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Secretariat of the Pacific Regional Environment Programme

PacWastePlus
PACIFIC WASTE MANAGEMENT

This initiative is supported by **PacWastePlus**-a 72 month project funded by the European Union (**EU**) and implemented by the Secretariat of the Pacific Regional Environment Programme (**SPREP**) **to sustainably and cost effectively improve regional management of waste and pollution.**

Waste Audit Report

PAPUA NEW GUINEA

March 2021

Supported by the Australian Government through the Pacific Ocean Litter Project

Australian Aid

The information and data gathered from these waste audits will be used by countries in the Pacific to support the development and monitoring of waste and resource recovery projects and recommend the infrastructure and policy interventions required. The regional dataset will also be used to identify and evaluate potential regional projects that would improve waste management in the region.

Acknowledgment: SPREP, through the PacWastePlus programme engaged Total Waste Management Group PNG Limited to undertake a waste audit in Papua New Guinea. This report presents the findings of the waste audit undertaken for PNG. The methodology applied for this waste audit was as per the Waste Audit Methodology – a step-by-step manual to conduct comprehensive waste audits in SIDs, produced by the Pacific Regional Infrastructure Facility (PRIF). We acknowledge the services of the TWM Group for the compilation of this report.

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Our vision: A resilient Pacific environment sustaining our livelihoods and natural heritage in harmony with our cultures.
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GLOSSARY of TERMS

AusAID	Projects supported by the Australian Government
CEPA	Conservation and Environment Authority, Papua New Guinea
DNPM	Department of National Planning and Monitoring, Papua New Guinea
EPS	Expanded polystyrene
EU	European Union
GNI	Gross National Income
GoPNG	Government of PNG
HDI	Human Development Index (United Nations Development Program)
HDPE	High-density polyethylene
HS Code	Harmonised Commodity Description and Coding System
JICA	Japanese International Cooperation Agency
J-PRISM II	Japanese Technical Cooperation Project for Promotion of Regional Initiatives on Solid Waste Management in Pacific Island Countries (second phase)
JSA	Job Safety Analysis
LDPE	Low-density polyethylene
LPB	Liquid paper board
MEA	Multilateral Environment Agreement
NSPT	National Strategic Plan Taskforce
NCDC	National Capital District Commission
NDoH	National Department of Health
NWCMP	National Waste and Chemical Management Policy, 2020-2030 (in draft)
PacWastePlus	An EU funded Program with SPREP that seeks to generate improved economic, social, health and environmental benefits for Pacific Island Countries.
PET	Polyethylene terephthalate
PICS	Pacific Island Countries
POM	Port Moresby
PP	Polypropylene
PPE	Personal Protective Equipment
PRIF	Pacific Region Infrastructure Facility a multi development partner coordination, research and technical assistance facility
PS	Polystyrene
PVC	Polyvinyl chloride
SME	Small to medium enterprises
SPREP	Secretariat of the Pacific Regional Environment Programme
SWM	Solid Waste Management
TWM	TWM PNG Limited
ULLG	Urban Local Level Government
UNEP	United Nations Environment Program
WHO	World Health Organisation
WMD	Waste Management Division within NCDC

PacWastePlus Programme

The Pacific – European Union (EU) Waste Management Programme, PacWastePlus, is a 72-month programme funded by the EU and implemented by the Secretariat of the Pacific Regional Environment Programme (SPREP) to improve regional management of waste and pollution sustainably and cost-effectively.

About PacWastePlus

The impact of waste and pollution is taking its toll on the health of communities, degrading natural ecosystems, threatening food security, impeding resilience to climate change, and adversely impacting social and economic development of countries in the region. The PacWastePlus programme will generate improved economic, social, health, and environmental benefits by enhancing existing activities and building capacity and sustainability into waste management practices for all participating countries.

Countries participating in the PacWastePlus programme are: *Cook Islands, Democratic Republic of Timor-Leste, Federated States of Micronesia, Fiji, Kiribati, Nauru, Niue, Palau, Papua New Guinea, Republic of Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu*.

KEY OBJECTIVES

Outcomes & Key Result Areas

The overall objective of PacWastePlus is "to generate improved economic, social, health and environmental benefits arising from stronger regional economic integration and the sustainable management of natural resources and the environment".

The specific objective is "to ensure the safe and sustainable management of waste with due regard for the conservation of biodiversity, health and wellbeing of Pacific Island communities and climate change mitigation and adaptation requirements".

Key Result Areas

- **Improved data collection, information sharing, and education awareness**
- **Policy & Regulation** - Policies and regulatory frameworks developed and implemented.
- **Best Practices** - Enhanced private sector engagement and infrastructure development implemented
- **Human Capacity** - Enhanced human capacity

Learn more about the PacWastePlus programme by visiting

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PacWastePlus
PACIFIC WASTE MANAGEMENT

https://pacwasteplus.org/

Executive Summary

Papua New Guinea (PNG) is a member of the Pacific Island Forum and the Secretariat of the Pacific Regional Environment Programme (SPREP), both intergovernmental organisations focused on achieving the United Nations Sustainable Development Goals. PNG is one of fifteen Pacific Island Nations taking part in the PacWastePlus Programme implemented through SPREP and funded by the European Union Delegation of the Pacific. The PacWastePlus Programme is focused on improving waste management activities and the capacity of Governments, Industry, and communities to manage wastes to protect human health and the environment. The program focuses on several priority wastes that include hazardous, recyclable, food packaging (inc. plastics), organic wastes, disasters, and bulky materials. TWM PNG Limited (TWM) was engaged to undertake waste audits in PNG as part of the Pacific-wide audit activity conducted by PacWastePlus.

The program sought to:

- Establish comprehensive data that would enable national policy interventions and contribute toward the objectives of the Cleaner Pacific 2025
- Determine the material composition of the domestic and commercial waste streams
- Establish potential areas for improvement in the country waste management system

The waste audit program introduces the *Waste Audit Methodology: A Common Approach, 2019, PRIF et al.* The methodology provides the tools to accurately measure the change in waste generation and the corresponding efficacy and improvement in waste management systems. Audits will ideally be repeated regularly throughout the Pacific, and it is therefore important the methodology is widely adopted in PNG.

This report provides a snapshot of waste audit generation and composition across the business and household waste streams for six locations within PNG. The study conducted audits in Port Moresby and Roku Village in the Central Province, received data from audits conducted in Lae and Alotau, and sourced historical data from audits conducted in Kokopo (2018) and Goroka (2019).

A compilation of the data generated by the study with historical data provided to the study found an estimated average waste generation rate of .39kg per capita per day. The study found the household waste stream comprises approximately 41% organic materials of which around 5% is betelnut; 17% plastics of which approximately 4% are defined as single-use plastics, 7% metals and less than 1% hazardous. Of the businesses sampled in this study, the highest recorded material type was plastics at 32% of which 23% were single-use plastics. This was followed by the paper and cardboard category at 27% and organics at 23%.

Household waste collections are the responsibility of local governments. In some circumstances, the local government engages private sector contractors to provide these services, which in general are limited to the urban areas only. Recycling in PNG is conducted by the private sector and is limited to scrap steel, e-wastes, oil, vehicle batteries and PET plastics (although the latter may have slowed due to market limitations). The disposal sites owned by the local government may be operated in accordance with local by-laws but may not hold an environmental permit issued by the national regulator, CEPA.

This study recommends further modelling be undertaken to apply the data from this study across a concordance of the rural and urban ULLG's, as grouped by the divisions in the national census.

This approach would deliver a reasonable set of national data statistics on waste generation characteristics across the country. This study further recommends comparison audits be conducted in the coming year using the adopted *PRIF Methodology, 2019*.

Background

The PacWastePlus waste audit study completed representative sampling across a range of waste streams within urban, peri-urban, and rural areas further split by low, medium, and high income. The planning and implementation of the waste audit program was a collaboration between TWM, local and national government authorities. The waste audit program received significant support from the Japanese International Cooperation Agency (JICA) who have had a long-standing presence in improving waste management systems in PNG.

The waste audit program included:

- Training of stakeholder counterparts in planning and delivery of waste audits in line with the adopted methodology: *Waste Audit Methodology: A Common Approach, 2019, PRIF et al* (herein referred to as the *PRIF Methodology, 2019*)
- Household waste sampling by physical audit and household interviews
- Business waste sampling by physical audit and business interviews
- Recovered material stockpile estimation by visual audit
- Compilation of customs import and export data

TWM was requested to incorporate data from historical and contemporary audits conducted outside of the PacWastePlus program to present a national data statistic. To this extent, the Lae City Authority, the Alotau ULLG and NCDC provided significant support to this project and the data from audits conducted in these locations which used the material sorting classifications in the *PRIF Methodology, 2019* have been included in the detailed data analysis. The data from historical audits in Goroka and Kokopo were obtained using a different methodology have been examined and reported separately throughout this document.

The project with assistance from the NCDC and the national focal point, CEPA, conducted qualitative surveys and quantitative audits in the National Capital District and Roku Village, a rural location within the Central Province during February and March 2021.

In March 2021, the Alotau Urban Local Level Government (ULLG) and Lae City Authority completed waste audits under the auspices of the JPRISM program sponsored by JICA and assisted by NCDC Waste Management Division staff. In May 2021, the data from both audits were made available to TWM for inclusion in this report.

The project has also incorporated quantitative data and qualitative information, where applicable from previous audits conducted by the Goroka ULLG under the JPRISM program in 2019 and by the Kokopo Vunamami ULLG under a project supported by AusAID in 2018.

This study has attempted to provide a national perspective on waste generation, waste stream composition and waste management systems in PNG.

Project Stakeholders and Communications

Preparations for the audit study were coordinated between the National Focal Point, CEPA represented by the Manager, Waste Management Division, the SPREP Project Manager and Technical Waste Project Officer, the TWM Project Manager and Project Coordinator. The final plan was approved by CEPA and SPREP who also both assisted to source previous reports and data for the project.

Consultations were held during the study with the administrations of the audit locations, industry stakeholders and community members. Approval for the Waste Management Division to participate in the audit program was provided by the National Capital District City Manager.

As audits were conducted in the Port Moresby area, the NCDC provided critical information to the project in the form of collection service schedules and advice regarding the methodologies used in previous audits, which helped form the waste audit schedule for the urban and peri-urban locations.

In particular, team members from the waste management division of NCDC and CEPA provided practical assistance to the project by leading and participating in the qualitative surveys and audit sample collection.

TWM appreciate the advice, assistance, and willingness to participate in the study which was provided by all stakeholders. The combined support has greatly assisted TWM's completion of the project deliverables. Further information is provided in the *Project Inception Report, November 2020.*

Country Profile

PNG has sustained around a 2%+ population growth over the past three decades and is currently home to over eight million people. It is a culturally diverse nation with around 800 different languages spoken among 10,000 different ethnic populations across its 600 islands (World Bank 2021).

In 2011, the PNG census (GoPNG, 2011) registered approximately 87% of residents living in rural areas and the remaining 13% in urban locations.

The administrative divisions at the high level are divided into four regions: Southern, Highlands, Momase and Islands.

PNG has three levels of government: Central, Provincial and Local. There are 22 provinces in total, (20 integrated provinces, the autonomous province of Bougainville and the National Capital District) with 89 districts. Within the districts, there are 31 urban level local governments and 265 rural level local governments.

Within the National Capital District, there are 7 traditional villages, which are represented by Councillors on the Motu-Koita Assembly, an organisation representing the interest of customary landowners. **Table 1** below details the population distribution by region as at the 2011 census.

Table 1: *PNG Population Distribution (2011)*

Papua New Guinea Population Distribution		
Region	**Provinces**	**Population 2011 Census**
Southern	Central, Gulf, Milne Bay, Northern, Western, National Capital District	1,456,250
Highlands	Southern Highlands, Hela, Enga, Western Highlands, Jiwaka, Chimbu, Eastern Highlands	2,854,874
Momase	Morobe, Madang, East Sepik, West Sepik	1,867,657
Islands	Manus, New Ireland, East New Britain, West New Britain, Autonomous Region of Bougainville	1,096,543

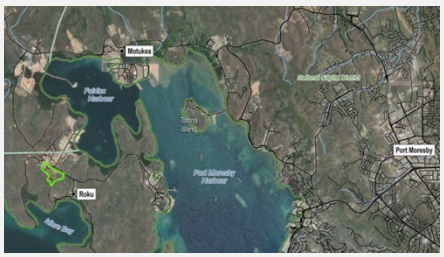
The information drawn from audits conducted throughout six urban and rural locations in PNG has been included in this report. The section below provides a high-level overview of these locations and details how the information gained from the audits conducted in these locations has been treated in this study.

Goroka forms one of the 7 districts in the Eastern Highlands Province. The Goroka township, administered by the Goroka ULLG lies approximately 285km from Lae City in Morobe Province and is the provincial capital. The population of Goroka township is approximately 19,000. Urban data from the waste audit conducted in 2019 has been examined in this study.

Alotau forms 1 of 4 districts in the Milne Bay Province and comprises one urban and six rural areas. The Alotau township administered by the Alotau ULLG is located on Milne Bay, approximately 365km east of Port Moresby and is the capital of Milne Bay Province. Alotau township has approximately 15,000 people. Urban data from the waste audit conducted in 2021 has been analysed in this study.

Lae is PNG's second-largest city and capital of the Morobe Province. Lae City is located in the delta of the Markham River at the start of the Highlands Highway and transport corridor between the highland's region and the cargo port. Lae is the industrial hub of PNG with over 88,000 residents. Urban data received from the waste audit conducted in 2021 has been analysed in this study.

Port Moresby (POM) is the largest city in PNG and the South Pacific Region outside of Australia and New Zealand. POM sits on the Gulf of Papua with a population of around 383,000 in 2020. POM forms the Province of the National Capital District, surrounded by the Central Province. Port Moresby city is administered by the NCDC. Urban and peri-urban data from the waste audit conducted in 2021 has been analysed in this study.



Roku is a rural village is situated on Idlers Bay in Hiri District, Central Province. The village has around 2000+ residents. Fishing is a key livelihood activity and local employment is sourced through adjacent industries. Rural data from the waste audit conducted in 2021 has been analysed in this study.

Kokopo forms 1 of 4 districts in East New Britain Province. Kokopo became the provincial capital after neighbouring Rabaul was severely damaged during the 1994 volcanic eruptions. Situated within a coastal island environment, Kokopo with an estimated 20,000 residents in 2020, is administered by the Kokopo-Vunamami ULLG. Urban data from the waste audit conducted in 2018 has been examined in this study.

Socio-Economic Background

PNG has a diverse natural environment ranging from mountain ranges to lowland rainforests, wetlands, and coastal plains. The rugged interiors of the main and outer islands are largely inaccessible by road or are only navigable by the river.

The country has a population of over 8 million people of which around 87% live in rural areas with the remainder residing in urban townships. Of the rural population, approximately 40% live in traditional groups with livelihoods dependent on subsistence farming.

The economy is dominated by two broad sectors:

- Agriculture, forestry and fishing engages most of the workforce mainly informally
- Minerals and energy extraction accounts for most of the export earnings and GDP

PNG is a significant contributor to the bulk of exports in the Melanesian region, with almost all destined for large, industrial markets. Its GDP as of December 2018 was US$2,683.92 per capita (Key Indicators Asia and Pacific, ADB 2019). The country's trade balance for that year was US$6.86B with exports at US$11B and imports at US$4.14B (OEC 2021). The United Nations Development Program (UNDP) monitors the human development index (HDI) annually and in 2020 reported a HDI rating of 0.555 or medium human development (below the average of 0.747 for Asia and Pacific) for PNG. The HDI is based on dimensions such as gender equality, health, education, and standard of living. PNG's gross national income (GNI) per capita in 2017 was US$4,301 per annum and in 2019 approximately 46.6% of the population experienced multi-dimensional poverty.

The qualitative survey of households and businesses conducted as part of the study provides a snapshot on social demographic and economic background. It also demonstrated PNG's rich cultural fabric with responses recording an ethnicity of nearly 30% Highlander in the urban area, 22% Islander in the peri-urban area with a smaller representation of residents identifying as from the Momase region.

The key comparison demographics drawn from the surveys are as follows:

- **Employment**: Nearly all respondents are living in individual houses and not shared housing circumstances. Employment numbers for both male and female are similar across the urban and peri-urban areas, while women in the rural area represented about a third of the level of employed males. Noting that the rural residents showed the highest self-employment of all audit locations, and this could be attributed to the fishing industry The source of employment showed a greater dependency on private sector jobs in the peri-urban area for both males and females, compared to a greater representation of government employment in the urban area, (largely male).
- **Education**: Generally, there is a greater male than female representation in higher/tertiary education and there is a stark contrast between urban and rural area participation. The numbers of male residents attending a trade school or university were similar between urban and peri-urban areas. However, no male or female residents in the rural sample were identified as attending a trade school or university.
- **Essential services**: The survey found that 97% of urban; 100% of peri-urban and 84% of the rural households had access to electricity. The number of households connected to a sewerage or septic system varied greatly between urban and peri-urban at between 97% and 100% respectively with only 6% of rural households having access to sanitation systems. The findings were similar in regard to the water supply to the households with 100% of the urban and peri-urban households connected to the town water supply and only 12% in the rural area.
- **Income**: which found higher levels of income in the urban area, with nearly 70% of households recording an income of between K500 and above K1,000 per week. The peri-urban area saw a more evenly distributed mid-income range with 78% recording an income of below K500 per week. The rural area recorded majority low income, however only 28% of respondents answered this question which may have been influenced using two residents in conducting the survey activities, giving rise to a reticence to disclose income.

Within the Major sampling strata, i.e., urban, peri-urban, and rural an effort was also made to capture a representation of "high", "medium", and "low" income areas in the sampling. Planned in consultation with the local authority, NCDC and National Focal Point the parameters used to identify income level are according to those used in the *NCDC/CEPA/J-PRISM, Methodology for Waste Audit – Papua New Guinea, 25 December 2019*.

For this survey the household income groupings were as follows:

- Low income: below K500 per week
- Medium income: between K500 and K1,000 per week
- High income: above K1,000 per week

Waste Management Stakeholder Roles and Responsibilities

The waste management sector in PNG comprises both public and private organisations. PNG's three levels of government (national, provincial, local comprising urban and district) have specific interests regarding waste management applied through a range of legislation and subordinate regulations.

While legislated responsibilities for waste management activities sit across several Ministries, it is the Conservation and Environment Protection Authority (CEPA) that leads policy and legislative development specific to waste management in accordance with its responsibilities under the Environment Act. CEPA is responsible for issuing environmental permits under the *Environment (Permits) Regulation, 2002* for works and operations that accord with the *Environment (Prescribed Activities) Regulation, 2002*. The environmental permits authorise the applicant to undertake certain activities with accompanying environmental management conditions.

The Government of PNG (GoPNG) identified the need for national policy and strategic planning for waste management and CEPA have, in partnership with United Nations Environment Programme (UNEP), SPREP, JICA, Department of National Planning and Monitoring (DNPM) and NCDC, coordinated the drafting of the National Waste and Chemical Management Policy, 2020-2030: Changing Our Ways (NWCMP). The policy also is an output of the (UNEP) Special Programme and JICA J-PRISM II project. The policy is in its second version and has been widely consulted. More recently CEPA has formed a technical steering committee for the continuing development of the NWCMP comprising multi-sectoral representation inclusive of government, industry, and universities.

CEPA has also been engaged in preparing regulations subordinate to the Environment Act, 2000 and to support the implementation of provisions contained with the Minamata Convention, which PNG is yet to ratify. The *Environment (The Control and Management of Mercury) Regulations*, *2019* will establish measures and conditions for the use, storage, manufacture and trade in mercury, mercury compounds and mixtures and mercury-added products and the management of wastes.

Similarly, CEPA has led the drafting of the *Environment (Hazardous Waste Management) (Control of Transboundary Movement) Regulations, 2018* to further support the implementation of provisions contained within the Basel and Waigani Conventions, each ratified by PNG in 1995. PNG also agreed to the inclusion of plastic waste into the Basel Convention list of materials in 2020. The draft regulations are yet to be finalised and adopted.

Also related to plastic waste specifically is the *Environment (Control of Biodegradable Plastic Shopping Bags) Regulation, 2011.* This regulation has been adopted and controls the import, manufacture, distribution or selling of biodegradable plastic shopping bags without an Environment Permit issued under the *Environment Act, 2000* and in accordance with the *Environment (Prescribed Activities) Regulation, 2002.*

Several key legislative instruments govern environmental protection and waste management and allocate responsibility to various levels of government.

The institutional framework for waste management in PNG does not provide a clear governance mandate. At a national level, the following Acts and their subordinate legislation apply to the management of wastes. The *Environment Act, 2000* is the principal legislation for environmental protection. Provisions within the Environment Act are implemented via multiple regulations through CEPA. The Environment Act empowers Provincial and Local Governments to develop environmental policies and by-laws for waste management and requires the development of national policies and a national solid waste management strategy with supporting regulations.

The *Public Health Act, 1974* enacted by the *Public Health (Sanitation and General) Regulation* is administered by the Department of Health and requires Local Authorities to provide waste collection and disposal systems to residents. The regulation specifies household waste storage and regulates waste picking and waste disposal activities while providing for fines in association with illegal dumping.

The *Organic Law on Provincial and Local Level Governments 1995* and the *Local Level Government Administration Act 1997* empower local governments to formulate waste management policies and by-laws. The *National Capital District Commission Act 2001* provides for public welfare protection to waste and environmental management.

The *Public-Private Partnership Act 2014* gives effect to public bodies to enter partnership arrangements and may include infrastructure for water supply, sanitation, solid waste collection and disposal.

Since the responsibility for the provision of waste services rests with local level governments, so too does the allocation of levies/charges to cover the costs of the services. Outside of the major centres, the application and collection of waste management revenue are limited, and the largely unfunded expenses are reflected in the standard of infrastructure and collection systems in place.

Development in PNG is guided by key strategic documents that also influence changes in the waste management sector and include the:

- *Vision 2050* (NSPT 2009) This strategy seeks to develop and grow the manufacturing, series, agriculture, forestry, fisheries, and ecotourism sectors between 2010 and 2050 to create more business opportunities for its citizens.
- *PNG Development Strategic Plan 2010-2030* (DNPM 2010). The Plan provides the framework to achieve the targets and strategies within Vision 2050 including the development of an increased number of small to medium enterprises (SME) and partnerships between the Government and the private sector to provide services and public infrastructure. The plan refers to the sustainable use of natural resources and protection of the environment for the benefit of future generations.
- *National Strategy for Responsible Sustainable Development* (DNPM, 2014). The STARS provides the guiding principles for a new approach to planning, investments and development incorporating protection of biodiversity and ecosystems and the promotion of international cooperation.

While outside of the direct jurisdiction of CEPA, there is a growing movement to establish a Waste Management and Recyclers Association in PNG. This effort, largely guided by JICA in collaboration with NCDC and CEPA, as part of the J-PRISM II program, follows on from the successful establishment of similar groups in Samoa, Vanuatu and Solomon Islands. The association intends to encourage membership from the public sector and private industry. While in its early stages the forming of the association also serves to demonstrate the growing appetite for improved leadership in waste management in PNG.

Study Methodology

Waste Audit Planning

TWM collaborated with the National Focal Point, CEPA and the NCDC Waste Management Division to finalise planning for the audits in the National Capital District (NCD) and the Central Province. The audit plan considered the consent sample selection processes used in previous audit programs.

Specific approval was required from the NCDC City Manager to conduct the audits within NCDC jurisdiction in Port Moresby and for the staff of the Waste Management Division to provide information to and participate in the project.

Occupational Health and Safety

A project risk register was prepared for the initial project planning, followed by a detailed Health, Safety, Security and Environment Management Plan specific to the audit environment in PNG. Further to this, a set of Job Safety Analysis and Safe Work Procedures was developed for each of the key stages of auditing:

- Conducting Qualitative Surveys
- Audit Sample Collection
- Sorting, Classifying and Measuring Audit Samples

A layout and traffic management plan were each developed for the audit site, due to the need to integrate safely with the operations of the functioning waste management site.

Further to these planning measures, checklists were drawn up for the monitoring and management of safety and emergency equipment installed in the vehicles and at the audit site, and for provisioning of personal protective equipment (PPE).

Finally, all training, including induction training, provided detailed instruction on the use and maintenance of PPE, safe use of audit equipment and identification and management of hazardous materials and utilization of safe work procedures for the stages of waste auditing.

Confidentiality

The waste audit team members were instructed on the terms of confidentiality at the commencement of the project. The identity of the participants, audit sample characteristics or items within a sample has not and will not be shared by this study.

Waste Audit Locations

The audit sample locations for POM were selected in consultation with the NCDC Waste Management Division to align with previous waste audit programs and the regular household waste collection schedules. This was done to arrive at data that may be compared and measured against previous audits. Household qualitative audits and quantitative surveys were conducted in the locations shown in **Table 2** below.

The sampling fractions detailed below formed the target data strata for the study.

Table 2: *Major sampling data strata for the National Capital District - Target*

Major Sampling Strata	Household Income Level	Target Sampling Fraction	Target Number of Samples
Urban area **Vatica Street, Hohola** **Spondias Street, Hohola** **Serculias Street, Hohola** **Touguba Hill** **Port Moresby**	 Medium Medium Medium High	33.33%	34 samples from households with access to collection services. Households were provided with audit sample bags to contain 4 days of waste materials.
Peri-urban area **Spoonbill Drive and surrounds, Erima** **Port Moresby**	Low	33.33%	33 samples from households with access to collection services. Households were provided with audit sample bags to contain 4 days of waste materials, aligning with the regular communal waste collection schedules (twice per week).
Rural area **Roku Village, Hiri District, Central Province**	Low, Medium, and High	33.33%	33 samples will be collected from a central disposal point or directly from households contained in sample bags previously supplied to households to capture 4 days of waste materials to align with urban and peri-urban audits.
			Total: 100

Note: The expected household income levels were drawn from previous NCDC waste audit locations as advised by NCDC Waste Management Division

Waste Audit Training

As a core requirement of the project, waste auditing training was delivered to local counterparts. To ensure the success of the training and subsequent audits, TWM prepared a comprehensive suite of resources including planning, data recording and analysis tools specifically for the project and contained in a training manual. The training and training resources combined were designed to provide the tools for future audits to be conducted consistent with the methodology recommended by the *PRIF Methodology, 2019.* The training program delivered over two full days was held at the Sanctuary Hotel in Port Moresby and the TWM Integrated Waste Management Facility located at Roku, Central Province.

The training provided both theoretical and practical approaches to planning and conducting a waste audit and covered the following topics:

- Planning a waste audit;
- Sample collection, labelling and identification;
- Conducting a waste audit; and
- Sorting measurement and data recording;
- Waste audit analysis and reporting
- Risk assessment / Job Safety Analysis;
- Audit site set up;
- Review of audit data sheets;
- Overview of procedure for auditing;
- Primary and secondary sorting and classification of samples, measurement and data recording; and
- Storage of completed data sheets

Fourteen participants from Port Moresby, Lae, Alotau, Goroka, Kokopo, and Madang attended the training. **Table 3** below provides the position and organisation of each of the participants. All participants attended both day 1 and 2 waste audit training days.

Table 3: *Waste Audit Training Participants*

Position	Organisation
Senior Environment Health Officer	Alotau ULLG
Environmental Health Officer	Milne Bay Provincial Administration
Environment Health Officer	Goroka ULLG
Town Engineer	Goroka ULLG
Town Manager	Kokopo ULLG
Senior Environment Health Officer	Kokopo ULLG
Environmental Health Officer	Morobe Provincial Administration
Environment Health Officer	LAE
Tutor	Department of Environmental Health Faculty of Medicine and Health Sciences, Divine Word University
Environment Officer	CEPA
Environment Officer	CEPA
Waste Management Officer	NCDC
Waste Management Officer	NCDC
Waste Management Officer	NCDC

TWM also trained its internal staff who would be participating in the project activities, bringing the total number of persons trained to 25. The TWM staff and affiliates trained through the PacWaste Plus program are described in **Table 4** below.

Table 4: *Waste Audit Training Participants TWM Project Personnel*

Position	Organisation
Environment Officer and Project Coordinator	TWM PNG Ltd
QHSSE Coordinator	TWM PNG Ltd
Audit team members (6)	TWM PNG Ltd
Collection vehicle drivers (3)	TWM PNG Ltd

The project has demonstrated its approach to building in-country capacity for the delivery of waste audits consistent with the *PRIF Methodology, 2019* to continue baseline and comparison waste audit programs into the future.

Qualitative Surveying (Consent to Audit)

Qualitative surveys were conducted with the households and businesses who were to participate in the audit program. The interviews were conducted by two teams comprising CEPA National Audit Lead, NCDC Waste Management Division staff with extensive experience in previous audits and TWM Audit Lead.

TWM was advised by NCDC Waste Management Division that prior consent would be required from each of the participating households and businesses. This was a protocol that had been established in previous audits conducted by NCDC and would need to be followed due to cultural sensitivities.

Householder and business operator consent to participate in the study was sought before the qualitative surveying. Audit personnel selected every third to the fifth house in the street to approach.

If consent was given the qualitative survey was conducted. In some circumstances, the household requested a re-visit after advice could be sought from the remainder of the household. In those circumstances, the survey was conducted once consent was received.

Interviewees were provided with a background of the PacWastePlus Programme, the waste audits and project objectives.

100 households and 25 businesses were interviewed over a period of five days. Each interview took around 30 minutes to conduct, and the information provided by the participant was handwritten into the preformed template.

The completed template was scanned and filed, and the entries then analysed.

The interviews included questions regarding the following issues:

- Demographic Information including household numbers, ages, work and educational background
- Income level
- Disposal behaviour by material types
- Collection services
- Willingness to pay for collection/ disposal systems
- Current recycling behaviours including further source separation
- Level of awareness about current waste services
- Access to amenities (electricity, sanitation, stormwater infrastructure)
- Consumption habits
- Waste volume over one week

A Job Safety Analysis (JSA) was prepared for this activity to support the safe conduct of household and business surveys which also formed part of the waste audit training manual provided to the participants.

Quantitative Auditing

The audit sample selection and schedule were prepared in collaboration with the NCDC Waste Management Division.

The sample period and collection timeframe needed to correlate with the regular household waste collection services provided by NCDC. In this way, the participants were not asked to prepare the sample in any way outside of the normal disposal behaviour.

The policy of prior consent from individual householders presents an opportunity for the size and characteristics of the audit sample to be influenced, either intentionally or otherwise, and should be considered when considering the audit findings.

The selection of samples was in accordance with the data strata defined in the agreed Waste Audit Plan which split samples between urban and peri-urban areas and in low, medium, and high-income locations. Refer to **Table 5** below.

Table 5: *Major sampling data strata for the National Capital District - Actual*

Major Sampling Strata	Location Estimated Income Level	Targeted Sampling Fraction	Number of Actual Samples
Urban area **Vatica Street, Hohola** **Spondias Street, Hohola** **Serculias Street, Hohola** **Touguba Hill** **Port Moresby**	Medium Medium Medium High	33.33%	31 samples from households with access to collection services. Households were provided with audit sample bags to contain 4 days of waste materials.
Peri-urban area **Spoonbill Drive and surrounds, Erima** **Port Moresby**	Low	33.33%	32 samples from households with access to collection services. Households were provided with audit sample bags to contain 4 days of waste materials, aligning with the regular communal waste collection schedules (twice per week).
Rural area **Roku Village, Hiri District, Central Province**	Low, Medium and High	33.33%	32 samples will be collected from a central disposal point or directly from households contained in sample bags previously supplied to households to capture 4 days of waste materials to align with urban and peri-urban audits.
			Total: 95

Samples were collected from the third to the fifth house in a street, dependent on those properties where prior consent had been given. Participants were issued specific waste disposal bags to collect and store waste over a four-day period which would be collected ahead of the normal collection service. The bags were positioned separately on their property to be collected by the audit team on the defined day.

While the target audit strata were followed, and arrangements were made for the collection of 100 household samples. During the collections, five properties did not place their waste out for collection on the agreed day which had the effect of reducing the sample size.

Two teams of four (including the driver/security) utilised two utility vehicles to collect the samples. One team was led by a TWM waste audit lead and the other by the National Audit Lead.

The samples were tagged with sample number, location and strata type and recorded into the sample collection data sheet along with additional observational information, including photographic evidence before placing in the collection vehicle. The sample number was recorded against the sample which was then used to track the sample throughout the audit process.

For the rural area audits, specific households were nominated for audit in consultation with the Village Elders. As there are no defined streets in Roku Village, the locations for audit were identified by several households. A total of 32 samples were collected in Roku Village and the same process used in the Port Moresby sample collections was followed.

Audit templates for recording collection samples and audit data were prepared early in the project and provided to participants as part of the waste audit training manual as were the job safety analysis which was prepared to support the safe implementation of the audit activities.

The household audit sampling strata for Alotau were as follows:

- **Low income**: KB compound (4 samples); Bottom town (4 samples) and Redhill (4 samples)
- **Medium income**: Southeast of KB compound (4 samples); Middle town (4 samples); Middle town Goilanai (4 samples)
- **High income**: South of KB compound (4 samples); Toptown (4 samples); Toptown Goilanai (4 samples)

The household audit sampling strata for Lae did not accompany the data provided in this study.

The business properties audited in POM, Lae and Alotau comprise:

- A**dministration and office** including financial services, government offices and labour-hire firms POM (4); Alotau (2) and Lae (3)
- **Food outlets** including restaurants and cafes POM (4); Alotau (2) and Lae (3)
- **Hotels** including accommodation providers POM (2); Alotau (2) and Lae (3)
- **Supermarket, retail and wholesale** including small and supermarkets, clothing and liquor stores POM (4); Alotau (2) and Lae (3)

The auditing of the samples followed the methodology for sorting, material classification and measurement as prescribed by the *PRIF Methodology, 2019,* refer to the **Appendix A** Audit Material Categories. However, audit data derived from audits at Goroka conducted in 2019 (pre the PacWastePlus program) are believed to be based on a previous World Health Organisation (WHO) sorting, classifying, and measuring method in which daily samples are collected over 7 days. Daily samples are combined and mixed to select a ¼ of the overall sample to be sorted, classified, and measured.

The Kokopo audit conducted in 2018 is understood to have used the methodology as prescribed by the *Guidelines for Conducting Household Kerbside Residual Waste, Recycling and Garden Organics Audits in NSW Local Government Area, 2007*. Both the Kokopo and Goroka primary sorting classifications differ from each other, and both represent an earlier standard than the classifications used in the PacWastePlus audits which have the effect of limiting comparability of these results with the data collected under this study. Refer to **Table 6** below.

Table 6: *Comparison Kokopo and Goroka Audit Classifications*

Kokopo	Goroka
Organics	Vegetables/putrescible; bones; shells; betelnut; grass, leaves and wood
Paper	Cardboard; other papers; tetra packs
Glass	Glass; ceramics
Non/ferrous	Aluminium cans; other metals
Plastics	PET bottles; other plastics
Hazardous	Hazardous waste
Earth-based	-
Other	Textiles; diapers; leather/rubber; miscellaneous

While this study did not receive the audit plan for the audits conducted in Alotau and Lae City, it was clear the classification methodology conformed to the *PRIF Methodology, 2019* and so was able to be measured reliably with the Port Moresby and Central Province data.

Desktop Research on Waste Service Provision

The lead agency for waste collection services falls to the local level governments. The type of service and coverage of services vary between the 31 ULLG's comprising PNG's local level governments.

Waste Service Distribution

The household waste collections in Port Moresby and Lae City are administered by the NCDC and Lae City Authority respectively, both of whom contract private companies to deliver the services.

NCDC provided a collection coverage of approximately 70% in 2020 to extend this to 78% by 2025. In Lae City only areas within the city limits are serviced, with peri-urban areas not all receiving a service, and this includes informal settlement areas within and around the city.

The smaller ULLG's of Goroka, Alotau and Kokopo Vunamami maintain and manage waste service vehicles and equipment and directly provide services within their respective municipalities.

In general, collection services are limited outside of the larger urban centres of Port Moresby and Lae. That said, the project found that Alotau ULLG provides a collection service to approximately 80% of the town's population, but not to the settlement areas of the township. This is thought to be similar for Kokopo and Goroka ULLG urban areas.

The percentage of households receiving collection services is also defined by their ability to pay the waste collection fees set by the ULLG.

The information on waste service distribution in **Table 7** below, was provided to the project directly by the local authorities and/or sourced through published publications.

Table 7: *Waste Service Distribution*

Location	Population with Waste Collection Services	Population Without Waste Collection Services	Type of Disposal Systems Outside of Waste Service Areas
Port Moresby	70%	30%	Access disposal sites operated by the local authority or privately; Open burning or burning in pits on owner premises; Illegal dumping in creeks, stormwater drains, beachfront, bushland and roadsides
Lae City	40%	60%	
Alotau ULLG	80%	20%	
Kokopo Vunamami	32%	68%	
Goroka	Not supplied to the study	Not supplied to the study	

Waste Collection Service

The range of collection services are generally limited to household general wastes and are provided in **Table 8** below. However, NCDC provides a broader range of services including commercial and healthcare wastes with plans to introduce recycling services in the future in accordance with the NCDC Waste Management Plan 2016-2025. Services are provided either from house to house or from a communal collection point. Regardless, services are scheduled on a twice-weekly regime.

In general, householders provide their waste bins or place their bagged waste in raised cages for collection. In some cases, such as in the Kokopo urban area, residents are provided with a sticker on payment of their service fees that identify their bin for collection. Waste service Information for Goroka was not supplied to the study.

Only households within the urban areas of the study locations receive waste collection services. The study was unable to confirm how widespread the services are outside of these locations.

Table 8: *Type of Collection Service*

Location	General Household Waste	General Commercial Waste	Recyclable	Bulky Waste	Healthcare Waste
Port Moresby	√	√			√
Lae City	√				
Alotau ULLG	√				
Kokopo Vunamami	√				
Goroka	√				

Financial Mechanisms for Waste Management

Waste management systems are not funded through the National or Provincial Governments, and it is, therefore, the responsibility of Local Government to apply sufficient charges to households through either a rates or levy system to cover the costs of waste management services.

Currently there appears a significant shortfall in the actual levies collected in relation to the number of rateable properties in urban locations.

Fees and rates charges vary between ULLG's and it is not known whether these have a basis in cost accounting principles. Noting the actual collection services may be provided by contractors, who are paid by the ULLG. When levies are not paid by the households the services may be suspended.

Annual financial allocations for waste management systems and services are generally very low representing around 3-5% of overall budget, as indicated in the *Draft National Waste and Chemical Management Policy 2020-2030.* Although in NCDC this represents 9% of overall budget, as indicated in the *National Capital District Solid Waste Plan, 2016-2025.*

Table 9: *Financial Mechanisms Supporting Waste Collection Services*

Location	Private Sector Service Fee	Local Government Levy	System for Waste Service Fee Collections
Port Moresby		√	Service charges are levied to household and commercial entities receiving a waste collection service. (Reported that as little as 20% of the households served by NCDC pay the charges.)
Lae City		√	Quarterly fees levied to householders' range between K27.50 and K65.50 dependent on whether low or high covenant household status.
Alotau ULLG		√	A monthly fee levied to householders. The fee is placed in consolidated revenue and not allocated specifically to the waste service budget.

Location	Private Sector Service Fee	Local Government Levy	System for Waste Service Fee Collections
Kokopo Vunamami		√	Monthly fee of K50 pre-paid 6 months in advance. This is a one bin system (either 120L, 240L or 360L purchased from the local supermarket)
Goroka			Information not supplied to the study

Disposal Facilities

Disposal infrastructure e.g., landfills are in limited supply and are generally of a rudimentary design and operating standard. Apart from the Baruni and Second Seven disposal sites, there are understood to be a further 21 disposal sites around PNG. It is unlikely these facilities are lined, leachate managed or covered daily and likely that regular burning is retained as a tool to manage volume capacity and as vector control. These sites would therefore be unlikely to meet guidelines within the Environmental Code of Practice for Sanitary Landfill Sites in PNG, DEC 2001, or indeed comply with environmental permits should they be in place. These sites may nonetheless operate under local authority by-laws e.g. Alotau ULLG 16 of 2000, Control and Management of Town Dump Law.

The Baruni landfill, operated by the NCDC is located in the northwest of the city of Port Moresby and covers an area of approximately nine hectares. It is understood, NCDC has received support through the JICA J-PRISM program for the design and operation of constructed lined and leachate managed cells at the site in recent years. Before this, Baruni had been operated as an uncontained site since its establishment in the 1980s. Likely to have resulted in legacy environmental issues related to groundwater and soil quality adjacent to the site. A daily cover regime does not seem to be in place at Baruni and evidence of fires on the landfill are common. The site is operated by a private contractor and receives approximately 200 tonnes per day. Around 60-70 informal waste pickers work in the disposal area recovering plastics, metal etc on a day-to-day basis, (National Capital District Solid Waste Plan, 2016-2025).

The Lae City Council owns the Second Seven disposal site which is operated by a private contractor and this study did not receive detailed information on the operations or design of this site.

Mining, oil and gas projects in PNG construct and operate waste management infrastructure to service their operations. These are in regional areas and are generally not made available to service local communities. Generally constructed to international standard, lined, and contained the operations of these sites are required to comply with the CEPA permit conditions and report on environmental performance.

Incineration plant located close to the Baruni landfill and informal housing settlements is observed to be of a sub-standard operation. When operational, the incinerator can commonly be seen emitting heavy dark smoke which permeates the surrounding area. Stockpiled wastes on-site and surrounding the incinerator are also burnt in situ. Information on the source of wastes received by this facility was not received by this study.

At the time of writing, TWM is preparing to commence construction of a multi-lined hazardous waste landfill cell complete with leak detection barrier, leachate collection and storage systems. The landfill is located at the Integrated Waste Management Facility in Roku, Central Province and is designed to meet USEPA standards to receive fixated and stabilised hazardous wastes, inert and putrescible wastes and will be operational by end of 2021.

TWM commissioned its high-temperature incineration plant at the Integrated Waste Management Facility in Roku in early 2019.

The incinerator's 500kg per hour capacity can treat quarantine, healthcare, commercial and industrial and general wastes. Manufactured in the United Kingdom, the incinerator meets EU standards for incineration operation and complies with USEPA emission standards for incineration. Various GoPNG agencies have utilised the high-temperature incineration services.

Table 10: ***Disposal Facilities***

Location	Facility type and name	Government Owned	Privately Owned	
Port Moresby	Baruni Landfill	√		CEPA permit approved Operated by contractor Stockpiling of recovered tyres, steel etc. Pickers recovery of recyclables, inc. plastics, aluminium and steel
Port Moresby **Nearby to the Baruni landfill**	Incinerator		√	Substandard operations Unlikely to be CEPA permit approved
Roku **Central Province**	High-temperature incineration Hazardous waste landfill (construction 2021)		√	ISO accredited company CEPA permit approved
Lae City	Second Seven Landfill	√		CEPA permit status unknown
Alotau ULLG	Gehua Dump	√		Without CEPA permit Operated under a by-law
Kokopo Vunamami	Raniolo Dump	√		CEPA permit status unknown
Goroka		√		CEPA permit status unknown

Management of Healthcare Wastes

The management of Healthcare wastes in PNG is the responsibility of the Department of Health (NDoH). There are approximately 19 public hospitals across PNG responsible for the collection, storage and transfer of medical wastes for treatment and disposal.

It is understood the hospitals operate a colour coded bag system for the separation of wastes as follows:

- Green for general wastes
- Pink for radioactive wastes
- Red for hazardous chemical wastes
- Separate containers are used for the containment of sharps

The incinerators previously installed at the public hospitals are old and in poor condition with many reported as having ceased to function.

A National Department of Health and World Bank program is understood to be supplying new incinerators to the regions as part of a COVID-19 pandemic emergency response initiative. This study has not been able to determine how and where the treatment and disposal of medical wastes are conducted under current circumstances.

In Lae City, the Angau General Hospital operates an incinerator for the disposal of healthcare wastes, while the hospital general wastes are collected by the municipalities collection service contractor.

In Alotau, Healthcare wastes are collected and managed by the Alotau Provincial Hospital under the Milne Bay Provincial Health Authority and the hospital general waste is collected by the municipal collection service.

Since early 2020 TWM has been contracted to collect, treat, and dispose of Healthcare wastes from Port Moresby's COVID-19 Healthcare facility during the pandemic emergency. The wastes are quarantined and transferred for high-temperature incineration at the companies Integrated Waste Management Facility in Roku. The incinerator also treats wastes received from the private and development agency sectors. The company has an environmental permit issued by CEPA, to treat and dispose of Healthcare and quarantine wastes. Weekly reporting on the management of these wastes is provided to the regulator.

Table 11: *Management of Healthcare Wastes*

Location	Local Government Collection Service	Commercial Collection Service	Hospital Collection & Disposal Service	System for Disposal of Healthcare Wastes
Port Moresby	√	√		Wastes from COVID healthcare facilities are integrated at TWM Waste Management Facility in Roku. Medical facilities engage contractors to manage waste disposal.
Lae City			√	Incineration at the Angau General Hospital
Alotau ULLG			√	Managed by the Alotau Provincial Hospital
Kokopo Vunamami				Information not provided to the study
Goroka				Information not provided to the study

Hazardous Waste Management Systems

The segregation of household hazardous wastes is uncommon with most materials being treated as general domestic waste. This finding is supported by the presence of items such as batteries and e-wastes in the household audits conducted by this study.

Outside of these arrangements hazardous wastes may be assessed for disposal by ULLG's however, the end disposal point will likely be an uncontrolled dumping site, unlined and without the technical capacity to safely manage the materials.

In general, the hazardous wastes primarily collected by the private sector recyclers will have a market value e.g., vehicle batteries and waste oil. The hazardous wastes that are without a market value and are purely a liability e.g., asbestos require the collection and offshore treatment. However, this is unlikely to occur particularly for smaller amounts generated in the domestic and commercial sectors.

Hazardous wastes generated by the resource industries including used oil and chemicals are generally exported for treatment and disposal at offshore facilities. These companies have the financial wherewithal to cover the service costs and are generally required to meet international standard e.g., USEPA.

Recycling Facilities

There are few recycling facilities in PNG. The bulk of the recycling that is conducted is by private sector companies predominantly trading in metals, aluminium cans, lead acid batteries and recovered PET plastics on the export market.

These companies include PNG Recycling, Branis, and Nuovo International. In terms of facilities, there are a small number of scrap metal yards, the TWM Integrated Waste Management Facility at Roku and recycling areas at the mining, oil and gas industry sites incorporated into larger industrial waste management areas.

Outside of this the Baruni landfill in POM hosts private teams of informal waste pickers who recover materials from the landfill face predominantly ferrous, non-ferrous and plastics. Other bulky items are recovered and stockpiled including end of life vehicles, scrap steel, tyres, ceramic tiles, e-wastes, glass, gas cylinders and whitegoods. Refer **Section 8** Recovered Material Stockpiles.

Further to this a limited number of larger retailers/wholesalers, such as Theodist, who are engaged in receiving products such as printer cartridges, mobile phones, and e-wastes for export recycling resembling producer responsibility systems.

Data Validation

Data validation was conducted during the entering of the data into the workbooks to compare the sum of the waste components with the total weight of the sample. The study also compared the data from this study with that of historical audits conducted by NCDC, Goroko ULLG, and Kokopo Vunamami ULLG. **Table 12** below, shows a comparison of average waste generation rates across 9 separate waste audits in PNG.

Table 12: *Average waste generation rates*

Audit Location	Waste Audit Conducted	Av. Generation per Capita (per day)	Data Source
Port Moresby	2011	0.47kg	NCDC data supplied by JICA
Port Moresby	2013	0.33kg	NCDC data supplied by JICA
Port Moresby	2014	0.36kg	NCDC data supplied by JICA
Kokopo	2018	0.37kg*	Supplied by CEPA
Goroka	2019	0.49kg	Supplied by CEPA
Port Moresby	2021	0.28kg	PacWastePlus Audit
Roku Village	2021	0.39kg	PacWastePlus Audit
Alotau	2021	0.53kg	JICA JPRISM-II audit
Lae	2021	0.30kg	JICA JPRISM-II audit

Note: *Kokopo waste audit imputed generation rate is based on weekly collection frequency and PNG Census, 2011 average house occupancy size data.*

The results in Table 12 show that the data from all these audits sit within a similar range (˜ 0.30kg per capita per day to 0.50kg per capita per day) with variation in this range potentially being explained by normal statistical variation in the samples, some change across time, and an inconsistency in sampling and classification methodologies use in historic audits.

A further comparison of the primary classification findings was undertaken to find similarities with historical data, refer to **Table 13** below.

The data is expressed as a percentage of the overall waste samples audited. Noting the comparison below has relied on high-level data from the Port Moresby 2014 and Kokopo 2018 audits as detailed data sets were not provided to this study.

****Note:** *Approximations using the pie chart segments (Section 1.2 of the NCDC Waste Management Plan 2016-2025) of all materials other than plastics, organics and paper have been made for the Port Moresby, 2014 data below.*

Table 13: *Comparison between PacWaste Plus and historical audit data*

Audit Location	Waste Audit	Organic*	Cardboard & paper	Textiles	Plastics	Metals*	Glass*	Hygiene*	Miscellaneous*	Hazardous
Port Moresby	2011	Detailed data not available to this study								
Port Moresby	2013	Detailed data not available to this study								
Port Moresby	2014	46%	24%	3%	13%	18%	11%		1%	2%
Kokopo	2018	49%	26%		15%	7%	2%		2%	<1%
Goroka	2019	43.7%	6.7%	10.4%	10.9%	5.8%	9.6%	10.3%	2.8%	
Port Moresby	2021	36.1%	10%	5%	16.5%	10.3%	9.6%	6.5%	.22%	1.6%
Roku Village	2021	33%	4%	11%	14%	1%5	9%	7%	1%	5.2%
Alotau	2021	42%	8%	2%	16%	19%	5%	6%	.24%	3.5%
Lae	2021	44%	7%	4%	22%	7%	5%	6%	1%	4.2%

- Organic includes betelnut, bones, garden waste, and timber
- Plastics include all polymers
- Glass includes ceramics
- Hygiene including diapers
- Miscellaneous includes leather/rubber
- Table entries may not sum to row total due to rounding
- Port Moresby 2011, 2013 data not available to the report

The previous audits conducted for Port Moresby, Goroka, and Kokopo classified and measured the samples according to the primary categories in the table above (considering inclusions as per the notes provided). Whereas 2021 audits measured to the more detailed secondary material categories as prescribed in the *PRIF Methodology, 2019.* To allow for comparison the secondary categories have been grouped into the primary as per the above table.

The comparison found once again that the composition across the historical and contemporary waste audits showed the level of materials to be similar particularly in the cardboard and plastics categories.

The audit data for the Lae City audit was provided in raw form for translation to excel workbooks for analysis. While the audit data for Alotau was provided in excel format with the preliminary analysis already completed. In both cases, the data were entered independently by two team members one for household and one for business. The entered data was then reviewed by the data analyst for any anomalies. Following this, a selection of random entries was reviewed by the project manager for consistency with the supplied data.

Audit Findings

As the data and information provided to the project were drawn from audits using a range of methodologies, not necessarily in alignment with that prescribed by the *PRIF Methodology, 2019* analytical assumptions have needed to be relied upon to deliver the project findings.

Household Surveys

Access to Services

A total of 95 households were surveyed throughout the urban, peri-urban and rural audit locations. The percentage of households that have access to waste collection services were as follows:

- **Urban** 97% of 31 surveyed
- **Peri-urban** 87.5% of 32 surveyed
- **Rural** 0% of 32 surveyed

Household Waste Separation

All respondents were asked about the level of waste material separation at the household level. The table below provides a snapshot of the responses and should be read as follows:

Organic wastes are generally separated for use in the garden, composting, or burning. Similarly, cardboard, paper and plastics are separated and burnt throughout the urban and rural audit locations. This is an interesting response, given the level of collection service available to the urban and peri-urban respondents. Of the materials separated for actual recycling, table 14 shows this is largely confined to aluminium and steel cans. A small number of respondents reported glass jars and bottles are separated for reuse at home or school.

Table 14: *Level of Waste Separation in Households*

Material Type	Urban	Peri-urban	Rural
Organics	83.87%	93.75%	15.63%
Cardboard and paper	22.58%	81.25%	6.25%
Plastics	19.35%	81.25%	3.12%
Aluminium and steel cans	58.06%	90.62%	12.5%

Waste Generation

The household interviews asked a range of questions regarding the types and volumes of waste generated by the occupants and the method of managing wastes in their household. The responses provided in **Table 15** below reflect the respondent's estimates on how much waste is generated in their household each week using a bag/box measure. It could be reasonably expected that the bag/box measure may compare to 20L per bag or box.

The actual method for storage of wastes in the household may differ as nearly half of the urban households reported the use of wheelie bins or steel cages to contain wastes while the rural households rely predominantly on boxes and bags. In this respect, the method for storing and placing wastes for collection varied greatly between the urban/peri-urban and rural households.

Table 15: *Weekly waste generation*

Rubbish generation per week reported by bag/box	Urban	Peri-urban	Rural
1-2 bags/box	32%	44%	59%
3-4 bags/box	54%	38%	10%
5-6 bags/box	6%	9%	1%
Other	8%	9%	11%

Waste Disposal Methods

While there are some common methods for disposal of wastes across the survey locations, there is a significant difference in access to services. The burning of waste for example appears to be a common disposal practice across all survey areas and within income levels but notably reducing in the high-level income group. Recycling of steel and aluminium cans appears across all survey areas and is evenly distributed across the low, medium, and high-income level groupings. Throughout the urban, peri-urban, and rural responses there is a small indication of reuse of plastics and glass at home or school. The rural community does not have a collection service and therefore rely solely on burning, burial or sea dumping as a waste disposal practice. Only one respondent reported taking their rubbish to a collection point.

Open dumping is evident, particular on the foreshore where wastes are transferred back to the beach and underneath houses by tidal movements. Survey responses registered the level of concern the community has regarding the potential health and environmental impacts of these practices. A very small percentage of rural respondents said they take their batteries, tin, and aluminium cans and glass jars/bottles to recyclers. Around 15% used their organic wastes in the garden. While 44% of respondents regularly burn their organic, plastic, paper, and cardboard waste. 19% of respondents regularly dispose of all waste types to the sea or mangrove areas and 37% bury all wastes in a pit.

Notwithstanding that the urban sample area has access to household collection services, 81% of respondents said they use their organic waste in their gardens/compost. 51% of respondents take their steel and aluminium cans to the recycler for which they are paid by weight. 51% report burning their cardboard and paper, and 42% burn plastic wastes. The remainder of materials including oils, batteries, gas cylinders, e-wastes are treated as general waste for disposal.

Once again, while the peri-urban area has access to waste collection services, 78% of respondent's separate steel and aluminium cans for sale to the recycler. 88% use organic wastes in their gardens/compost and 78% burn their cardboard and paper with 22% burning plastic wastes.

Willingness to Pay

The survey sought responses regarding the level of satisfaction with current waste disposal methodologies and the willingness to pay for improved services. The responses to these questions did not always align where respondents were dissatisfied and suggested changes or additional services e.g., bulky waste collections, separate collections for recycled materials but did not show a willingness to pay for improved services.

Table 16 shows that where there are no collection services in place the willingness to pay is far greater.

Table 16: *Satisfaction with rubbish disposal services*

Methods for waste disposal	Urban	Peri-urban	Rural
Satisfied with the current method for waste disposal	71%	66%	25%
Identified improvements to waste collection services	52%	75%	75%
Improved how	Increased collection frequency Segregated recycling service Closed collection vehicles and PPE	Increased collection frequency Bulky waste collection Segregated recycling service	Household collection service
Willingness to pay for an improved service	52%	66%	94%

Table 17 shows that where there are no collection services in place the awareness of potential human health and environment effect is greater.

Table 17: *Awareness of impacts from poor waste management*

Survey Question	Urban	Peri-urban	Rural
Is the way in which waste has managed an issue	YES: 35%	YES: 62%	YES: 75%
Why? What are the key impacts	1. Attracts stray dogs	1. Eyesore	1. Environment pollution and health impacts
	2. Human health impacts	2. Blocked drains; Odours	2. Eyesore
	3. Environment impacts	3. Human health & environment	3. Bad odour, flies

Household Data

The study analysed data from each of the audit locations. The data was either drawn from the audits (Port Moresby and Roku) conducted within the study, provided to the study from audits conducted by the ULLG's directly after the audit training (Lae and Alotau) or historical audit information from relatively recent audits (Goroka and Kokopo).

These locations are considered to represent a cross-section of the PNG community (including rural, regional urban, capital city urban, island and highland urban locations. The data from these locations may be used to model a detailed waste generation picture for the whole of PNG.

Analysis of waste generation rates and composition was in accordance with the classifications prescribed by the *Audit Methodology, 2019, n*oting the existence of any exceptional items as found during the audits.

The following daily average waste generation rates were found within each of the audit locations.

- Port Moresby urban NCDC: 2.4kg per household / 0.29kg per capita
- Port Moresby NCDC peri-urban: 2.3kg per household / 0.27kg per capita
- Roku Village Central Province rural: 2.6kg per household / 0.39kg per capita
- Lae City, Morobe Province: 2.1kg per household / 0.30kg per capita
- Alotau urban, Milne Bay Province: 3.6kg per household / 0.53kg per capita
- Goroka urban Eastern Highlands Province: 3.1kg per household / 0.49kg per capita
- Kokopo Vunamami East New Britain Province: 2.5kg per household / 0.37kg per capita

Refer to the pie charts in Section 6.3 which set out the individual waste generation data for high, medium, and low-income households in each of the audit locations. All measures quoted in this section are percentages by weight.

Rural Sample General Findings

A 0.39kg generation rate per capita per day seems high for a rural location in comparison with the urban data findings. Nonetheless, there is a level of confidence in the rural data findings because of using the measurement framework as per the PRIF methodology. It is considered the sample size per household may have been influenced by the advantage of having a waste collection where there is not normally one available. Resulting in additional materials in the waste stream and a larger waste generation finding.

Urban Sample General Findings

The indicators for higher-income disposal are seen more in the Lae sample than in POM. The high-income areas in Lae showing a greater presence of e-wastes, glass, and single-use plastics. The POM samples showed a greater presence of metals and hygiene products which were predominately baby nappies.

Peri-Urban Sample General Findings

Goroka, Kokopo, and Alotau are included as they are all small urban centres that may be more comparable with the POM peri-urban findings than the urban city findings.

The comparison shows the difference in the average per capita waste generation rates for POM at 0.27kg, which is 260mg less than the highest comparison from Alotau.

Both Alotau and POM findings show higher levels of glass in the lower and medium income samples, where the expectation was to find higher levels of glass in the high-income sample. POM showing the highest portion of glass in the waste stream is followed by Goroka. Kokopo by comparison had the lowest level of glass. The audit found higher levels of single-use plastics in the high-income samples from both locations which may speak to a greater level of disposable income.

Recyclable Material Distribution

This section provides a breakdown of the key findings from the quantitative waste audits. It is presented by primary waste type (category) and further described by sub or secondary classifications included in the primary category.

This section also provides an analysis of the distribution of materials that could be made available for recovery and recycling and presents the findings for each primary material category.

Primary Category: Organics

The audit measured the following secondary or sub-classifications:

- food;
- wood and timber;
- garden organics;
- other organics;
- betelnut;
- shells and bones.

Overall, organic waste is the highest contributor, ranging between 32% and 41% of the rural and urban samples respectively. The Goroka and Kokopo audit found a slightly higher representation at 43% and 49% respectively. 2021 audits measured betelnut and bones/shells as separate categories (within the overall organics primary classification), this was done to achieve a comparison with previous audits, although the 2021 study did not receive the raw data for earlier NCDC audits.

In 2021 urban samples in POM, Lae, and Alotau recorded betelnut as representing between 4.5% and 6% of the waste stream. The NCDC Waste Management Plan 2016-2025 (Figure 1.1 Domestic Waste Contribution, 2014) represents betelnut as approx. 5% (assumed) and the Goroka, 2019 audit reported this material as representing 10% of the household waste sample.

Primary Category: Metals

The audit measured the following secondary or sub-classifications:

- aluminium cans;
- aluminium;
- steel containers and
- metal other.

Metals measured between 6% and 15% of the respective waste samples from each of the audit locations. Kokopo was in this range, however, Goroka was slightly less at just under 6%. Steel containers generally constituted tin food cans and had the highest presence in the metal's category across all audit locations. POM and Lae urban areas, displayed a high presence of aluminium cans in the medium and high-level income samples.

Primary Category: Cardboard & paper

The audit measured the following secondary or sub-classifications:

- cardboard;
- liquid paper board (LPB);
- composite;
- paper and
- tetrapak.

Paper and cardboard measured between 4% and 12% of the respective waste samples from each of the audit locations. Kokopo recorded the highest at 26% of the overall waste stream.

In nearly all samples, cardboard independently was measured as having the higher presence followed by paper.

Much smaller amounts of LPB and composite materials were measured throughout all samples, but the presence of these items increased markedly in the Lae and Alotau audit samples. Notably, there was very little presence of any paper and cardboard in the rural samples.

Primary Category: Glass

The audit measured the following secondary or sub-classifications:

- glass bottles;
- glass jars;
- glass fines and
- glass other.

Glass measured between 4% and 12% of the respective waste samples from each of the audit locations. The POM peri-urban sample recorded the highest. While Goroka and Kokopo both came within this range, Kokopo recorded the lowest rate of glass.

Across the POM urban and peri-urban, Alotau and Roku rural audits, glass bottles represented the highest portion of the glass subcategory in the waste samples. However, glass jars were the highest in the samples taken from Lae.

Primary Category: Plastics

The audit measured the following secondary or sub-classifications:

- PET (Polyethylene terephthalate) containers
- HDPE (High-Density Polyethylene) containers
- LDPE containers
- PVC containers
- EPS (expanded polystyrene)
- PS (Polystyrene)
- PP (Polypropylene)
- Flexible/film
- Other plastics

Data for the various polymer types (listed above) were collected from the 2021 audits. These are presented in **Table 18** below. Data were also collected on each of the sub-classifications for single-use plastics presented separately in **Table 18** below.

Each of the sample's audits recorded between 15% and 17% plastics including for the Kokopo audit. Goroko had the lowest representation of plastics at around 11%. In the urban areas, the predominant plastic types were flexible/film for POM (18%) and PET (33%) for Lae. There was also a high representation of HDPE containers at POM (7%) and Lae (6%). In the single-use plastics category, the data agreed across the two cities as No. 1: heavy carry bags; No. 2: light supermarket bags and No. 3 takeaway styrofoam containers. Both POM and Lae recorded similar rates of coffee cups and cigarette butts at around 1% and 0.3% respectively.

The Alotau urban area had a reasonably even representation of HDPE containers, flexible/film plastics (12% each), PP (5) (11%) and PET containers (9%).

The 'other plastics' category had the largest representation of 40%, although it's not known what these plastics were. In the single-use category, the Alotau audit measured light supermarket bags and takeaway plastics (excluding EPS) as the highest, followed by cigarette packets and takeaway Styrofoam containers.

In the rural area, the predominant plastic was single-use plastic - heavy carry bags (22%), followed by PET, PP (5) and HDPE containers and flexible/film plastics ranking fourth in primary order. Takeaway plastic containers were significantly less represented in the rural samples than would be expected. Similar to the Alotau audit, the 'other plastics' category ranked highest.

Table 18: Average composition of the household plastics waste stream

Plastic Polymer	Percentage of plastics waste sample	As a percentage of the overall household waste sample
PET containers (1)	15.19%	2.53%
HDPE containers (2)	9.0%	1.50%
LDPE containers (4)	1.40%	0.23%
PVC containers (3)	0.66%	0.11%
EPS - polystyrene	1.17%	0.19%
PS (6)	2.2%	0.37%
PP (5)	10.4%	1.74%
Flexibles/film	16.7%	2.79%
Other plastic	18.37%	3.06%

Table 19: Average composition of the household single-use plastics waste stream

Single-Use Plastic Type	Percentage of plastics waste sample	As a percentage of the overall household waste sample
Beverage containers	0.11%	0.01%
Cigarette butts	0.42%	0.07%
Cigarette packets	1.66%	0.27%
Straws	0.35%	0.05%
Coffee cups	0.54%	0.09%
Bags – heavy carry bags	10.49%	1.75%
Bags – supermarket lightweight	5.33%	0.89%
Takeaway plastic other	0.81%	0.13%
Takeaway styrofoam	2.92%	0.48%
Takeaway paper	0.38%	0.06%
Takeaway lids	0.02%	<0.01%
Bottle lid	1.62%	0.27%

Hazardous Waste Distribution

There was generally little presence of hazardous wastes across the audit samples, including for the Kokopo (<1%) and Goroko (0%) audits. Of the remaining audits, fluorescent bulb/tube was the most consistently recorded. The Alotau audit recorded the greatest level of hazardous waste across all samples, with relatively high levels of clinical waste and hazardous other (not defined).

E-waste: All locations other than rural showed varying levels of e-waste in the audit samples. The items that presented consistently were electrical items, toner cartridges and mobile phones in small amounts. Only Alotau recorded computer waste in the medium and high-level income samples.

Batteries: Non-rechargeable batteries formed the most consistent across all income level samples, including for the rural location. This was followed by relatively small amounts of mobile and lithium-ion batteries, noting these items were not present in the rural sample at all. The absence of lead-acid batteries could be explained by these items being a recyclable commodity and a relatively low vehicle ownership rate across the audit locations. Similarly, the absence of power tool batteries could be explained by an assumed low ownership rate.

Table 20: Composition of the household hazardous waste stream

Material	Percentage in the Hazardous Waste Sample	Percentage of Overall Household Waste Sample
Batteries		
Non rechargeable	7.66%	0.21%
Rechargeable	0.00%	0.00%
Lead acid	0.00%	0.00%
Mobile batteries	0.82%	0.02%
Power tool	0.00%	0.00%
Lithium batteries	0.37%	0.01%
Lithium ion	0.03%	<0.01%
Other batteries	0.00%	0.00%
E-waste		
Computer	9.21%	0.25%
TV's	0.00%	0.00%
Mobile phones	1.53%	0.04%
Electrical items	64.98%	1.79%
Toner cartridges	4.06%	0.11%
Household Hazardous		
Paint	0.00%	0.00%
Fluorescent	3.47%	0.09%
Household chemicals	0.35%	<0.01%
Asbestos	0.24%	<0.01%
Clinical (medical)	0.47%	0.01%
Gas bottles	0.93%	0.02%
Mercury	0.00%	0.00%
Hazardous other	5.8%	0.16%

Hygiene Waste Distribution

Of this category, baby nappies recorded the highest presence in the samples taken across all locations and income levels, followed to a far lesser degree by feminine hygiene materials.

Detailed Household Waste Composition

The following section provides a series of pie charts to present the major categories of the household waste audit. The results are broken down by *urban* (Central Province, Lae, Alotau), *peri-urban* (Central Province) and *rural* (Central Province). The pie charts show household waste composition by weight. The Goroka household data provided here is courtesy of Goroka ULLG who conducted the audit in 2019. The Goroka data provides a comparison point for the audit data collected and provided to the PacWastePlus study, however, may use different categorisations in some places.

The data provided courtesy of the Kokopo Vunamami ULLG for the audit conducted in 2018, as below shows the representation in the overall waste stream, which has also been examined as part of this study:

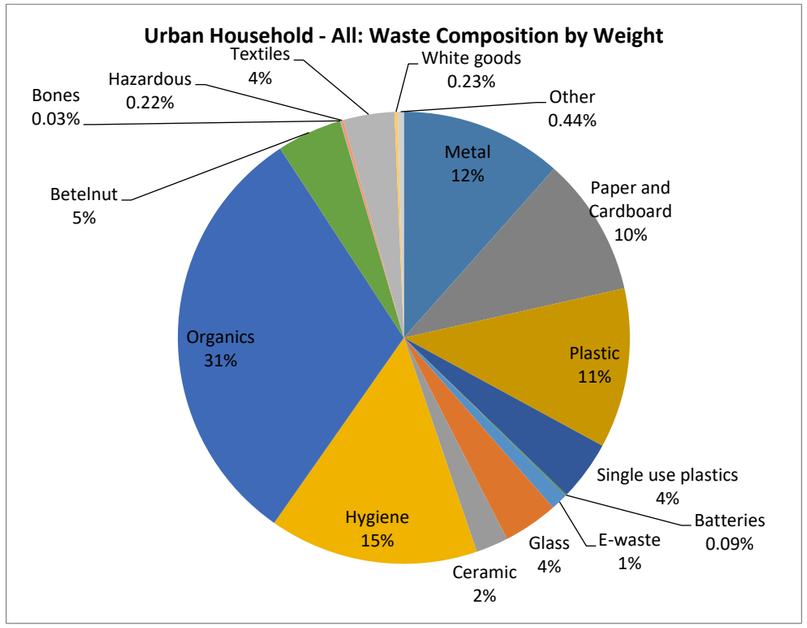
- Total Paper: 26%
- Total Organics: 49%
- Total Glass: 2%
- Total Plastics: 15%
- Total Metals: 7%
- Total Hazardous: <1%
- Total Other: 2%

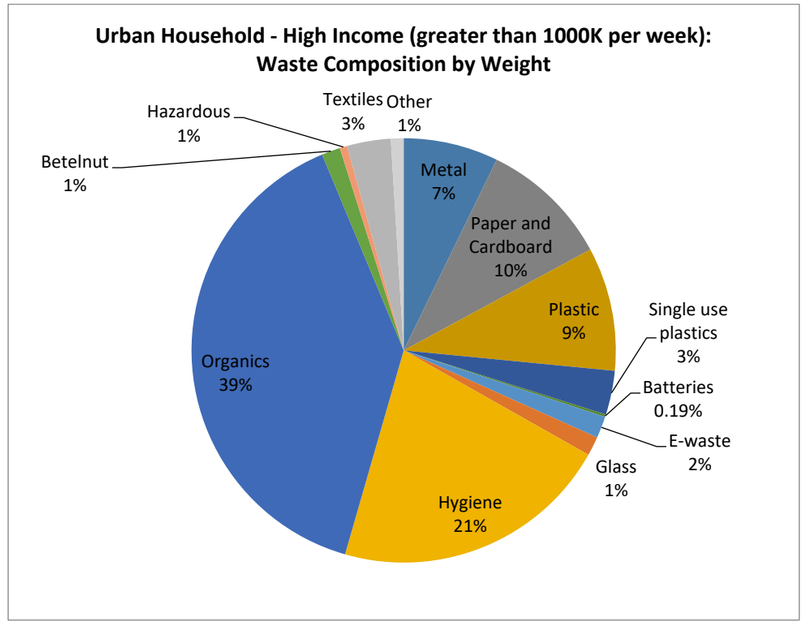
The waste composition in each of the following pages is broken down into high, medium, and low-income households as well as the combined sample result. Whilst we report high, medium, and low waste breakdowns in these panel sets the results should be treated with caution at this level of disaggregation.

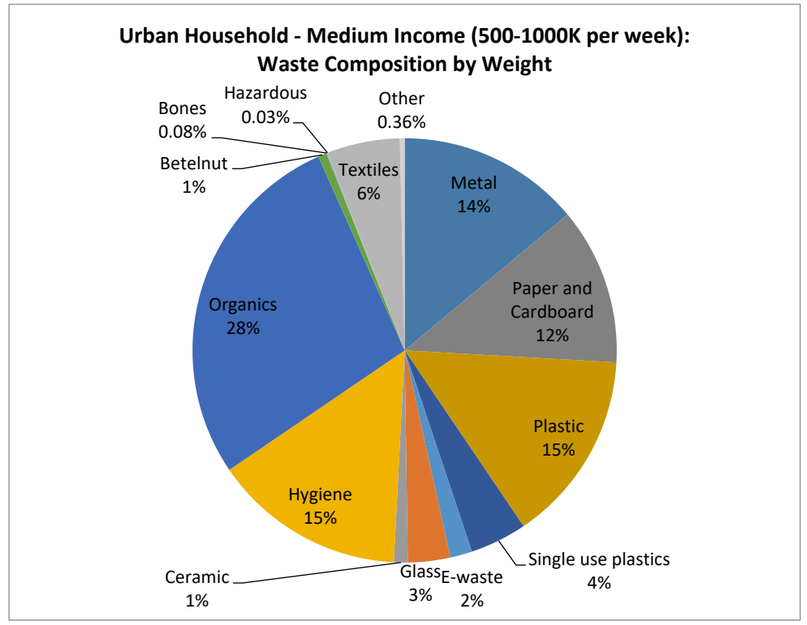
The overall sample result represents a stratified mean by income level for the audit locations and therefore sample sizes within each income strata are not necessarily sufficient to produce a low variation statistical result.

Household Results

Figure 1: *POM Urban household audit results*







POM Urban Household Type	Average Household Size (*PNG Census 2011)*	Kilograms per Household per Day	Kilograms per Person per Day
High income	8.5	2.8	0.33
Medium income	8.5	2.5	0.30
Low income	8.5	2.0	0.24
All	8.5	2.4	0.29

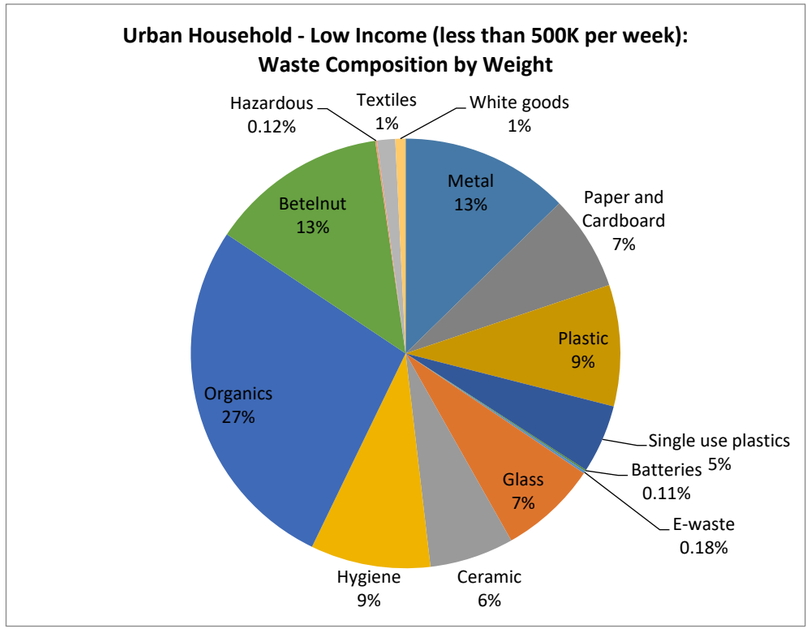
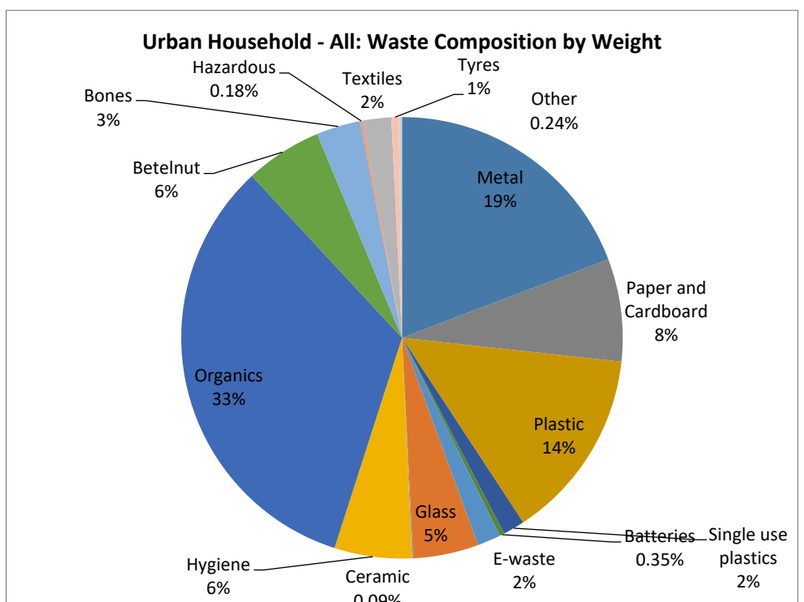
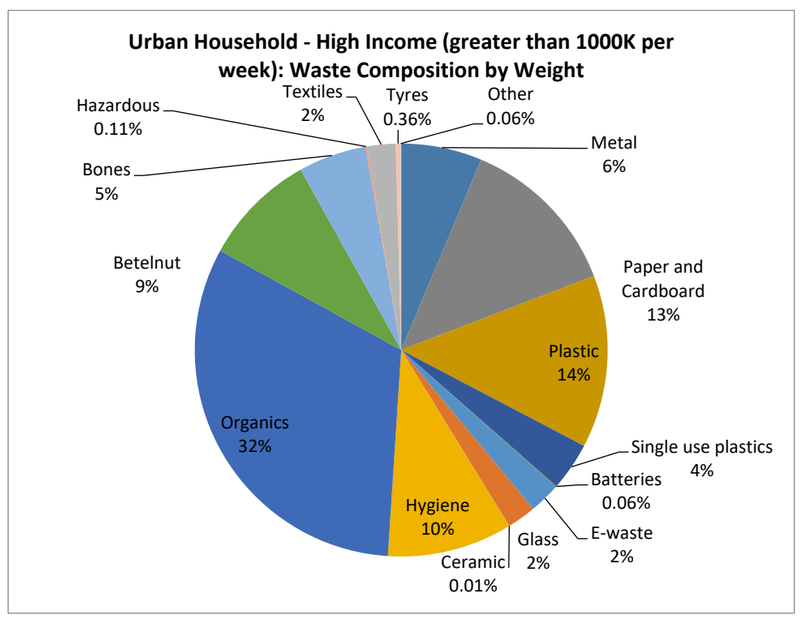
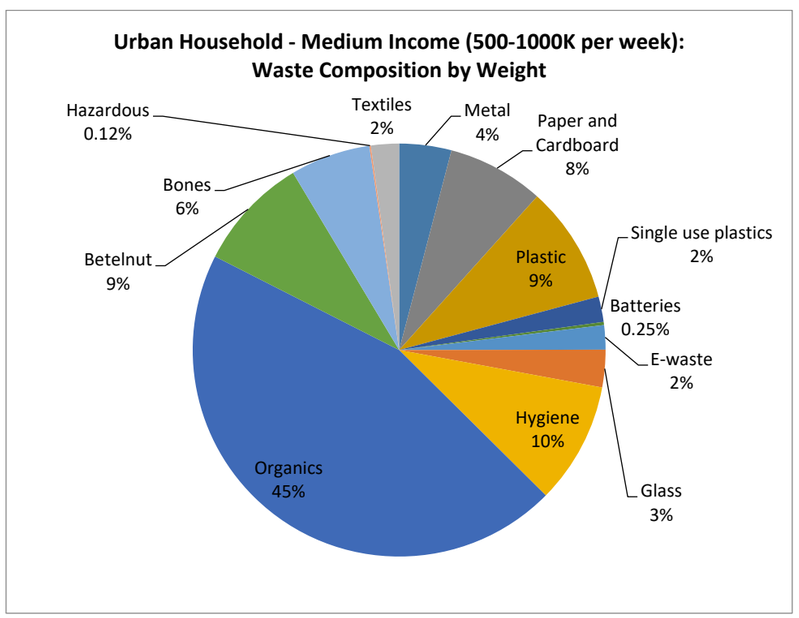


Figure 2: *Alotau ULLG urban household audit results*







Alotau ULLG Household Type	Average Household Size (*from the Data Provided)*	Kilograms per Household per Day	Kilograms per Person per Day
High income	6.9	2.0	0.29
Medium income	6.9	3.0	0.44
Low income	6.9	5.9	0.86
All	6.9	3.6	0.53

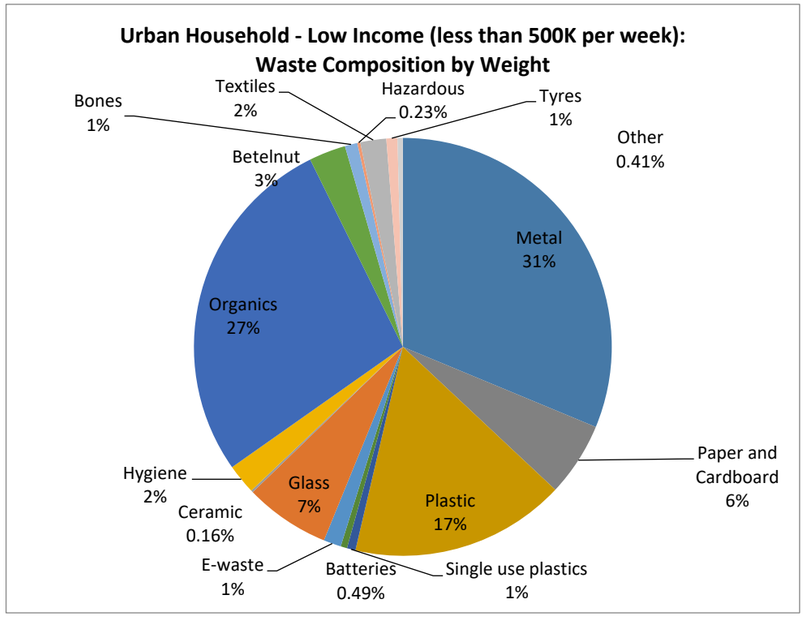
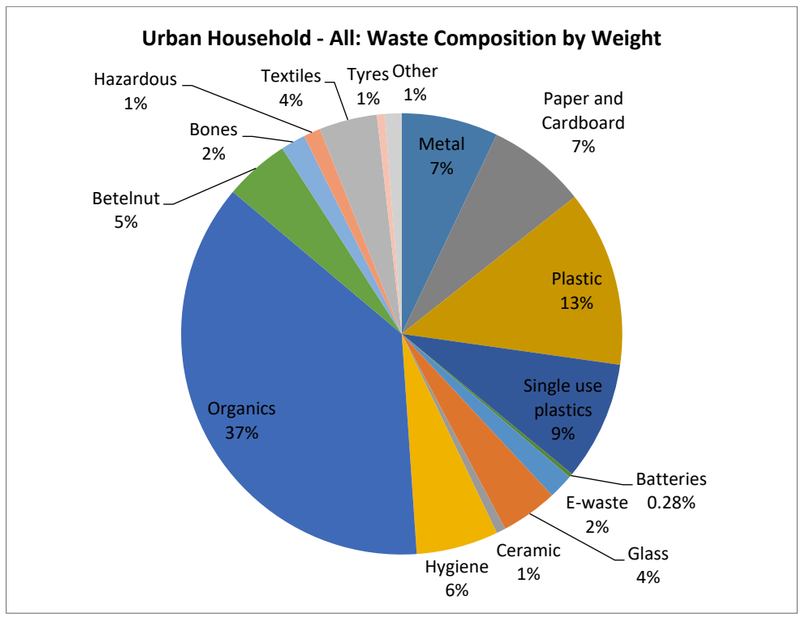
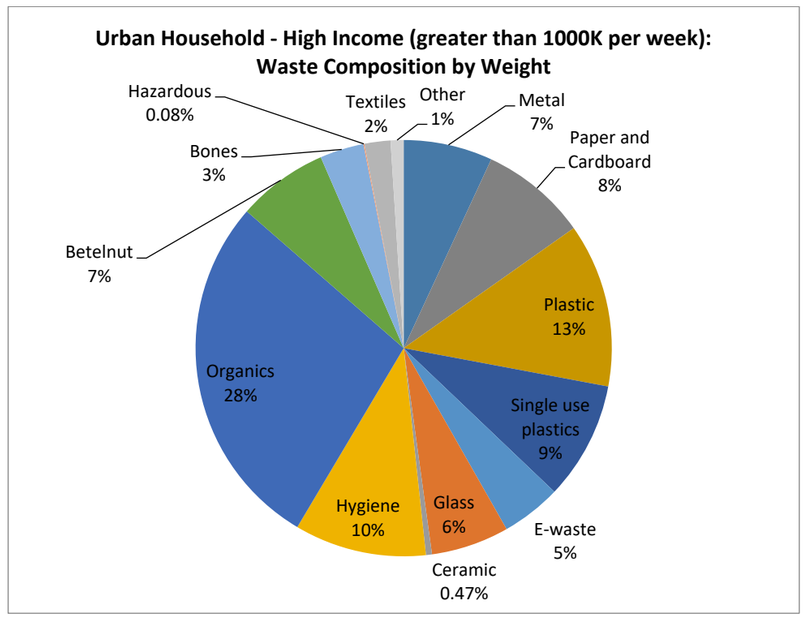
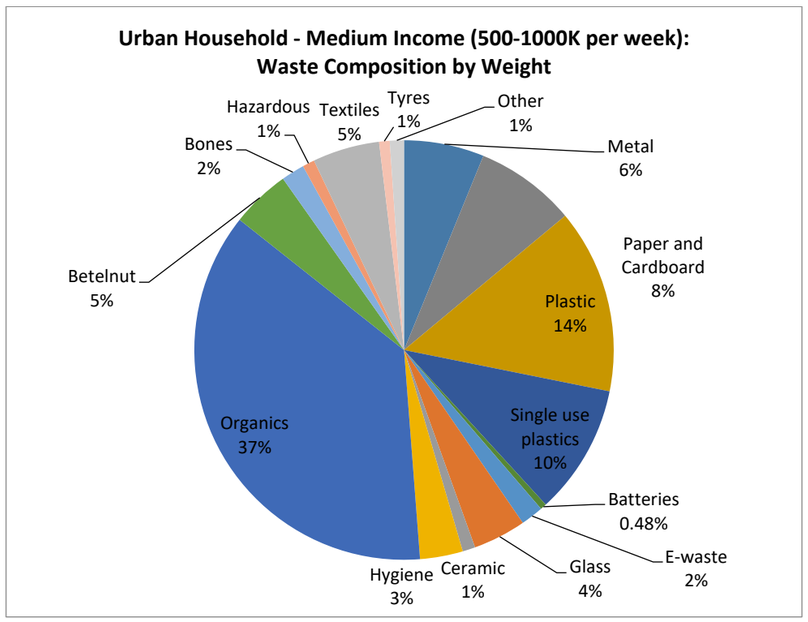


Figure 3: *Lae City urban household audit results*







Lae City Household Type	Average Household Size (*PNG Census 2011)*	Kilograms per Household per Day	Kilograms per Person per Day
High income	7.2	1.3	0.18
Medium income	7.2	2.7	0.37
Low income	7.2	2.4	0.34
All	7.2	2.1	0.30

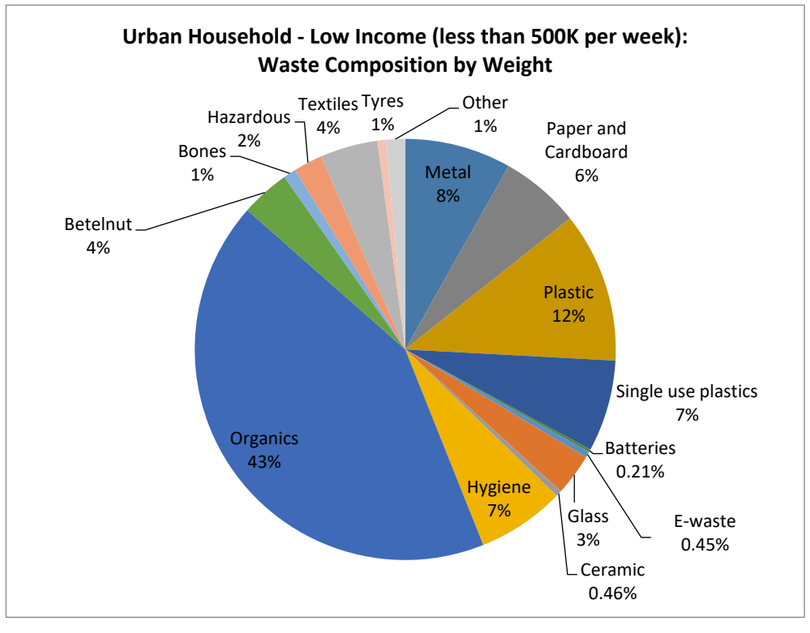
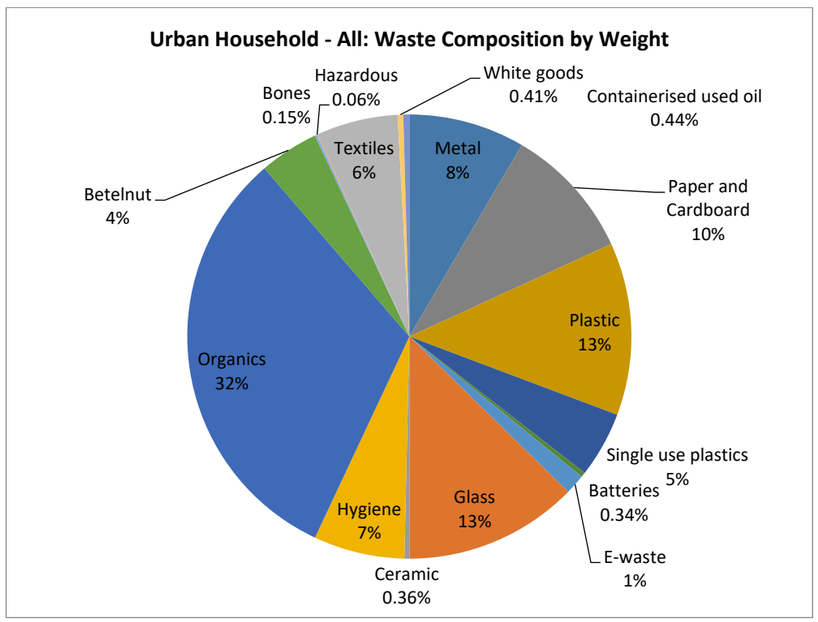
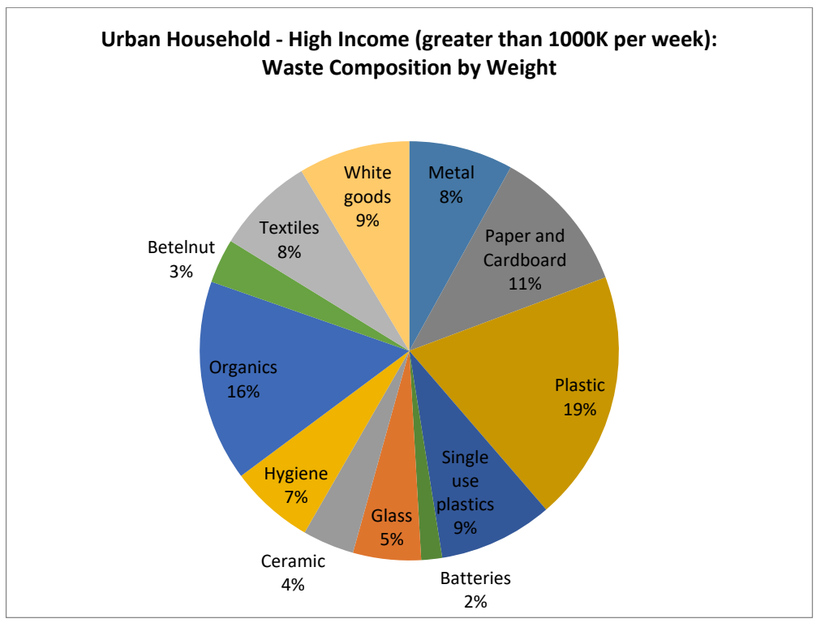
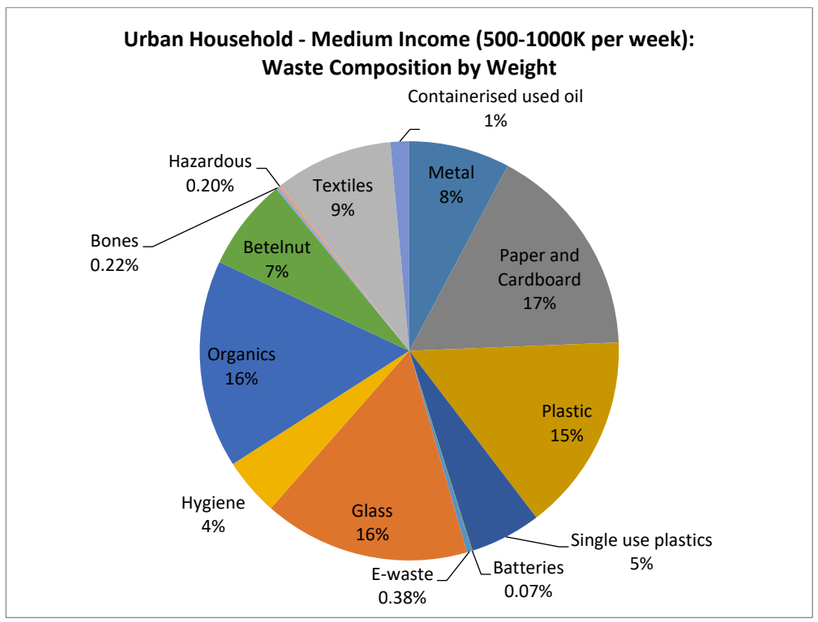


Figure 4: *POM peri-urban household audit results*







POM Peri-Urban Household Type	Average Household Size (*PNG Census 2011)*	Kilograms per Household per Day	Kilograms per Person per Day
High income	8.5	3.6	0.42
Medium income	8.5	2.5	0.29
Low income	8.5	2.2	0.26
All	8.5	2.3	0.27

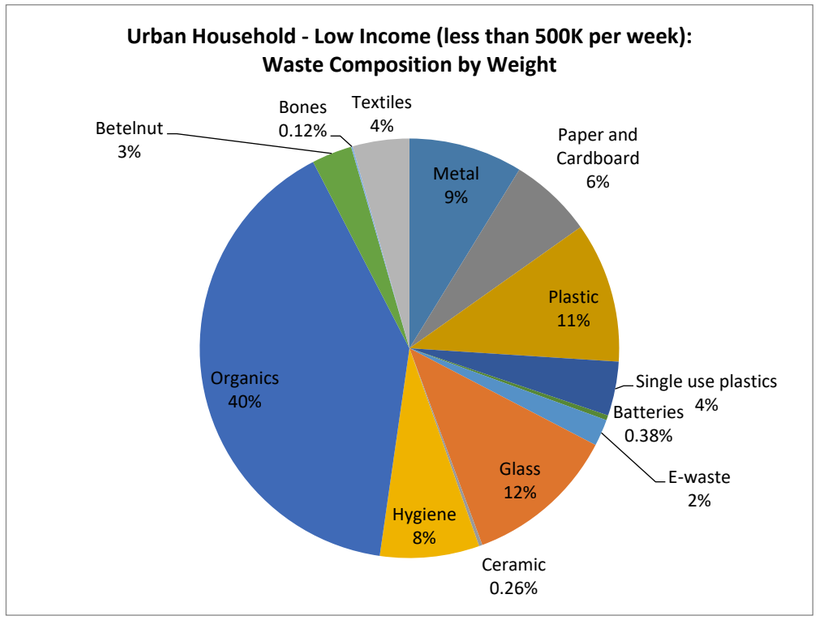
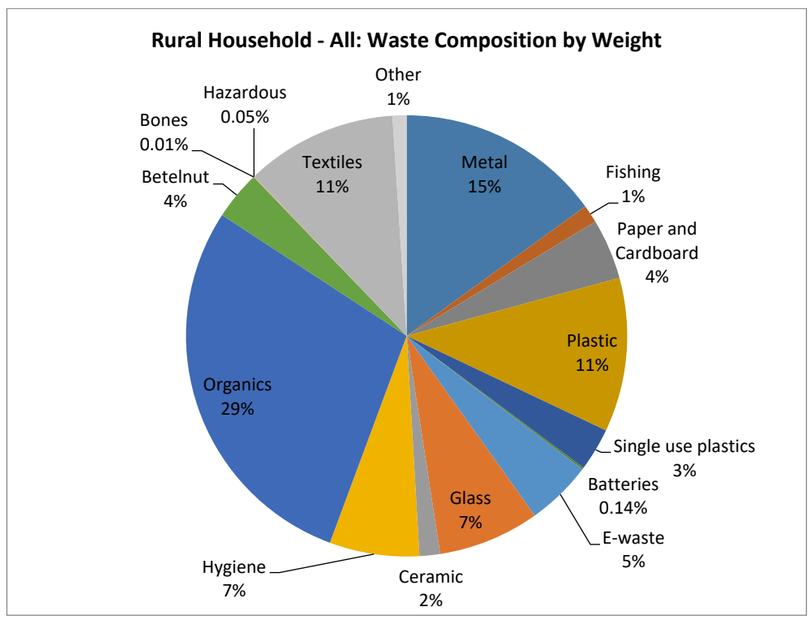
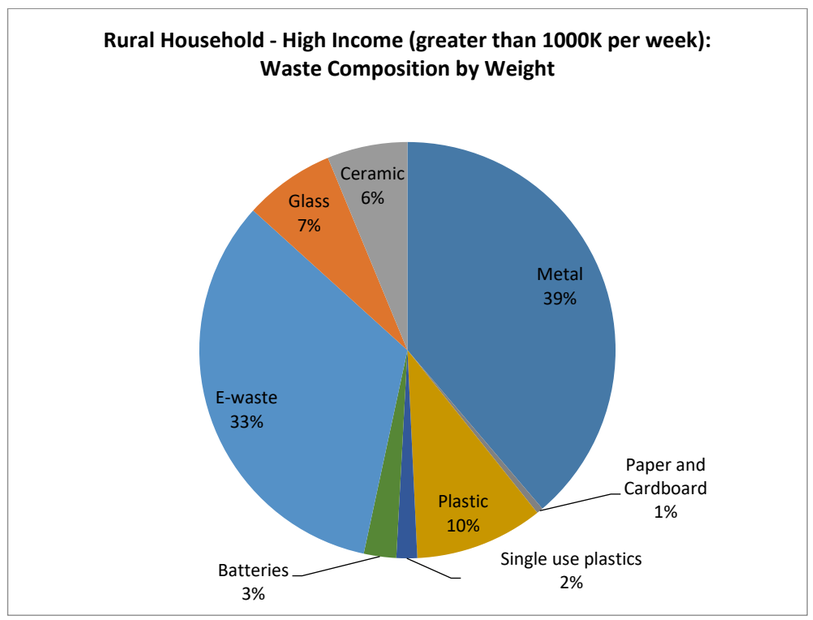
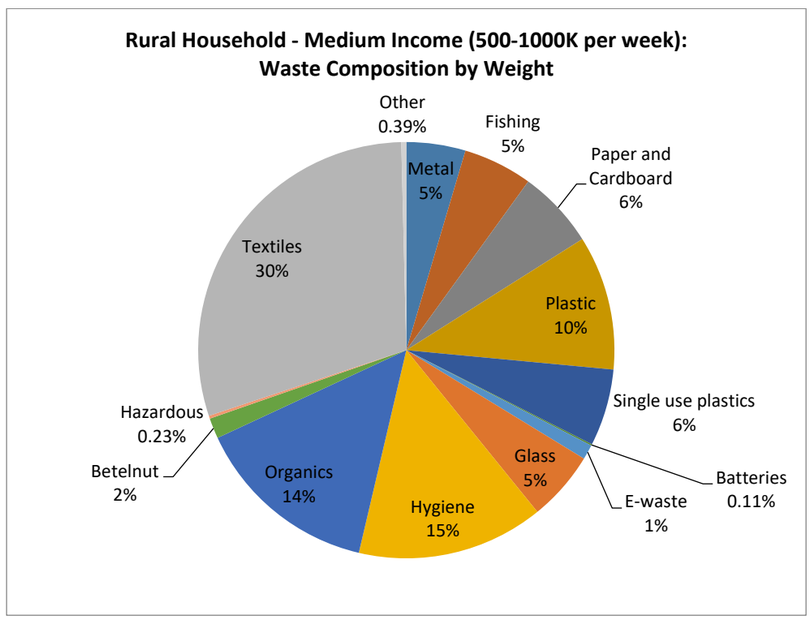


Figure 5: *Central province rural household audit results*







Central Province Rural Household Type	Average Household Size (*PNG Census 2011)*	Kilograms per Household per Day	Kilograms per Person per Day
High income	6.7	2.5	0.37
Medium income	6.7	4.4	0.65
Low income	6.7	2.3	0.35
All	6.7	2.6	0.39

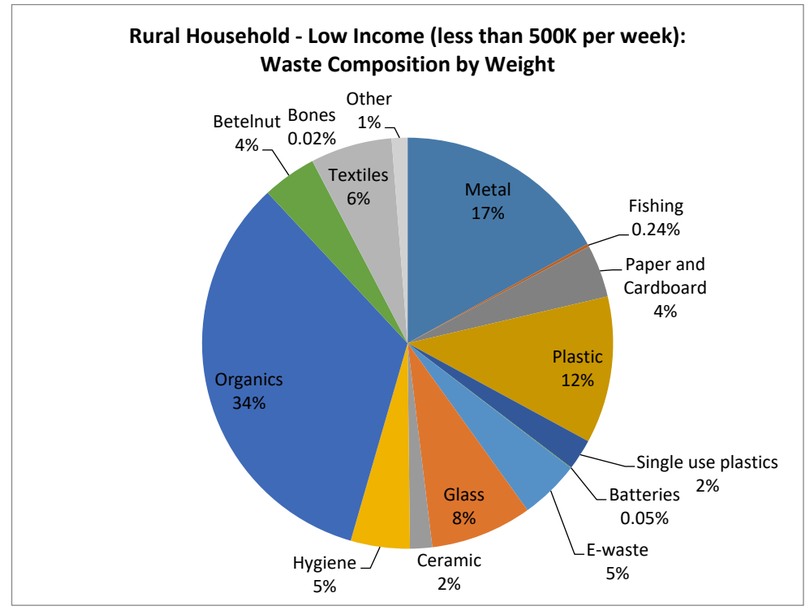
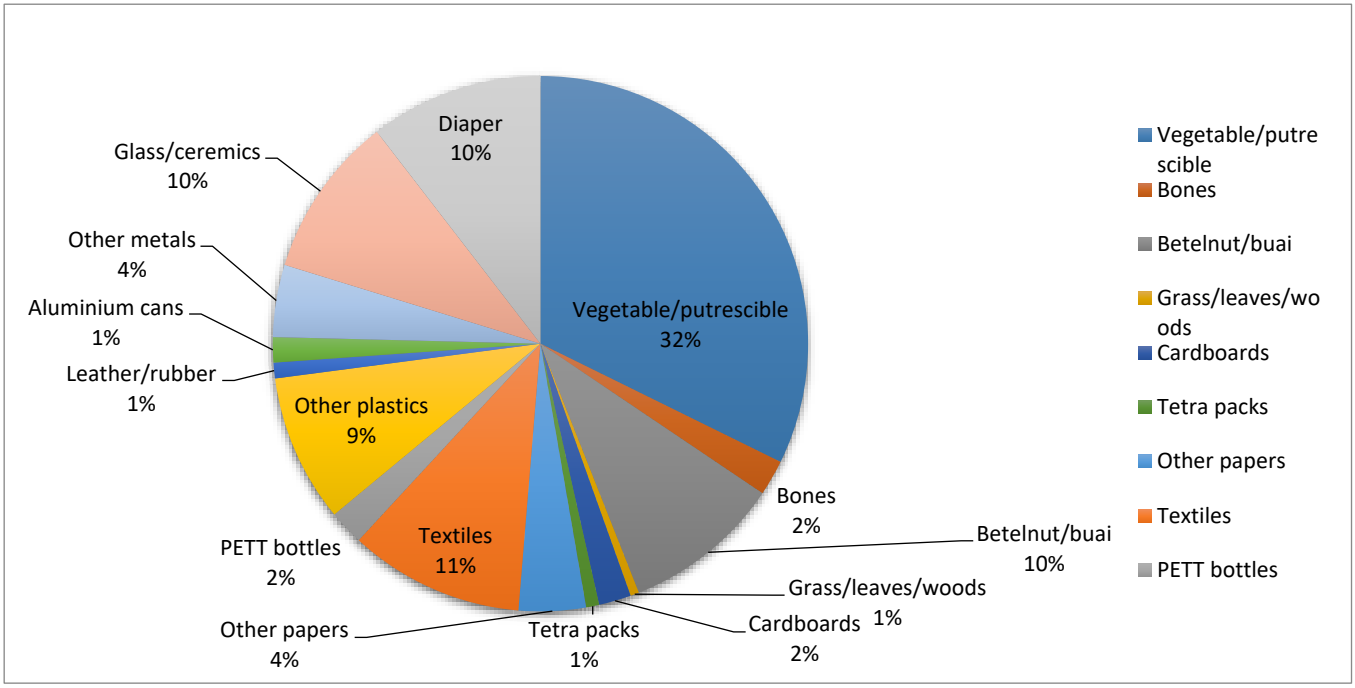


Figure 6: *Goroka ULLG household audit results*



Goroka ULLG Household Type	Average Household Size (*PNG Census 2011)*	Kilograms per Household per Day	Kilograms per Person per Day
High income	6.5	4.81	0.74
Medium income	6.5	2.67	0.41
Low income	6.5	2.34	0.36
All	6.5	3.19	0.49

Business Surveys

The following business types in POM, Alotau, and Lae took part in the study:

- Administration office
- Food outlet
- Supermarket, retail /wholesale outlet
- Hotel

Qualitative surveys were not conducted as part of the Lae or Alotau audit.

Administration Office

These respondents included financial services, labour-hire firms, and government offices.

The mean average waste generation for this business category was 10kg per business per day. The POM survey found these businesses predominantly generate paper, however, no offices in the survey reported conducting any recycling. Wastes are generally collected from the premises.

Food Outlets

These respondents included restaurants and cafes.

The mean average waste generation for this business category across the audits was 19 kg per business per day. The POM survey found these businesses generally used wheelie bins for storage of wastes which were collected either daily or twice weekly. The main wastes for collection comprised food wastes, cardboard, and plastic bags. No wastes were reported as being recycled however one business reported reuse of steel and aluminium cans and glass jars/bottles within its business operations.

Hotels

These respondents included hotels and accommodation providers.

The mean average waste generation for this business category was 43kg per day. The POM survey wastes are predominantly stored in wheelie bins and steel cages for smaller hotels. One premise reported separating aluminium and steel cans, batteries, oil, electronic wastes, and gas cylinders for collection by a recycler. This premises also used the organic wastes from the hotel kitchen in the garden composting and burnt the paper and cardboard wastes. Collections for this hotel were provided by NCDC on a twice weekly basis.

A larger hotel reported storage of mixed wastes in wheelie bins which were collected daily. Items recovered for resale were batteries and oil. This hotel felt that there is an increasing environmental impact from mismanaged wastes that could be addressed through improved storage facilities and collection services that included recycling.

Supermarkets and Retail / Wholesale outlets

The respondents included both small and supermarkets and department stores, clothing, and liquor stores.

The mean average waste generation for this business category was 65kg per day noting that Alotau individually audit recorded an average of 134kg per supermarket, retail/wholesale outlet per day.

The POM survey found smaller retail outlets reported producing mainly cardboard, paper, plastic wrap, plastic bags, and aluminium foil. None of which was recycled. One supermarket reported burning cardboard, paper and plastic wastes with the remainder being collected from the premises.

A small wholesaler reported the main waste generated as organic, cardboard and paper, stored in boxes/bags for collection. Organic waste was used in the garden.

Wastes at mid-range supermarket premises comprised cardboard, paper, plastic, and glass bottles. No recycling was undertaken, and general wastes were collected from the premises every week. The premises felt there could be much more awareness-raising regarding the storage and placement of wastes.

The larger supermarkets stored their waste in skip bins, and it was unclear how often this was collected. Steel and aluminium cans are recovered for sale to the recycling agent. The businesses in POM were generally satisfied with how waste is managed.

Business Data

Refer to the pie charts in **Section 6.6** which set out the individual waste composition data for each business type group by each of the audit locations. All measures quoted in this section are percentages by weight and the discussion under each business type quotes composition measurements that have been taken as an average overall sample in the audit.

Administration Office Category General Findings

The predominant material typically found in the administration office sample was surprisingly plastics which overall made up the highest primary category at 32%, noting the higher contributor to this was single-use plastics (heavy carry bags). Paper and cardboard followed at 27% then organics at 23%, noting a reasonably high representation of betelnut in these samples (9%).

Food Outlet Category General Findings

The predominant material typically found in the food outlet/restaurant sample was not surprisingly, organics at 52%. This was followed by plastics at nearly 20% (single-use component 9.6%) and paper and cardboard at 13%.

Hotel Category General Findings

The predominant material typically found in the hotel sample was organics, primarily food waste at nearly 40%. Followed by plastics at 18% (single-use component 9.3%) paper and cardboard at 15%, and glass comprising 10% of the sample.

Retail, Wholesale, Supermarket Category General Findings

The predominant material typically found in the retail, wholesale and supermarket category was 36% paper and cardboard (cardboard component 32%) followed by organics at 32% (primarily food) and plastics at 22% (single-use plastics 8%).

Recyclable Material Distribution

This section provides a breakdown of the key findings from the quantitative waste audits. It is presented by primary waste type (category) and further described by sub or secondary classifications.

This section provides an analysis of the distribution of materials that could be made available for recovery and recycling.

Primary Category: Organics

The audit measured the following secondary or sub-classifications:

- food
- wood and timber
- garden organics
- other organics
- betelnut
- shells and bones

Across the business samples, food organics represented the highest proportion with garden organics the second highest. All business categories registered food waste as the highest contributor except office administration which was expected. The category 'other organics' was primarily made up of betelnut and bones/shells. Understanding the level of organics in the waste stream is critical to being able to evaluate the potential carbon emissions and to have the data on which to model potential alternative technologies to treat organic wastes such as composting and power generation.

Primary Category: Metals

The audit measured the following secondary or sub-classifications:

- aluminium cans
- aluminium
- steel containers
- metal other

Aluminium cans were the predominant metal across all business samples followed by steel including tin containers. Metal products made up approximately 3% of the business waste stream.

Primary Category: Paper and cardboard

The audit measured the following secondary or sub-classifications:

- cardboard
- liquid paper board (LPB)
- composite
- paper
- tetra-pak

The findings for the business analysis were similar to that of the household audits, which found cardboard measured as having the highest presence in the waste stream followed by paper.

Much smaller amounts of liquid paper board (LPB) and composite materials were measured throughout all samples, but the presence of these items increased markedly in the Lae audit samples. Cardboard and paper overall made up approximately 30% of the business waste stream.

Primary Category: Glass

The audit measured the following secondary or sub-classifications:

- glass bottles;
- glass jars;
- glass fines and
- glass other

Glass bottles were the main type of glass recorded across all business samples and as expected were found in larger quantities in the hotel and food outlet samples. Glass made up approximately 6% of the business waste stream.

Primary Category: Plastics

Data for the various polymer types (listed above) were collected from the 2021 audits. These are presented in **Table 21** below. Data were also collected on each of the sub-classifications for single-use plastics presented separately in **Table 22** below.

Of the plastics waste stream, PP (5) is the highest contributor to the plastic wastes (21%) followed by flexible/film plastics (14%) with the remaining polymers reasonably evenly distributed throughout the remaining fraction of this waste stream.

Lightweight supermarket bags (8%) made up the greater portion of the single-use plastic stream, followed by heavy plastic carry bags (7%) and takeaway Styrofoam containers (4%). Noting that beverage containers appear to have been measured according to their polymer (and therefore included in **Table 21** and not 22).

Plastic waste made up approximately 19% of the overall business waste stream averaged across the audit locations (POM, Lae, and Alotau). This compares with the Goroka ULLG 2019 audit which measured 17.6%. See **Section 6.6** below for more details.

Table 21: Composition of the business plastics waste stream

Plastic Polymer	Percentage of Plastics Waste Stream	As a Percentage of the Overall Business Waste Stream
PET containers (1)	4.32%	0.81%
HDPE containers (2)	3.97%	0.74%
LDPE containers (4)	6.30%	1.81%
PVC containers (3)	3.35%	0.62%
EPS – polystyrene	3.64%	0.68%
PS (6)	4.46%	0.83%
PP (5)	21.49%	4.02%
Flexibles/film	14.01%	2.62%
Other plastic	2.95%	0.55%

Table 22: Composition of the business single-use plastics waste stream

Plastic Polymer	Percentage of Plastics Waste Stream	As a Percentage of the Overall Business Waste Stream
Beverage containers	0.00%	0.00%
Cigarette butts	1.23%	0.23%
Cigarette packets	2.33%	0.43%
Straws	1.91%	0.35%
Coffee cups	2.16%	0.40%
Bags – heavy carry bags	7.73%	1.44%
Bags – supermarket lightweight	8.79%	1.64%
Takeaway plastic other	3.34%	0.62%
Takeaway styrofoam	3.96%	0.74%
Takeaway paper	0.09%	0.01%
Takeaway lids	1.67%	0.31%
Bottle lid	2.20%	0.41%

Hazardous waste distribution

The analysis found a relatively small presence of hazardous wastes in the audit samples (which is consistent with the Goroka 2019 audit), and similar to the household data findings. The most consistently recorded material was fluorescent tubes and 'hazardous other' (undefined).

E-waste: No e-waste was found in the food outlet or retail samples. Electrical items and toner cartridges were the primary materials found across the remaining samples in relatively small quantities.

Batteries: Non-rechargeable batteries and lithium-ion batteries, were found in very small quantities across all samples from the POM, Alotau, and Lae audits.

Table 23: Composition of the business hazardous waste stream

Material	Percentage in the Hazardous Waste Stream	Percentage of Overall Business Waste Stream
Batteries		
Non rechargeable	14.60%	0.36%
Rechargeable	0.00%	0.00%
Lead acid	0.00%	0.00%
Mobile batteries	0.00%	0.00%
Power tool	0.00%	0.00%
Lithium batteries	0.00%	0.00%
Lithium ion	24.10%	0.60%
Other batteries	0.00%	0.00%

Material	Percentage in the Hazardous Waste Stream	Percentage of Overall Business Waste Stream
E-waste		
Computer	0.00%	0.00%
TV's	0.00%	0.00%
Mobile phones	0.00%	0.00%
Electrical items	7.08%	0.18%
Toner cartridges	34.33%	0.86%
Household Hazardous		
Paint	0.00%	0.00%
Fluorescent	18.12%	0.45%
Household chemicals	0.00%	0.00%
Asbestos	0.00%	0.00%
Clinical (medical)	0.04%	<0.01%
Gas bottles	0.00%	0.00%
Mercury	00.00%	0.00%
Hazardous other	1.70%	0.04%

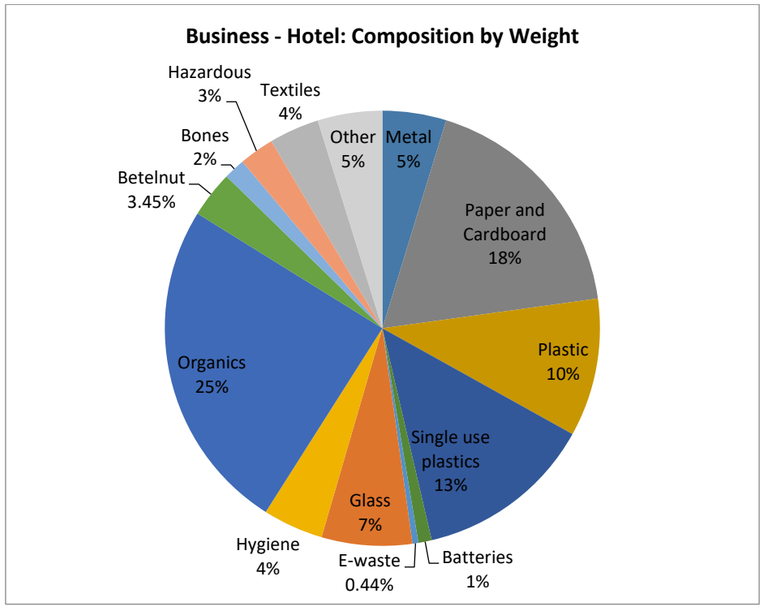
Business Graphs

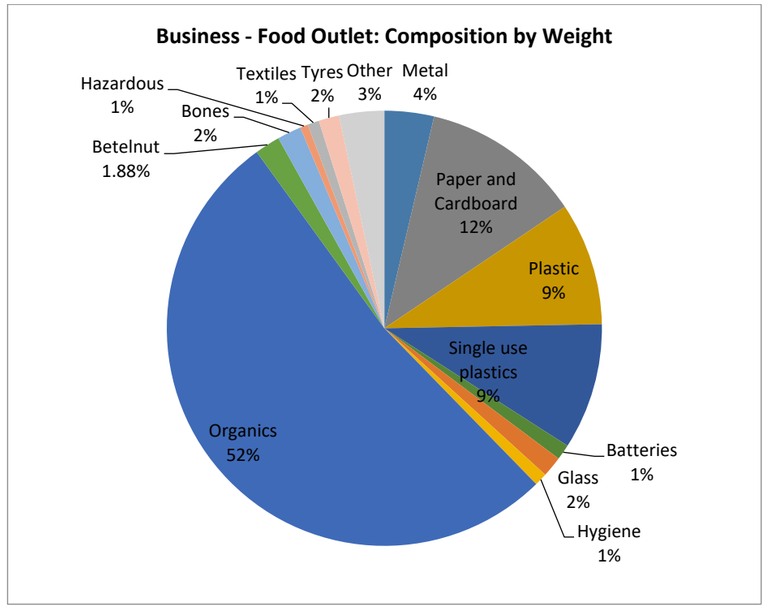
The following section provides a series of pie charts to present the major categories of the business waste audit. The results are broken down by business type (hotel, food outlet, admin/office, retail, and supermarket) for each of the audit locations: POM, Alotau, and Lae and refer to the business waste stream composition by weight.

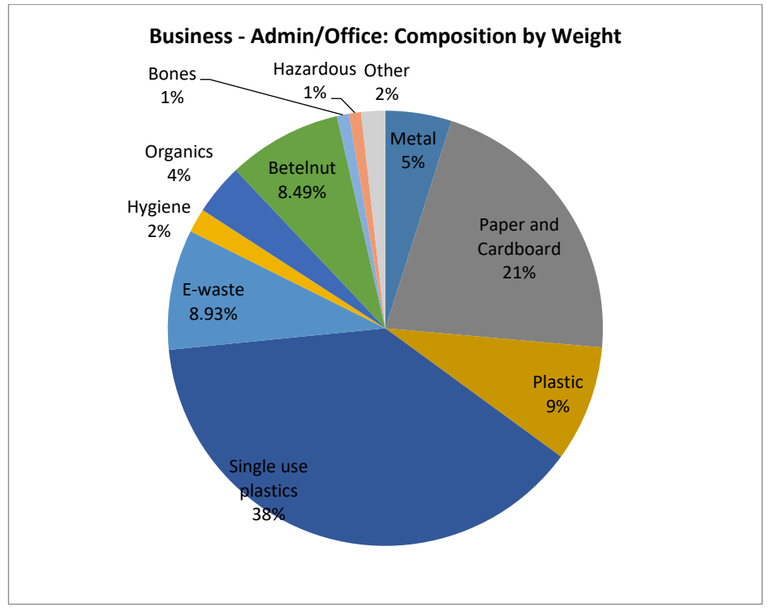
The Goroka business data provided here is courtesy of Goroka ULLG who conducted the audit in 2019. This provides a comparison between the audit data collected and provided to the *PacWaste Plus* study however may use different categorisations in some places.

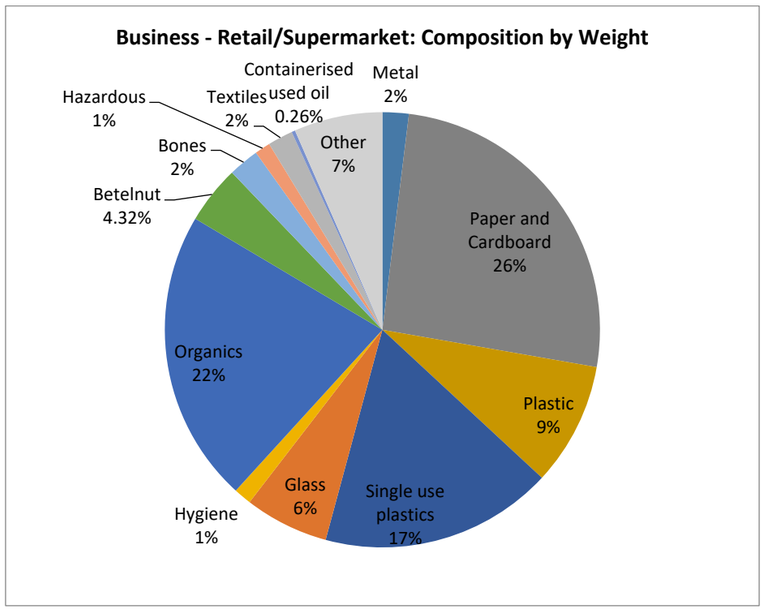
Business Results

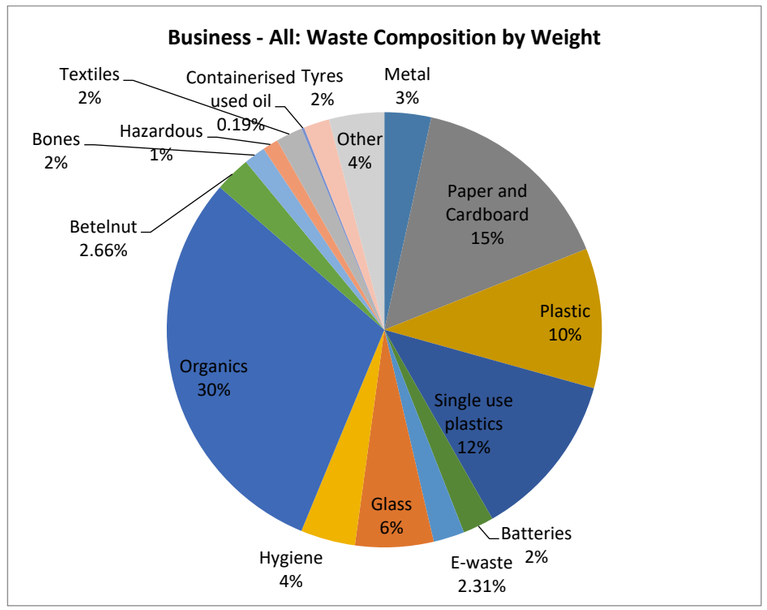
Figure 7: *Law City and POM combined business audit results*





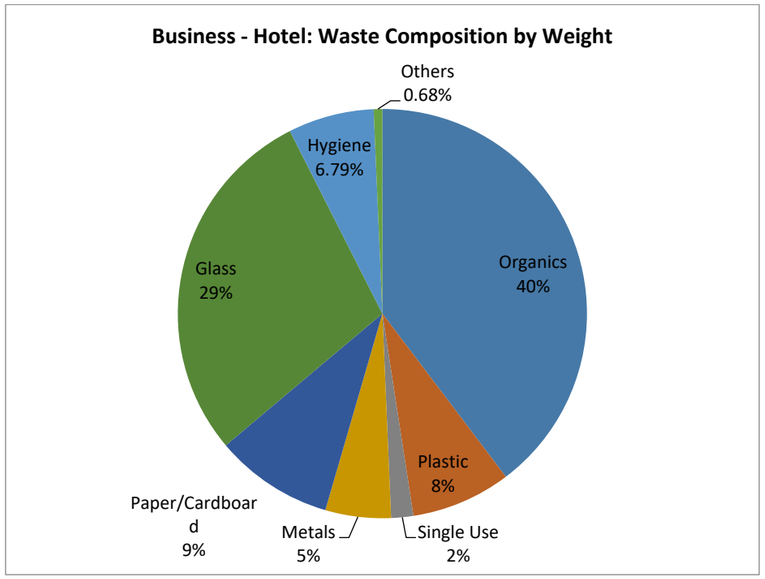


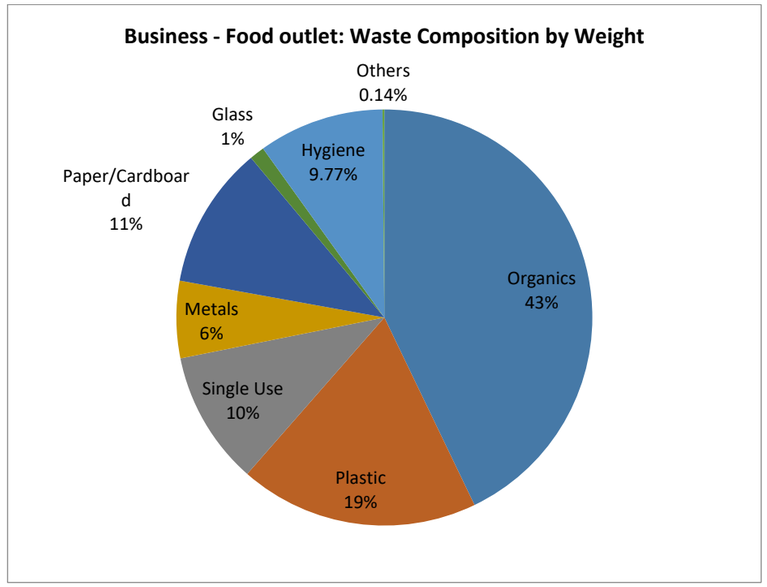


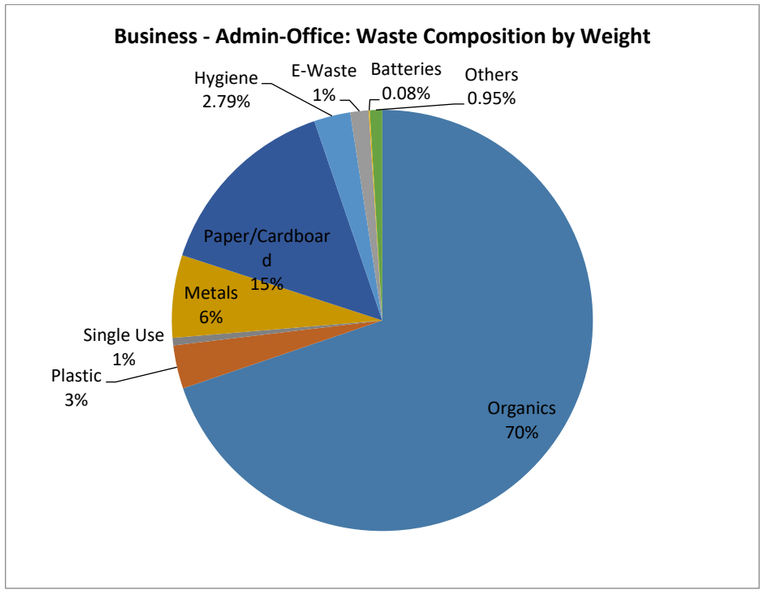


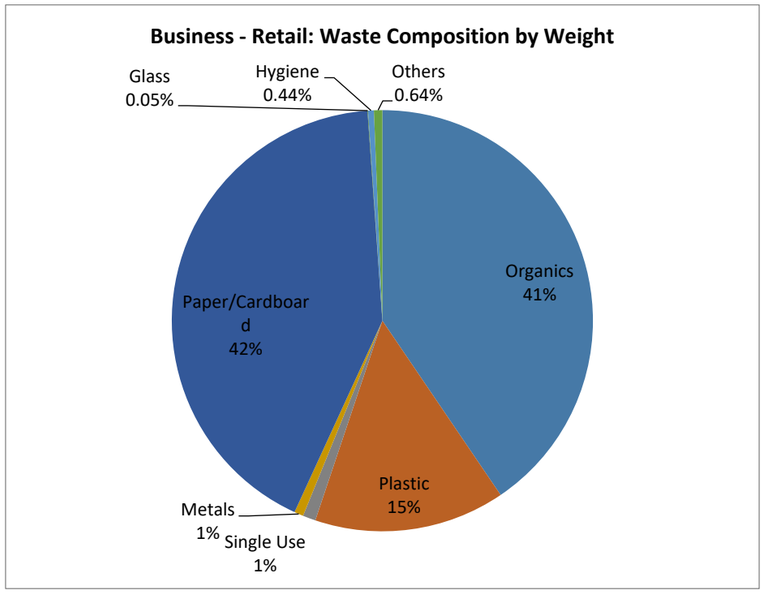
Lae City and POM Combined Business Type	Kilograms per Business per Day
Hotel	90.9
Food outlet	130.8
Admin/office	22.4
Retail/Supermarket	76.0
Av. across all business types	**104.0**

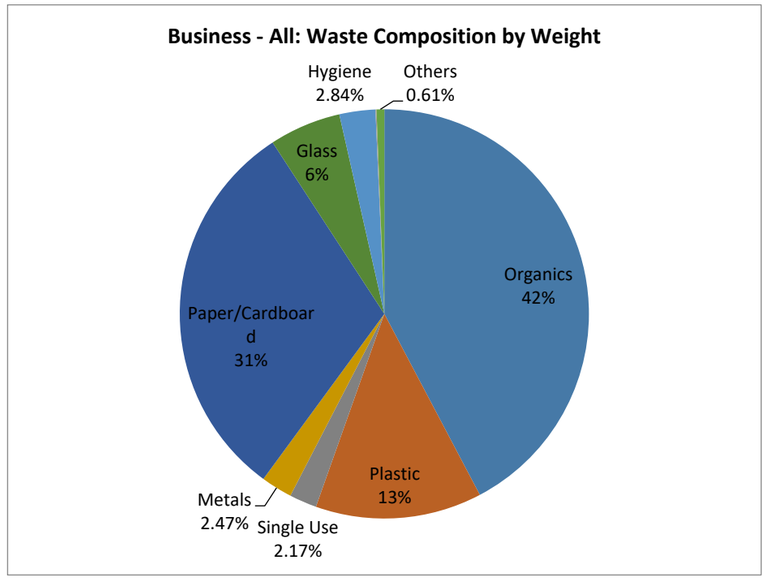
Figure 8: *Alotau ULLG business audit results*





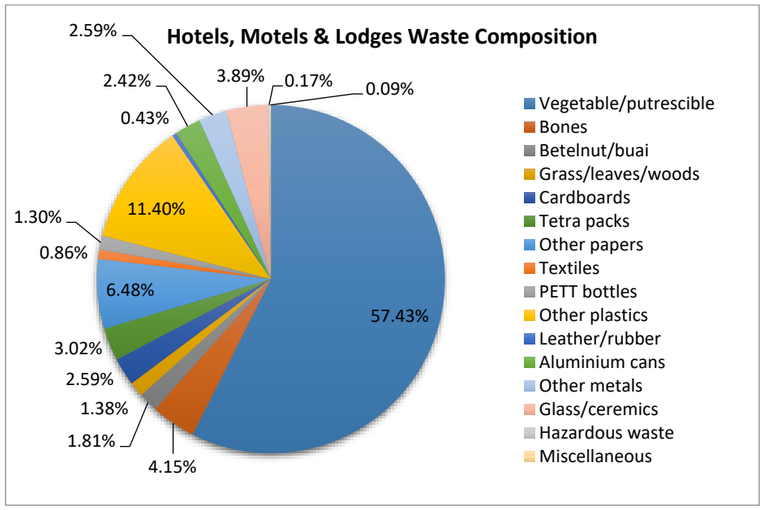


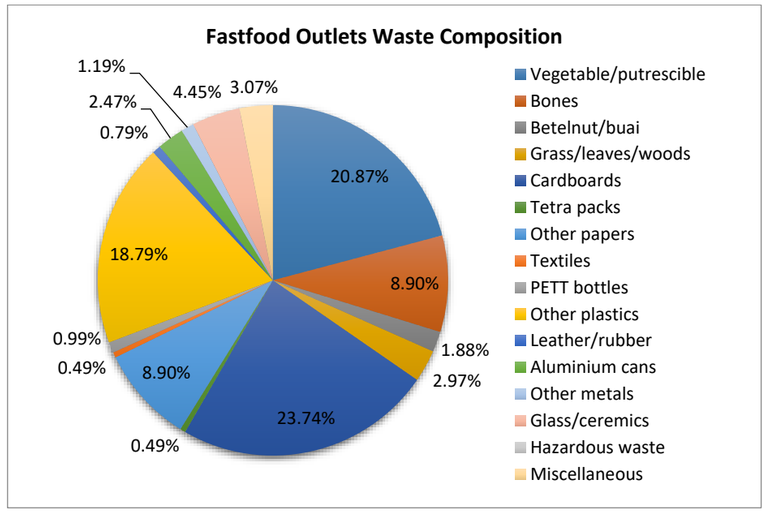


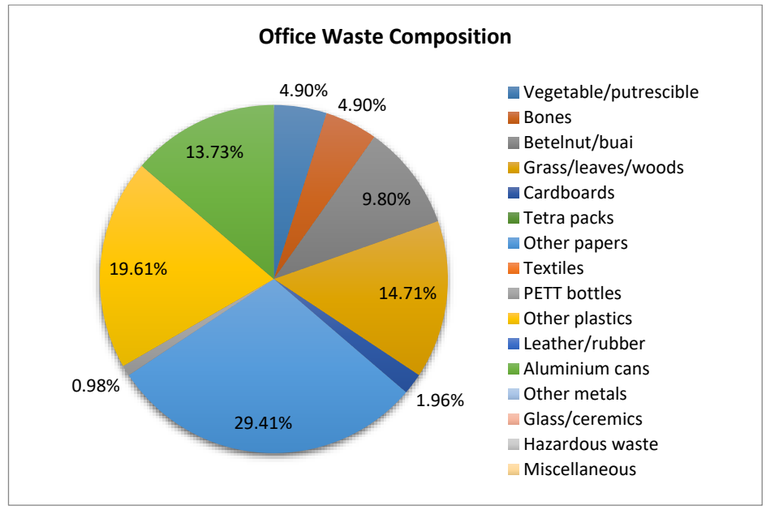


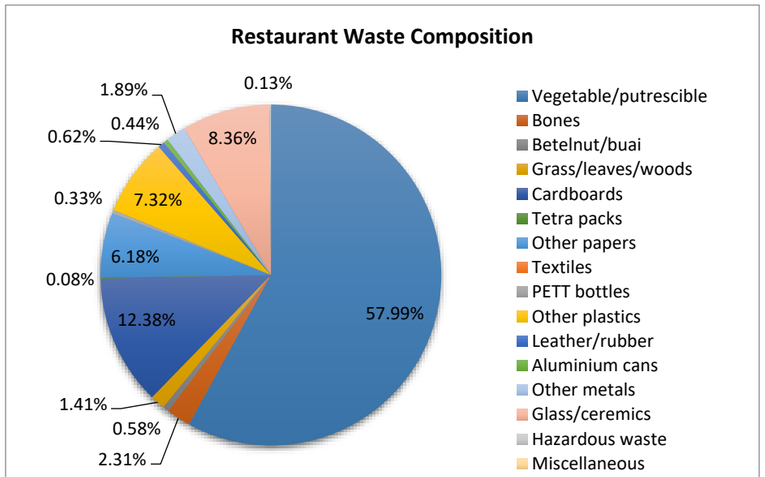
Alotau ULLG Business Type	Kilograms per Business per Day
Hotel	25.8
Food outlet	15.1
Admin/office	7.6
Retail/Supermarket	86.0
Av across all business types	**33.6**

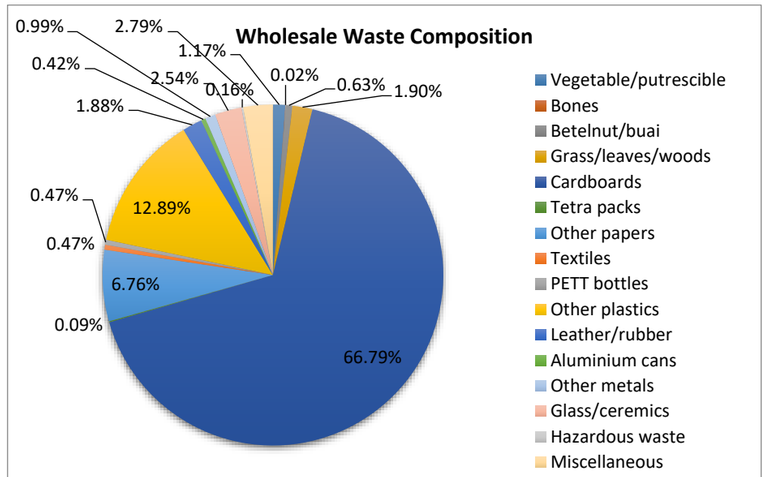
Figure 9: *Goroka ULLG business audit results*

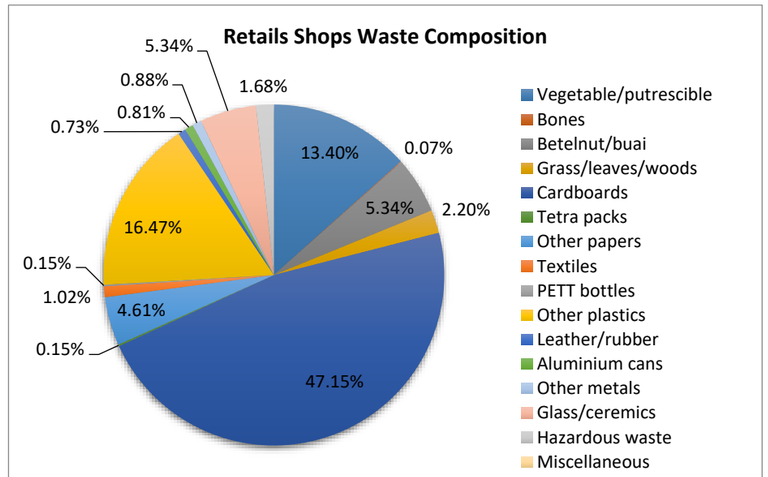


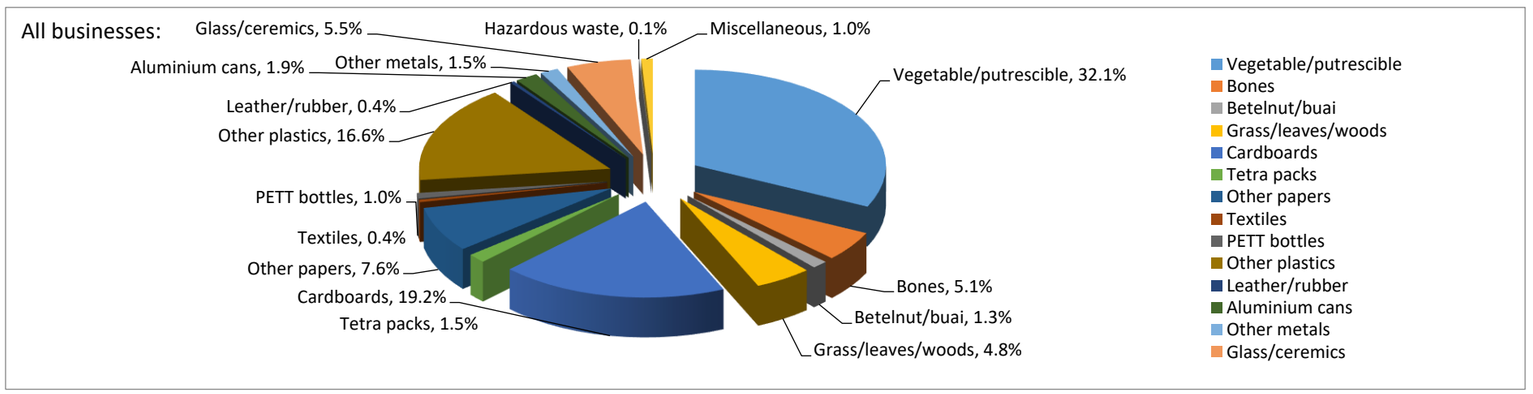












Goroka ULLG Business Type	Kilograms per Business per Day
Hotels/Lodges/Motels	11.1
Fast Food	12.6
Office	0.6
Restaurant	16.9
Wholesale	2.7
Retail Shops	8.3
Av. Across all Business Types	**9.5**

Landfill

Due to the increasing COVID-19 restrictions, heightened security conditions and heavy rainfall during the audit period, it was not recommended to send staff in to conduct full-day audits at the Baruni Landfill. As an alternative TWM requested the weighbridge data from NCDC to enable an analysis of the incoming waste to calculate a per capita rate for disposal able to be measured against data collected from household and commercial audits. Unfortunately, the data was not forthcoming, and the study was unable to complete this activity.

Originally established in the 1980s as an unlined dumpsite, the Baruni landfill, located in the northwest of Port Moresby now covers an area of approximately nine hectares. The facility is owned by the NCDC and operated by a private contractor servicing Port Moresby and the surrounding area.

The site commenced rehabilitation and improvement works as part of the J-PRISM project in 2014. Two-lined cells inclusive of a leachate collection and reticulation system were constructed for operation as a semi aerobic facility. It is understood the first cell was commissioned in June 2015 (JICA, 2016) and the second cell is rapidly filling.

It seems the Baruni landfill has a limited lifespan and is dependent on the procurement of adjacent land for the expansion and construction of new cells. The topography of the adjacent nine-hectare block that is owned by NCDC is problematic and likely to only achieve around 60% additional footprint for expansion. Predictions in 2016 were for a 4 to 5-year life with improvements made in the current footprint and a possible ten-year extension with the construction of a new cell over three adjacent blocks of land. To address this issue, NCDC plans to strategically focus on waste reduction technologies (material recovery facility and composting plant) and incineration plants to reduce the volume of waste entering the landfill for disposal.

The site receives approximately 200 tonnes per day of which approximately 1 tonne of materials per day comprising aluminium cans, metals, plastic bottles glass bottles and food waste is recovered by approximately 60-70 waste pickers. (*Waste Management Plan 2016-2025, NCDC*).

It is understood the Baruni landfill operates under a Level 2 environmental permit which excludes the disposal of hazardous wastes.

Cost estimates for NCDC Solid Waste Management operations indicate annual landfill opex costs in the vicinity of PGK1,080,000 in 2021 rising to PGK1,575,000 in 2025. A landfill disposal rate of K35 per tonne is estimated to recoup K930,581 from independent commercial operators accessing the site based on usage of 40% of landfill space. The remainder of the opex costs is drawn from the collection fees charged by NCDC at K17 per household per year (K10,058,667) and K374 per tonne (K6,705,778) per year for commercial premises. (drawn from information provided in the *Waste Management Plan 2016-2025, NCDC*).

Recovered Material Stockpiles

The project sought approval to measure stockpiled recovered materials at several public and privately owned sites. Unfortunately, access to these sites was not received and the project focused instead on assessing the stockpiled materials at the Baruni landfill site and sourcing recovery data from publications and other documents.

Timeframes for generating and clearing the stockpiles were not received and so the information is provided here for contextual purposes only. Additional information provided in **Table 24** below has been sourced through desktop research (referenced).

Table 24: *Recovered Material Stockpile Data*

Assessment Date	Location	Material Type	Estimated m^3 Stockpiled	Destination
25 March 2021	Baruni Landfill	Galvanised roofing iron	20.85	Unknown
25 March 2021	Baruni Landfill	Gas bottles	2.28	Unknown
25 March 2021	Baruni Landfill	Ceramics (tiles)	3.22	Unknown
25 March 2021	Baruni Landfill	Scrap metal	26.71	Unknown
25 March 2021	Baruni Landfill	Vehicle tyres	50.31	Unknown
25 March 2021	Baruni Landfill	Glass	24.13	Unknown
25 March 2021	Baruni Landfill	End of life vehicles	72.09	Unknown
25 March 2021	Baruni Landfill	E-wastes	237.95	Unknown
25 March 2021	Baruni Landfill	End of life vehicles and steel	201.49	Unknown
Waste Management Plan 2016-2025, NCDC	Recycling Company, unnamed	Scrap steel (est 50% sourced from within Port Moresby area)	1,600 – 2,000 tonnes exported per month	Export for recycling
Waste Management Plan 2016-2025, NCDC	Recycling Company, unnamed	Aluminium cans (est 80 tonnes sourced from within Port Moresby area)	300 tonne per month	Export for recycling
TWM PNG Limited February 2021	TWM PNG Limited	Waste oil, non-halogenated solvent, alkalis, acids, e-waste		Export for treatment and repurpose
Request for Tender, February 2021	Company unnamed	E-waste	Approx. 250 Port Moresby 250 Lae	Export for treatment and recycling

Customs Data

The PNG Customs Service provided comprehensive commodity data to the study based on a series of the international Harmonised Commodity (HS) Codes aligned to the waste product categories in the *PRIF Methodology, 201.* Based on the HS codes, the import-export entries for the 2020 year were collated and provided to the study through the National Focal Point. The study has prepared the import and export material flow chart shown in **Figure 10** below using the data received from the Customs Service.

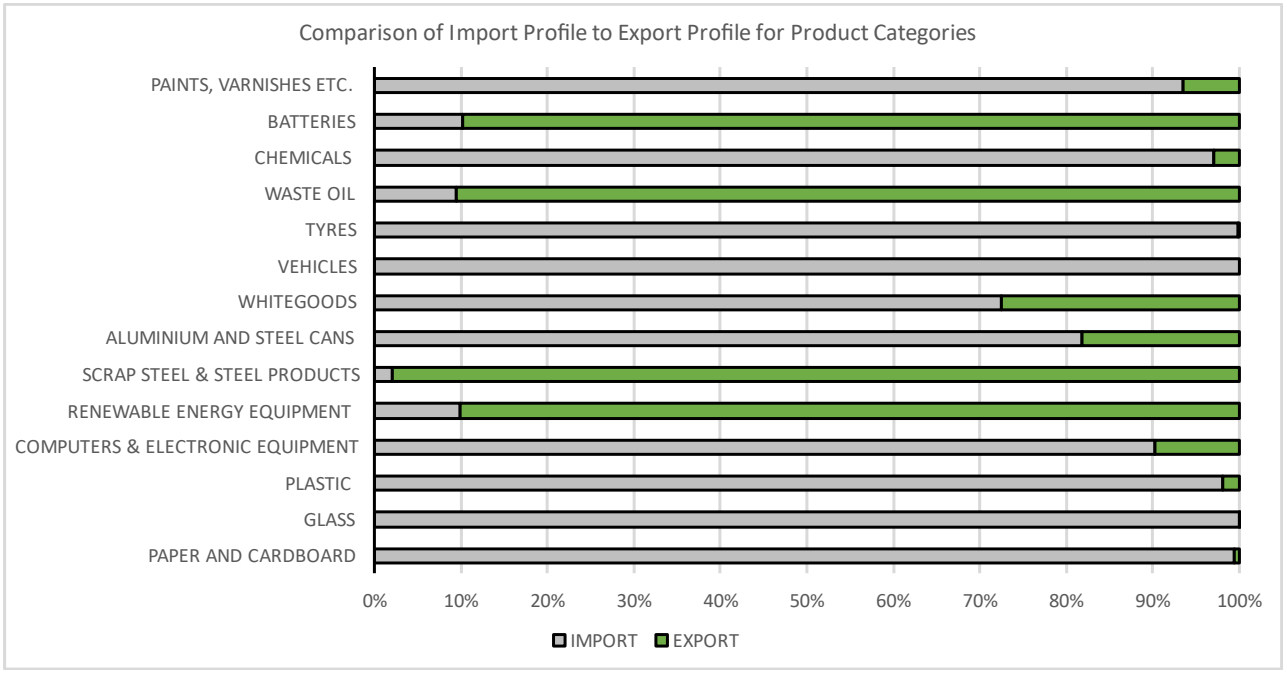
For each product category, **Figure 10** below shows how many times greater the fraction of total imports is to the total exports for the same category.

All product categories, except for scrap steel and steel products are represented in much greater total quantities (the sum of reported weights and units) in imports than exports. Except for scrap steel and steel products, renewable energy equipment, waste oil and batteries, all product categories were present more strongly (in proportional terms) in imports than in exports.

The data is interesting in that it provides a single vision of the extent of the incoming commodities against the outgoing. However, marrying the import commodities to those of a corresponding waste product export can be somewhat of an opaque process as it relies on the correct usage of the HS codes in the shipping and customs declarations. As there is not always a 'scrap' or 'waste' category an HS code may be selected based on duties applied and therefore the data output may not be consistent or reliable.

The data for imports/exports and stockpiled recovered waste materials can be measured against one another to provide a picture of resource recovery (i.e., of incoming products that form waste products over time), however, the process cannot provide a true measure unless a life expectancy is applied to the import product category and sound records are kept of the stockpiling commencement and clearance dates. Unfortunately, these were not known at the time of the study.

Figure 10: Import-export material flow



Notes:

- *Where a bar is mostly grey, with very little green, this indicates that the product category made up a much greater fraction of the total imports (of all product categories) than it did for the total exports of the same categories*
- *Where a bar is a mostly green and very little grey, the opposite is the case*

Conclusion and Recommendations

The findings from this study provide a snapshot of waste generation and waste stream composition in a range of location types in PNG. This was made possible by the data from this project combined with the data provided by local and national government stakeholders from audits conducted externally to this project.

The consolidated data shows a waste stream that is unsurprisingly weighted by organics, with a significant representation of packaging wastes that are predominantly plastics. The study has further reported a granular set of estimations on the presence of the plastic polymer types found in the waste streams which can be used to model future container stewardship schemes and collection systems. The findings on the per capita rates between income regimes and audit locations are provided in the pie charts and the body of the report.

The study, however, is unable to provide the same level of detail for hazardous wastes due to a very limited presence of these materials in the waste stream. Historical audits were similar in their low recording of hazardous waste, and this may be due to limited usage of these materials in the community but may also be influenced by the prior consent approach to auditing. That said, the larger representation of plastics across the household and business waste streams in combination with limited collection services and the continuing propensity for burning and open dumping should be of significant concern. Particularly considering recent amendments to the Basel Convention (an international agreement for the control of hazardous wastes and their disposal) to which PNG is a signatory and which include:

- A3210 which clarifies plastic wastes presumed to be hazardous, and
- B3011 clarifies plastic polymer wastes that are presumed not to be hazardous dependent on their recycling treatments.

Waste collections are limited to urban areas and potentially limited further by the ability of residents to pay local government fees for these services. There was a marked difference in the willingness to pay between those residents with access services and those that do not. The residents in the rural sample articulated a greater awareness of the potential impacts to health and the environment from inappropriate waste disposal and a stronger willingness to pay for improved systems.

The findings from this study generally speak to a seriously under-resourced waste management sector in PNG. An immediate capacity needs assessment would greatly benefit future planning at a national and regional level in the form of an infrastructure development plan.

There are significant challenges in managing the wastes of a growing population. The application of producer and user responsibilities implemented through financial mechanisms at all government levels (e.g., levies, import tax, service fee) will underpin urgently needed improvements required to manage wastes in an equitable, safe, and sustainable manner.

These initiatives will also create investment certainty for the private sector to build infrastructure and deliver waste services that are efficient, compliant, and able to be sustained over the longer term on a commercial basis.

The continuing development of legislation for waste management must be accompanied by adequate levels of resourcing to the regulator to enable compliance monitoring and the consistent enforcement of environmental protection laws.

A technical steering committee recently established to guide the development of PNG's first national waste management policy is representative of both public and private sectors. As will be the proposed Waste Management and Recyclers Association of PNG; such initiatives may well form the foundations for greater collaboration on much-needed improvements to waste management in PNG in the future.

The consolidated data from this study may be further modelled to create a national data set by applying the waste generation and composition findings to a concordance of municipalities throughout PNG using population data from the national census. Further modelling will provide a reasonable basis on which to determine the availability of recoverable and recyclable materials for stewardship programs and to map future service and infrastructure needs.

This study further recommends comparison audits continue to be conducted in future according to a standardised manner that applies the *PRIF Methodology, 2019*

Appendices

Appendix A: Audit material categories

Primary Category	Secondary Category	Description
Metal	Aluminum cans (NCDC category 12 Aluminum Cans)	**Alcoholic sodas and spirit-based mixers, beer and soft drink, Food cans, pet food cans, aerosols, industrial cans**
	Aluminum recyclable	**Steel Packaging**
	Steel containers	**Alcoholic sodas and spirit-based mixers, beer, soft drink, Food cans, pet food cans, aerosols, industrial cans, clean/empty paint cans**
	Metal other (NCDC category 12 Other Metals)	**100% ferrous items that are not cans/tins/packaging materials, any other steel, Beer bottle tops, jar lids, composite ferrous items for which the weight of the ferrous metal is estimated to be greater than the other material items, Foils 100% aluminum items that are not cans/tins/or packaging materials, any other aluminum**
Fishing	Fishing/seafood metal	
	Fishing/seafood plastic	
	Fishing/seafood wood	
Paper and Cardboard	Cardboard NCDC category 5 Cardboard	**Cardboard without corrugation (glossy and non-glossy), cereal boxes, business cards,**
	LPB (NCDC category 6 Tetra Pack)	**Soymilk cartons, some fruit juice cartons, UHT/long-life milk**
	Composite	**Composite paper items for which the weight of the paper is estimated to be greater than the weight of the other materials**
	Paper (NCDC category 7 Other Papers)	**Office paper, writing pads, letters, envelopes, books, Newspapers, newspaper like pamphlets, paper, magazines, brochures, wrapping paper, labels, paper packaging (no plastic or wax coating)**
Plastic	PET containers (NCDC category 9 PETT bottles)	**(Polyethylene) – soft drink, flavored water, fruit juice, sports drinks, plain water (carbonated/non-carb), Food containers, mouthwash containers, detergent bottles**
	HDPE containers	**(High-density polyethylene) milk and flavored milk bottles Bleach bottles, oil containers, food containers**
	LDPE containers	**(Low-density polyethylene) squeeze bottles**
	PVC containers	**(Polyvinyl chloride) clear cordial and juice bottles, Detergent bottles**
	PP	**Bottles and containers**
	EPS	**Yoghurt and dairy containers, vending cups, clam shells**
	PS	**Meat and poultry trays, vending cups, fragile-item packaging**
	PP	**Bottles and containers**
	Flexibles/Film	**No shopping bags, just chip packets and other MLM packaging**
	Other plastic (NCDC category 10 Other Plastics)	
Single use plastic	Beverage containers	**the total count from the beverage container sort**
	Cigarette Butts	
	Cigarette Packets	
	Straws	
	Coffee Cups	

Primary Category	Secondary Category	Description
	Bags - heavy glossy typically	
	Branded carry bags	
	Bags - supermarket type light weight carry bags	
	Takeaway containers	
	plastic other than EPS	
	Takeaway containers	
	Styrofoam	
	Takeaway containers	
	Takeaway container lids	
	Bottle lids	
Battery	Non-rechargeable battery	**Common batteries, AAA, AA etc. single use**
	Rechargeable battery	**Common batteries (rechargeable), AAA, AA etc. rechargeable**
	Lead acid batteries	**Large batteries used in vehicles or other machinery**
	Mobile battery	**Batteries used in mobile phones**
	Power tool battery	**Batteries used in power tools**
	Lithium battery	**Small lithium batteries**
	Lithium-ion battery	**Batteries used in electric cars**
	Other battery	**All other battery types**
E-Waste	Computer Equipment	**Keyboard, monitor, hard drives, printers, etc.**
	TVs	**TVs**
	Mobile Phones	**Mobile phones, phones, pads, charges, car kits, Bluetooth**
	Electrical Items & Peripherals	**Radio, iPod, Gameboys, stereos, speakers, VCR, DVD players, power tools, wiring and cables, small electrical items (toaster, blender, etc.), computer discs, cassettes, DVDs, CDs**
	Toner Cartridges	**Printer and toner cartridges**
Glass	Glass bottles NCDC category 14 Glass ex.	**Recyclable (all colors) – beer bottles, wine bottles, spirit cider/fruit-based, flavored water, fruit juice, sports drinks, plain water**
	Glass Jars	**Non-beverage containers (all colors) – sauce bottles, jam jars, vegetable oils, other food containers**
	Glass fines	**Mixed glass or glass fines < 4.75 mm**
	Glass other	**Plate glass (window and windscreen), Pyrex, mirror glass, Corning ware, light globes, laboratory and medical glass, white opaque glass (e.g. Malibu alcohol bottles)**
Hygiene	Feminine hygiene	**Used disposable feminine hygiene products**
	Pharmaceutical	
	Nappies	**Used disposable nappies/diapers**
	Medical waste	**Sharps, human tissue, bulk bodily fluids and blood, any blood-stained disposable material or equipment**
	Other sanitary waste	
Organic s	Food NCDC Category 1 vegetables/putrescible	**Vegetable/fruit/ meat scraps**
	Wood/timber	

Primary Category	Secondary Category	Description
	Garden organics	**Grass clippings, tree trimmings/pruning, flowers, tree wood (< 20mm diam)**
	Other organics	**Animal excrement, mixed compostable items, cellophane, kitty litter**
	NCDC category 2 bones	**Bones**
	NCDC category 3 Betelnut/buai	**Betelnut/buai**
Hazardous	Paint	**Containers containing paint (dry or wet)**
	Fluorescent Tubes	**Fluorescent tubes; compact fluorescent lamps (CFLs)**
	Household Chemicals	**Containers containing bleach, cleaning products, unused medical pills**
	Asbestos	**Asbestos and asbestos containing products or building materials**
	Clinical (medical)	**Sharps, human tissue, bulk bodily fluids and blood, any blood-stained disposable material or equipment**
	Gas Bottles	**Gas bottles**
	Mercury	**Mercury used in medical applications**
	Hazardous Other NCDC category 15 hazardous	**Any other hazardous material**
Other	Textiles NCDC category 8 textiles	**Wool, cotton and natural fibre materials**
	White goods	
	Ceramics NCDC category 14 ceramic exc. glass	
	Containerised used oil	
	EOL renewable energy equip	**Includes EOL solar panels**
	End of life Vehicles	
	Tyres	
	NCDC category 16 miscellaneous	


EUROPEAN UNION


SPREP
Secretariat of the Pacific Regional
Environment Programme


PacWastePlus
PACIFIC WASTE MANAGEMENT