	4.9	1220.0706	0.83	1012.658598	0.38	384.8102672	
							627.848

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

Table A8 Prescribed Burning of Savannah- Total carbon released

This spreadsheet contains sheet 2 of Worksheet 4-3, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	AGRICULTURE			
SUBMODULE	PRESCRIBED BURNING OF SAVANNAS			
WORKSHEET	4-3			
SHEET	2 OF 3			
SESSION	PNG SNC			
YEAR	2000			
	STEP 3			
	I Fraction Oxidised of living and dead biomass	J Total Biomass Oxidised (Gg dm)	K Carbon Fraction of Living and Dead Biomass	L Total Carbon Released (Gg C)
		Living: J = (G x I) Dead: J = (H x I)		L = (J x K)
Living	0.8	307.8482138	0.45	138.5316962
Dead	1	627.848	0.4	251.1392
Totals				389.6708962

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

Table A9 Prescribed Burning of Savannah- Emissions from savannah burning

This spreadsheet contains sheet 3 of Worksheet 4-3, in accordance with the
Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	AGRICULTURE						
SUBMODULE	PRESCRIBED BURNING OF SAVANNAS						
WORKSHEET	4-3						
SHEET	3 OF 3						
SESSION	PNG SNC						
YEAR	2000						
STEP 4					STEP 5		
L Total Carbon Released (Gg C)	M Nitrogen-Carbon Ratio	N Total Nitrogen Content (Gg N)	O Emissions Ratio	P Emissions (Gg C or Gg N)	Q Conversion Ratio		R Emissions from Savanna Burning (Gg)
		N = (L x M)		P = (L x O) or P = (N x O)			R = (P x Q)
			0.004	1.558683585	16/12	CH4	2.07824478
			0.06	23.38025377	28/12	CO	54.55392547
389.6708962	0.006	2.338025377					
			0.007	0.016366178	44/28	N2O	0.025718279
			0.121	0.282901071	46/14	NOx	0.929532089

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

CO_2 Emission = Total Carbon Released x Emission Ratio x Conversion Ratio
= 389.67 GgC x [1-(0.004+0.06)] x 44/12
= 1,337.346 Gg

Table A10 : Field burning of sugar cane residues; biomass burned

This spreadsheet contains sheet 1 of Worksheet 4-4, in accordance with the
Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	AGRICULTURE							
SUBMODULE	FIELD BURNING OF AGRICULTURAL RESIDUES							
WORKSHEET	4-4							
SHEET	1 OF 3							
COUNTRY	Papua New Guinea							
YEAR	2000							
	STEP 1			STEP 2		STEP 3		
Crops (specify locally important crops)	A Annual Production (Gg crop)	B Residue to Crop Ratio	C Quantity of Residue (Gg biomass)	D Dry Matter Fraction	E Quantity of Dry Residue (Gg dm)	F Fraction Burned in Fields	G Fraction Oxidised	H Total Biomass Burned (Gg dm)
			C = (A x B)		E = (C x D)			H = (E x F xG)
Suger Cane	45000	0.2	9,000.00	0.1	900.00	0.5	0.9	405.00
Total:								405.00

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software programm

Table A11 : Field burning of sugar cane residues: carbon and nitrogen released

This spreadsheet contains sheet 2A of Worksheet 4-4, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**AGRICULTURE**
SUBMODULE	**FIELD BURNING OF AGRICULTURAL RESIDUES**
WORKSHEET	**4-4**
SHEET	**2 OF 3**
COUNTRY	**Papua New Guinea**
YEAR	**2000**

	STEP 4		**STEP 5**	
Crops	I Carbon Fraction of Residue	J Total Carbon Released (Gg C)	K Nitrogen-Carbon Ratio	L Total Nitrogen Released (Gg N)
		J = (H x I)		L = (J x K)
Suger Cane	0.4072	164.92	0.02	3.30
Total:		164.92		3.30

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software programm

Table A12: Field burning of residues

This spreadsheet contains sheet 3 of Worksheet 4-4, in accordance with the
Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**AGRICULTURE**
SUBMODULE	**FIELD BURNING OF AGRICULTURAL RESIDUES**
WORKSHEET	**4-4**
SHEET	**3 OF 3**
COUNTRY	**Papua New Guinea**
YEAR	**2000**

STEP 6

	M Emission Ratio	N Emissions (Gg C **or** Gg N)	O Conversion Ratio	P Emissions from Field Burning of Agricultural Residues (Gg)
		N = (J x M)		P = (N x O)
CH_4	0.005	0.82	16/12	1.10
CO	0.06	9.89	28/12	23.09
		N = (L x M)		P = (N x O)
N_2O	0.007	0.02	44/28	0.04
NO_x	0.121	0.40	46/14	1.31

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software programe

CO_2 Emission = Total Carbon Released x Emission Ratio x Conversion Ratio
= 164.92 GgC x [1-(0.005+0.06)] x 44/12
= 565.4 Gg CO_2

Table A13 Direct nitrous oxide emissions from agricultural fields

This spreadsheet contains sheet 1 of Worksheet 4-5, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**AGRICULTURE**		
SUBMODULE	**AGRICULTURAL SOILS**		
WORKSHEET	**4-5**		
SHEET	**1 OF 5 DIRECT NITROUS OXIDE EMISSIONS FROM**		
	AGRICULTURAL FIELDS, EXCLUDING CULTIVATION OF		
	HISTOSOLS		
SESSION	**PNG SNC**		
YEAR	**2000**		
	STEP 1	**STEP 2**	
Type of N input to soil	A Amount of N Input (kg N/yr)	B Factor for Direct Emissions EF1 (kg N2O-N/kg N)	C Direct Soil Emissions (Gg N2O-N/yr)
			C=(AxB)/1 000 000
Synthetic fertiliser (FSN)	4983600.14	0.01	0.049836001
Animal Waste (FAW)	5885600.602	0.01	0.058856006
N-fixing Crops (FBN)	0	0	0
Crop residue (FCR)	0	0	0
Total			0.108692007

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

The UNFCCC version of MODULE4.xls, Synthetic fertiliser (FSN) does not include the amount of synthetic fertiliser N that volatilizes; however, the emission factor reported here (EF1), which is based on the 2006 IPCC Guidelines, multiplies total synthetic fertiliser applied to soil to calculate Direct N2O emissions. Therefore, Synthetic fertiliser (FSN) here equals total Synthetic Fertiliser N Applied to Soil, NFERT (column A, 4-5s4).

Emissions for N-fixing crops are included in Crop residue (FCR) as recommended by the 2006 IPCC Guidelines.

Table A14 Manure nitrogen Use

This spreadsheet contains 4-5A (supplemental), in accordance with the
Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	AGRICULTURE				
SUBMODULE	AGRICULTURAL SOILS				
WORKSHEET	4-5A (SUPPLEMENTAL)				
SHEET	1 OF 1 MANURE NITROGEN USED				
SESSION	PNG SNC				
YEAR	2000				

A Total Nitrogen Excretion (kg N/yr)	B Fraction of Nitrogen Burned for Fuel (fraction)	C Fraction of Nitrogen Excreted During Grazing (fraction)	D Fraction of Nitrogen Excreted or Emitted as NOx and NH3 (fraction)	E Sum (fraction)	F Manure Nitrogen Used (corrected for NOx and NH3 emissions), FAW (kg N/yr)
				E = 1 - (B + C + D)	F = (A x E)
35884012.03	0	0.813534477	0	0.186465523	6691131.071

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

Column B includes nitrogen used for constuction and feed as well as nitrogen burned for fuel.
Column D, the fraction of nitrogen excreted emitted as NOx and NH3, is not included as
recommended by the IPCC 2006 Guidelines.

Table A15: Direct Nitrous Oxide emissions from agricultural fields

This spreadsheet contains sheet 2 of Worksheet 4-5, in accordance with the
Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	AGRICULTURE
SUBMODULE	AGRICULTURAL SOILS
WORKSHEET	4-5
SHEET	2 OF 5 DIRECT NITROUS OXIDE EMISSIONS FROM CULTIVATION OF HISTOSOLS
COUNTRY	Papua New Guinea
YEAR	2000

	STEP 3			STEP 4
	D Area of Cultivated Organic Soils F_{OS} (ha)	E Emission Factor for Direct Soil Emissions EF_2 (kg N_2O–N/ha/yr)	F Direct Emissions from Histosols (Gg N_2O–N/yr)	G Total Direct Emissions of N_2O (Gg)
			F=(D x E)/1 000 000	G = (C+F)[44/28]
Subtotal	171,612	10	1.72	12.45

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software programe

Table A16 Direct Nitrous Oxide emissions from Grazing animals

This spreadsheet contains sheet 3 of Worksheet 4-5, in accordance with the
Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	AGRICULTURE		
SUBMODULE	AGRICULTURAL SOILS		
WORKSHEET	4-5		
SHEET	3 OF 5 DIRECT NITROUS OXIDE EMISSIONS FROM GRAZING ANIMALS -		
	PASTURE RANGE AND PADDOCK		
SESSION	PNG SNC		
YEAR	2000		
	STEP 5		
Animal Waste Managment System (AWMS)	A Nitrogen Excretion Nex(AWMS) (kg N/yr)	B Emission Factor for AWMS EF3 (kg N2O-N/ha/yr)	C Emissions of N2O from Grazing Animals (Gg)
			C = (A x B)[44/28]/1 000 000)
Pasture range & paddock	29998411.43	0.02	0.942807216

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

Table A17 Indirect Nitrous Oxide emissions from Atmospheric Deposition of NH_3 and NO_x

This spreadsheet contains sheet 4 of Worksheet 4-5, in accordance with the
Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	AGRICULTURE							
SUBMODULE	AGRICULTURAL SOILS							
WORKSHEET	4-5							
SHEET	4 OF 5 INDIRECT NITROUS OXIDE EMISSIONS FROM ATMOSPHERIC DEPOSITION OF NH3 AND NOx							
SESSION	PNG SNC							
YEAR	2000							
	STEP 6							
Type of Deposition	A Synthetic Fertiliser N Applied to Soil, NFERT (kg N/yr)	B Fraction of Synthetic Fertiliser N Applied that Volatilizes FracGASFS (kg N/kg N)	C Amount of Synthetic N Applied to Soil that Volatilizes (kg N/kg N)	D Total N Excretion by Livestock NEX (kg N/yr)	E Fraction of Total Manure N Excreted that Volatilizes FracGASM (kg N/kg N)	F Total N Excretion by Livestock that Volatilizes (kg N/kg N)	G Emission Factor EF4 (kg N2O-N/kg N)	H Nitrous Oxide Emissions (Gg N2O-N/yr)
			C = (A x B)			F = (D x E)		H = (C + F) x G /1 000 000
Total	4983600.14	0.1	498360.016	35884012.63	0.2	7176802.525	0.01	0.076751625

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

Column A in 4-1s2 includes manure used as feed, manure used for construction, and manure burned as fuel,
whereas Column D here excludes these 3 manure management categories, consistent with the IPCC GPG 2000.

Table A18 Indirect Nitrous Oxide from Leaching

This spreadsheet contains sheet 5 of Worksheet 4-5, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	AGRICULTURE						
SUBMODULE	AGRICULTURAL SOILS						
WORKSHEET	4-5						
SHEET	5 OF 5 INDIRECT NITROUS OXIDE EMISSIONS FROM LEACHING						
SESSION	PNG SNC						
YEAR	2000						
	STEP 7					STEP 8	STEP 9
	I Synthetic Fertiliser Use NFERT (kg N/yr)	J Livestock N Excretion NEX (kg N/yr)	K Fraction of N that Leaches FracLEACH (kg N/kg N)	L Emission Factor EF5 (kg N2O-N/kg N)	M Nitrous Oxide Emissions From Leaching (Gg N2O-N/yr)	N Total Indirect Nitrous Oxide Emissions (Gg N2O/yr)	O Total Nitrous Oxide Emissions (Gg)
					M = (I + J) x K x L/ 1 000 000	N = (H + M)[44/28]	O = (G + C + N)(G from Worksheet 4-5, sheet 2, Step 4; C from Worksheet 4-5, sheet 3, Step 5; N from Worksheet 4-5, sheet 5, Step 8).
Total	4983600.14	35884012.63	0.3	0.008	0.098082271	0.27473898	1.332546196

Documentation box:

These estimates were produced from the Agriculture and Land Use National Greenhouse Gas Inventory Software program (ALU).

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