Samoa Waste Audit Report

Tonga Waste Characterization and Situation Analysis Report

Analysis of Waste Generation and Disposal Data and a Review of the Current Waste Management Systems in Tonga

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WORLD BANK GROUP

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Executive summary

Waste is a global issue and is increasingly recognized as a major challenge for world communities. Proper waste management is essential for thriving societies, livable cities, and robust economies. In addition to the ongoing waste management issues of mainland countries, Pacific Island countries (PICs) are faced with a unique set of challenges – such as geographic isolation, vulnerability to climate change, high cost of transporting waste, limited availability of suitable land, and a small consumer base.

In 2018, the Pacific Region Infrastructure Facility (PRIF)[1] researched the benefits and challenges of establishing a regional recycling network[2] as Pacific Island Countries (PICs) move from a linear to a circular economy. Opportunities to improve social, environmental, and economic outcomes were identified. However, the absence of reliable data was a key constraint to both the design phase and to attracting public–private partnerships. As a result, a Pacific-wide auditing program is being funded by a range of agencies including the United Nations Environment Programme (UNEP), and the South Pacific Regional Environment Programme (SPREP) (through the EU-funded PacWaste Plus Programme), with support from the Australian-funded Pacific Ocean Litter Project and the Pacific Regional Infrastructure Facility (PRIF). The aim of the series of waste audits is to gather data that is robust, reliable, current, and comparable across the region. The information and data gathered will be used by Pacific countries as a baseline to support the future development and monitoring of waste and resource-recovery projects, and to assist in the design and development of the required infrastructure and policy interventions. The regional dataset will also be used to identify and evaluate potential projects that would improve waste management in the region.

As part of this Pacific-wide activity, The World Bank has been involved in waste data collection in Samoa, Kiribati, and Tonga. Asia Pacific Waste Consultants (APWC) was engaged to undertake this activity in 2020–2021. This technical report presents the results of the data-gathering exercise in Tonga and is one of three reports.

The report presents the findings of the study and includes:

- An overview of the Tonga waste sector
- Regulations, strategies, and agreements
- Results of the 2021 waste audit
- Estimates of the quantities and composition of waste generated across Tonga
- Current resource recovery

1 https://theprif.org/what-we-do

2 https://www.sprep.org/attachments/Publications/Presentation/cprt-2018/resource-recycle-pacific-prif.pdf

- Institutional arrangements, private-sector engagement, and available infrastructure for both waste management and recycling.

The work was conducted in March–April 2021 after the COVID-19 pandemic led to the closing of the Tonga's borders. This technical report completes Phase 1 of a three-phase process. Phase 2 comprises of an Institutional Capacity Assessment and Phase 3 comprises a Feasibility Assessment of Establishing a Recycling Hub.

It is anticipated the findings will provide the basis for future policy work, feasibility studies, and other waste management treatment options in Tonga.

Key findings

- Approximately 18,553 tonnes of waste are generated annually in Tonga
- Organic matter is the most abundant material in the waste stream
- Plastics pose a major problem to waste management and are generally not separated, stockpiled, or recycled
- Waste disposal rates are higher in Tonga compared to other PICs
- There are four designated disposal sites and three of these will reach capacity by 2028 if not action is taken to reduce input
- There is a need to develop a national waste policy and strategy
- Tonga has the potential to contribute recyclable material to future recycling activities at a regional level.

Summary of audit activities

- 207 household samples collected and sorted
- 49 commercial samples collected and sorted
- Eight local government staff trained
- Data collected from three islands – Tongatapu, Vava'u, and Ha'apai
- Landfill audit completed over the course of 14 days at Tapuhia Landfill and 7 days at Kalaka Landfill
- Data collected for:
  - › household and commercial waste
  - › stockpiles
  - › recyclers
  - › producers.

Waste generation rates	• Overall waste disposal rate in Tonga is 0.51 kg/person/day, higher than other PICs in the region. This is represented by households at 0.25 kg/person /day; commercial and institutional premises at 0.63 kg/person/day • Households generate 0.27 kg/person/day at Tongatapu and households in outer islands of Ha'apai and Va'vau generate 0.185 kg/person/day.
Stockpiles	• Stockpiles were audited on all islands • Stockpiled materials include tires, cars, PET bottles, aluminum cans, heavy machinery, and white goods • Stockpiles include known illegal dumps and materials stockpiled in recycler yards for potential recycling.
Materials of interest – generation	• Almost 18,553 tonnes of waste is disposed of by households in Tonga of which 3,048 tonnes or 17 percent is made up of plastics • Organics are the most abundant material in the waste stream at almost 40 percent. This is regardless of the fact that only 20 percent of the households audited reported placing their organic matter out for collection. Composting and burning of organics is widespread • Hygiene items represent 11 percent of the waste stream and paper and cardboard make up 21 percent • Interestingly, 3.5 percent of all waste is single-use plastic bags indicating that the import levy on bags is not having the desired effect on lowering their use and disposal in Tonga.
Landfill life	• The landfill capacity and current fill rates at Tapuhia, Kalaka, and Ha'apai landfills was estimated based on audit results • At the current rate, with no recovery measures in place, the estimated lifespan is: Tapuhia until 2026, Kalaka until 2028, and Haápai until 2023. A number of recovery measures can extend the lifespan of all landfills.

Challenges for Tonga

- Lack of qualified, experienced, and trained personnel in all waste management aspects
- Limited recycling opportunities for most waste (e.g. plastics, papers, cardboards)
- Limited capacity of the private sector to support waste management technology
- High cost of equipment and facilities maintenance
- Expensive shipping costs to overseas recycling markets
- Geographic distribution of the population
- Absence of mechanism to promote appropriate waste management practices (e.g. CDL)
- Limited land for developement of waste management infrastructure
- Absence of national direction for waste management
- Lack of appropriate infrastructure and facilities
- Lack of funds to provide efficient and effective collection, disposal, and recycling serivces.

Potential future interventions

- A number of measures are proposed to increase resource recovery and improve landfill life. These measures include:
  - › A CDL on beverage containers
  - › Advance recovery fee (ARF) system for tyres, white goods, ELVs and e-waste
  - › Recovery of organics, cardboard, and paper
  - › Ban on plastic bags with appropriate alternatives and intervention for nappies (diapers).

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List of acronyms

ADB	Asian Development Bank
APWC	Asia Pacific Waste Consultants
CDL	Container deposit levy
CDS	Container deposit scheme
DFAT	Australian Department of Foreign Affairs and Trade
E-waste	Electronic waste
FAO	Food and Agriculture Organization of the United Nations
EDF 11	European Development Fund
EEZ	Exclusive economic zones
EIB	European Investment Bank
ELV	End-of-life vehicles
EU	European Union
GEF	Global Environment Facility
HDPE	High-density polyethylene
IFC	International Finance Corporation
JICA	Japan International Cooperation Agency
J-PRISM	Japanese Technical Cooperation Project for Promotion of Regional Initiative on Solid Waste Management
LDPE	Low-density polyethylene
LPB	Liquid paperboard
MEIDECC	Ministry of Meteorology, Energy, Information, Disaster Management, Climate Change and Communications
MSW	Municipal solid waste
MSWM	Municipal solid waste management
NZMFAT	New Zealand Ministry of Foreign Affairs and Trade
OEC	Observatory of Economic Complexity
PET	Polyethylene terephthalate
PICs	Pacific Island Countries
PLCO	Pacific Liaison Coordination Office
POPs	Persistent organic pollutants

PP	Polypropylene
PPE	Personal protective equipment
PRIF	Pacific Region Infrastructure Facility
PS	Polystyrene
PVC	Polyvinyl chloride
SIDs	Small island developing states
SPREP	South Pacific Regional Environment Programme
SWM	Solid waste management
UN	United Nations
UNEP	United Nations Environmental Programme
US	The United States of America

1. Introduction

1.1 Pacific waste management challenges

Waste is a global issue and is increasingly recognized as a major challenge for world communities. Proper waste management is essential for thriving societies, livable cities, and robust economies.

In addition to the ongoing waste management issues of mainland countries, Pacific Island countries (PICs) are faced with a unique set of challenges. PICs are extremely vulnerable to the impacts of climate change and severe weather events, which generate shock loads to normal waste levels. PICs have particularly challenging circumstances relevant to solid waste management and recycling networks, including:

- High costs of transporting waste to processing and disposal facilities from geographically isolated areas such as islands, including the high cost of skilled labor
- Limited availability of suitable land for the construction of waste management infrastructure
- High costs of servicing small and largely dispersed populations
- An inability to achieve critical mass (for efficiency and economic viability) due to a relatively small consumer base
- Relative financial disadvantage, where eight of the 15 countries studied are in the lower to middle Gross National Income (GNI) bracket.

PICs are also particularly vulnerable to the impacts of marine pollution as their economies, tourism, and way of life are intrinsically linked with the health of the ocean. Addressing land-based and marine-based sources of pollution is therefore an ecological, social, and economic priority.

Globalization has had a substantial impact on the amount and diversity of waste generated within PICs, fueled by increasing affluence and consumer-based lifestyles. Many PICs have become heavily reliant on international development assistance and imported goods such as electronics, white goods, and vehicles, and these goods require safe end-of-life disposal. Additionally, PICs import a significant proportion of their food, such as pasta, poultry, and tinned food, which requires single-use packaging for transport. These imports are pricing locally produced, healthier foods out of the market and have a detrimental effect on the health of islanders (FAO, 2014).

To combat the rising tide of waste in island communities, it is clear that recycling needs to play a key role. However, after recyclable materials are successfully reclaimed from the waste stream, several factors combine to make shipping services to and from PICs relatively expensive, including long distances between ports, lack of available shipping routes, and low trade volumes – all of which make it difficult to take advantage of economies of scale. The economic viability of shipping small quantities of low-value commodities over long distances is perhaps the greatest challenge, with marine transportation costs accounting for as much as 30 percent of the commodity market value. Often extreme trade imbalances exist, with exports far outweighed by imports (SPREP, 2016), leading to costly container repositioning (Asian Development Bank, 2007). In addition, poor segregation, especially in outer island communities, and an absence of local demand for local recyclable goods, have resulted in a lack of available markets for recyclables across the Pacific.

Although solid waste management, and specifically recycling and material recovery, often requires higher government expenditures and greater revenue collection from waste producers, the health and environmental costs of not collecting waste are many times higher than the cost of developing and operating simple, adequate waste management systems (Kaza et al., 2018). In one study looking only at the impacts of marine litter on marine industries, it was found that there is a minimum of US$1.4 billion of economic costs annually in the Asia-Pacific region alone with losses to tourism, entangled ship propellers, and time lost for fishing (McIlgorm et al., 2011). Therefore, there is a strong motivation to explore the development of recycling systems for PICs.

1.2 Project background and objectives

Pacific Region Infrastructure Facility (PRIF)[3] is a multi-agency coordination mechanism aimed at improving the delivery of development assistance from donors and development partners to the infrastructure sector in the Pacific region.[4] As part of its technical assistance activities, PRIF has been investigating the benefits, challenges, and feasibility of establishing a regional waste management and recycling network for the Pacific. It is expected that such an initiative would reduce the risk of plastic and toxic pollution from solid waste, which would lead to health improvements of PIC populations and have benefits for the economy.

A regional waste management and recycling network would also provide numerous opportunities for public–private partnerships. The recycling network assessment, when done, will assess the efficiencies of treating waste through a

[3] PRIF supports infrastructure development and maintenance in PICs through coordination and technical assistance. The PRIF Coordination Office (PRIF CO) is hosted by the ADB Pacific Liaison Coordination Office (PLCO) in Sydney, Australia. It follows procurement procedures and financial management in accordance with ADB practices.

[4] Current PRIF partners are Asian Development Bank (ADB), Australian Department of Foreign Affairs and Trade (DFAT), European Investment Bank (EIB), European Union (EU), the Japan International Cooperation Agency (JICA), New Zealand Ministry of Foreign Affairs and Trade (NZMFAT), United States Department of State (US), and The World Bank Group.

regional-level intervention to increase economies of scale that could attract private sector investment and generate local employment.

An initial investigation conducted by PRIF identified several benefits of a regional waste management and recycling network in addition to existing regulatory constraints of each PIC. This study informed the publication of Pacific country profiles regarding solid waste management and recycling.[5] A shared methodology was developed as a model for future common audits and data collection with PICs and regional partners such as PacWaste, UNEP, JPRISM, SPREP, and PRIF partners.

The waste audits using this methodology will provide crucial and important data to scope a tailored regional recycling network and other national and regional recycling initiatives based on actual quantities of recycling material available in the region.

A series of comprehensive waste audits is being funded by UNEP, SPREP (through PacWaste), PRIF, and The World Bank. The scope of the audits is as follows:

- Audits were undertaken on household waste, commercial waste, and landfill
- A systems gap analysis was undertaken to understand the current status of waste management in Tonga, including the institutional arrangements, private sector involvement, and infrastructure available to effectively manage waste and recycling outcomes, as well as participate in regional recycling activities.

As part of this collaboration, PRIF commissioned waste audits in Cook Islands, Fiji, and Tuvalu. PacWaste Plus commissioned audits in Nauru, Niue, Vanuatu, Solomon Islands, PNG, Timor Leste; UNEP commissioned audits in Palau; and The World Bank commissioned APWC to undertake audits in Kiribati, Samoa, and Tonga. This technical report presents the outcomes of the audit conducted by APWC consultants in Tonga from March to April 2021. It is anticipated the findings will provide the basis for further work on waste management policy, feasibility of recycling opportunities, and other waste management treatment options in Tonga and the wider Pacific region. See Appendix J for 'Key assumptions and limitations of the study'.

5 https://www.theprif.org/sites/default/files/documents/prif_waste_book_web_0.pdf

2. Overview of Tonga

Tonga (officially the Kingdom of Tonga) is a Polynesian country spread across 360,000 km^2 of the southwestern Pacific Ocean. It consists of 171 islands, approximately 40 of which are permanently inhabited (TSD, 2019). There are five administrative island divisions: Tongatapu (population 74,611), Vava'u (13,738), Ha'apai (6,125), 'Eua (4,945), and Ongo Niua (1,232) (TSD, 2019).

Table 1: Tonga overview

Feature	Description
Official name	Kingdom of Tonga
Total land area	749 km^2 (419 km of coastline)
Capital	Nuku'alofa
Neighboring countries	Fiji, Vanuatu, and Tuvalu
Climate	Semi-tropical
Population	100,651 (2016)
Language(s)	Tongan, English
Ethnicity	Tongan (97%), part-Tongan (1%), foreign (2% – Chinese, European, other Asian)
Government	Constitutional monarchy
Currency	pa'anga (TOP)
GDP	US$493 million
HDI	0.725
Exports	Other vegetables, non-fillet fresh fish, processed fruit and nuts, antiques, coral, and shells
Signed international agreements	Hazardous Wastes, Law of the Sea, Ship Pollution, Ozone Layer Protection, Biodiversity, Climate Change, Wetlands

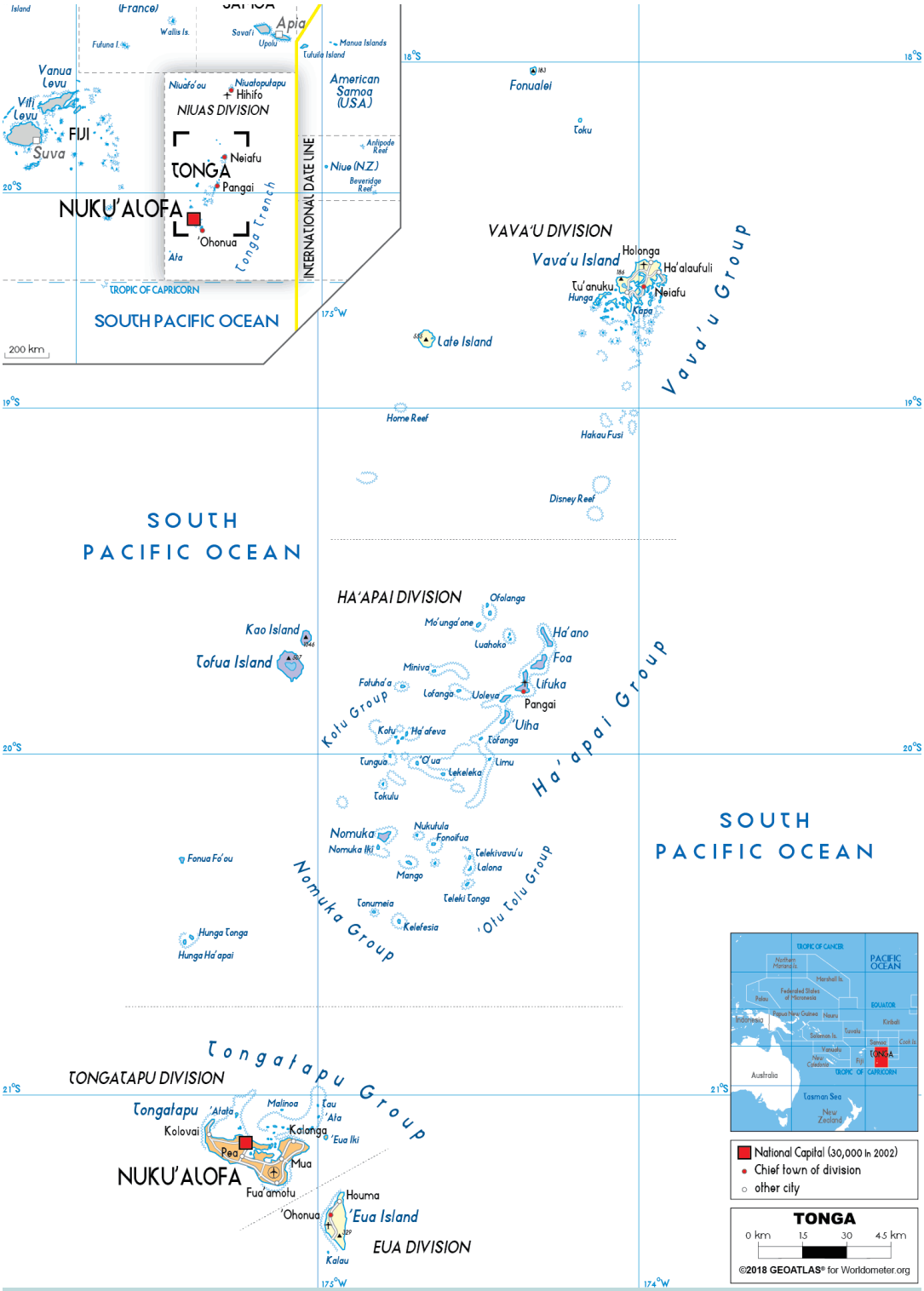

Figure 1:
Map of Tonga[6]

6 https://www.worldometers.info/maps/tonga-political-map/

2.1 Socioeconomics

A little over a quarter of land in Tonga (27.8 percent) is arable (Knoema, 2021), with 77 percent of the population living in rural areas (TSD, 2019). The urban population is concentrated in Nuku'alofa, Tonga's capital, situated on the main island Tongatapu. The urban–rural ratio has remained stable since 2006 and does not follow the increased urban population witnessed in other PICs in recent years. Tongan society has strong cultural traditions and customary laws. These provide a solid foundation for Tongan families and their close-knit communities, and play an important role in wealth distribution (FAO & SPC, 2019). There are 18,003 households in Tonga with an average of 5.5 people per household (TSD, 2019).

The main industries supporting Tonga's economy are agriculture, manufacturing, forestry, and fishing (TSD, 2019), employing 41 percent of workers. The main source of household income is wages and salaries (46 percent), followed by trade of fish, crops, and handicrafts (20 percent). All land belongs to the Tongan monarchy and nobles (Britannica, 2021). The land is parceled and, in line with tradition, given to peasant proprietors (males aged 16 and over), who receive an allotment of three hectares for cultivation. As the population grows, the size of these allotments is decreasing.

2.1.1 Imports and exports

In 2019, Tonga imported US$43.5 million in goods and exported only US$3.06 million, giving a negative trade balance of US$40.44 million (OEC, 2019). The main imports into Tonga include refined petroleum (21.1 percent), poultry meat (5.3 percent), sheep and goat meat (2 percent), broadcasting equipment (1.9 percent), and cars (1.8 percent).[7]

7 Cars imported into Tonga from Fiji (28.6 percent), New Zealand (23.1 percent), China (14.3 percent), United States (7.9 percent) and Japan (6.1 percent).

3. Tongan institutional framework

3.1 National government

The Kingdom of Tonga is a constitutional monarchy (Vaea, 2019; PACLII, 2021). The monarch and heir adhere to the Constitution (1875), which is built on history, strong culture, heritage, and the ocean. Tonga became a protected state under a Friendship Treaty with Britain in 1900 and gained its independence on 4 June 1970.

The national government consists of three main institutions: the Executive (the government), Legislative Assembly (Fale Alea, a parliament of 26 seats), and a court system which includes the High Court (the judiciary) (Vaea, 2019). An elected prime minister leads the Executive, an elected noble is the Speaker of the Assembly, and the Chief Justice is the head of the High Court. The Monarch appoints a Privy Council, which consists of the Monarch and the Cabinet (Britannica, 2021). The Privy Council is formally a body of advisers to the King. It is an important link between the executive powers of ministers and the constitutional authority of the sovereign.

Local government is provided by three island councils: Tongatapu (covering Tongatapu, 'Eua, and the Niuas), the Ha'apai Group, and the Vava'u Group (Britannica, 2021; PACLII, 2021). Although there are no constitutional provisions for local governments, the *Fono Act 1988* and the *District and Town Officers Act 1988* provide the legislative texts. There are 23 district officers and 156 town officers elected by popular vote every three years. They report directly to the prime minister's office – or the Governor's office in the case of Ha'apai and Vava'u divisions. The town officers are empowered to call community meetings to discuss matters of priority, and special meetings where the Minister of Internal Affairs or other government officials may address the people on any government issues, including waste management. The town officers support the district officers in public health, agriculture, and license compliance inspections, recording births and deaths, as well as waste management activities. Town officers, as chairpersons or members of most village committees, are in the best position to promote waste management initiatives, including support and compliance from the communities on waste management laws.[8]

There are 18 ministries in Tonga. The Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECCC); the Ministry of Health; and the government public enterprise Waste Authority Limited (WAL) are responsible for waste management. WAL was established by the *Waste Management Act 2006* and it is mandated to manage waste in Tongatapu. It reports to the Ministry of Public Enterprises (SPREP, 2019).

[8] For more information, see www.clgf.org.uk/default/assets/File/Country_profiles/Tonga.pdf

3.2 International agreements

Tonga has ratified numerous environment-related international and regional commitments and remains in general compliance with the spirit of such commitments.

Table 2: Multilateral agreements (MEAs) and conventions ratified by Tonga

Multilateral agreements and conventions (MEAs)	Status
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (in effect)	21 Jan 2010
Stockholm Convention on Persistent Organic Pollutants	26 Oct 2004
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	22 Jun 2010
UN Convention on the Law of the Sea	2 Aug 1995
London Convention 72 ('Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter')	8 Dec 1995
MARPOL 73/78: International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (Annexes I, II, III, IV, V, and VI)	1 May 1996
International Convention on Civil Liability for Oil Pollution Damage 1969 (CLC 92)	1 May 1996
International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND 92)	1 May 1996
International Convention on Oil Pollution, Preparedness, Response and Co-operation (OPRC 90)	1 May 1996
International Convention for The Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances By Sea Convention (HNS 1996)	18 Sept 2003
International Convention on Civil Liability for Bunker Oil Pollution Damage (BUNKER 2001)	30 Sept 2003
Montreal Protocol	29 Jul 1998
Vienna Convention for the Protection of the Ozone Layer	29 Jul 1998
Paris Agreement on Climate Change	21 Sept 2016
The Kyoto Protocol to the United Nations Framework Convention Climate Change	14 Jan 2008
Minamata Convention	22 Jan 2019
Small Island Developing States Accelerated Modalities of Action (Samoa Pathway)	Unknown
Noumea Convention for the Protection of the Natural Resources and Environment of the South Pacific Region (SPREP) (1986)	
Dumping Protocol	
Emergencies Protocol	
Oil pollution Protocol	
HNSP Protocol	
Waigani Convention to Ban the Importation into Forum Island Countries of Hazardous and Radioactive Waste and to Control the Transboundary Movement and Management of Hazardous Waste within the South Pacific Region 1995	21 Jun 2003

3.3 Regional agreements

Table 3: Regional agreements and memberships

Regional agreements	Status
Pacific Islands Forum (PIF)	Member
Secretariat of the Pacific Regional Programme (SPREP)	Member
Secretariat of the Pacific Community (SPC)	Member
Pacific Region Infrastructure Facility (PRIF)	Member
Cleaner Pacific 2025: Pacific Regional Waste and Pollution Management Strategy 2016–2025	Member
Pacific Islands Development Forum (PIDF)	Member, 4 Sept 2015

3.4 National regulation and strategy

The law-making process in Tonga consists of two steps: a legislative development and drafting process by government; and a law-making process of the Legislative Assembly (AGO, 2019). Prior to the parliamentary process, Cabinet drafts a required piece of legislation to give legal effect to a particular policy initiative.

The most important environmental legislations dealing with waste management are (SPREP, 2019):

- *Waste Management Act Cap 14.06* (as at 2020), including *Waste Management (Plastic Levy) Regulations Cap 14.06.01*, which provides for the development of the waste management sector, with wide-ranging powers and responsibilities for the Waste Authority Limited (WAL).
- *Hazardous Wastes and Chemicals Act Cap 21.05 (as at 2020)*, which provides for the regulation and proper management of hazardous wastes and chemicals in accordance with accepted international practices and the international conventions applying to the use, transboundary movement, and disposal of hazardous substances.
- *Environment Management Act Cap 21.03 (as at 2020),* including Environment Management (Litter and Waste Control) Regulations Cap 21.03.01, which establishes the Ministry of Environment and Climate Change to ensure the protection and proper management of the environment and the promotion of sustainable development.
- *Public Health Act Cap 12.15* (as at 2020), which regulates waste collection and waste containers, as well as disposal of solid and hazardous waste. It prohibits import of toxic and hazardous waste, ensuring recyclers are issued licenses. The provisions of the Act extend to ships.
- *Pesticides Act Cap 12.13* (as at 2020), which proscribes persons from disposing of a pesticide or pesticide container except in accordance with

instructions on a registered label, and as prescribed/directed by the Registrar.

- *Ozone Layer Protection Act Cap 21.07* (as at 2020), which implements Tonga's obligations as a party to the Vienna Convention and Montreal Protocol. Its list of prohibited imports includes pre-polymers used in the manufacture of rigid plastic foams.
- *Marine Pollution Prevention Cap 22.06* (as at 2020), which provides for the prevention of and response to marine pollution and the dumping of wastes and other matters and to give effect to international marine pollution conventions.
- *Ports Management Act Cap 22.08* (as at 2020), which regulates the management of harbors and wharves, including pollution prevention.
- *The Fono Act 1988* makes it mandatory for any adult citizen to attend a *fono*, which is a meeting called within the town. The *fono* is classed as either normal or grand, depending on the level of government officials involved.
- *District and Town Officers Act 1988* provides legal provisions on how district and town officers are to be elected, candidates' qualifications, their responsibilities, and how they are paid.

The *Litter and Waste Control Regulation (2016)* of the *Environment Management Act (2010)* is the most comprehensive piece of legislation addressing littering and pollution, hazardous wastes, waste burning, and other harmful waste-associated activities. The was amended with a plastic bag levy regulation in 2013, according to which a levy of 10 percent of the customs value will be charged for each plastic bag upon importation.

Tonga does not have a comprehensive and integrated waste management strategy to guide overall resource recovery and waste management challenges.

3.5 Stakeholders – Roles and responsibilities

Table 4: Stakeholder roles and responsibilities (Source: SPREP, 2020).

Stakeholder	Responsibility
Government of Tonga	
Ministry of Environment, Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communication (MEIDECC)	Administers the *Environment Management Act 2010*. Environment officers have enforcement powers under the Act (e.g. to issue an infringement notice). Under the *Waste Management Act*, the standards of environmental waste management practices and facilities are prescribed, monitored, and enforced by the Ministry of Environment.
Ministry of Health	Responsible for the administration and implementation of the *Public Health Act*.

Department of Environment	The regulating government agency for waste management. It has a waste management unit directly responsible for all waste-related management issues.
Government Public Enterprise	
Tonga Waste Authority Ltd (WAL)	Established by the *Waste Management Act 2006,* WAL is a government public enterprise mandated to manage waste in Tongatapu. It reports to the Ministry of Public Enterprises. WAL has expanded its operations to Vava'u, Ha'apai, and 'Eua in collaboration with J-PRISM II. Collection and disposal services are now implemented in these islands. WAL is also the designated collection authority for the plastic bag levy, which supports the agency with the financing of waste management services in the above areas, in addition to the monthly waste fees.
Local councils	
Districts and towns	Led by district and town officers to coordinate meetings and promote government developments and activities, including waste management.
Village committees	Although there is no constitutional provision for local governments, Tonga has a form of local government featuring district and town officers elected every three years in local elections, similar to parliamentary elections. Some villages establish village committees. District and town officers are involved in the committees to discuss different developments and issues for the good of the villagers.
Recyclers	
Sustainable Resources Management (SRM)	Recycles scrap metal (non-ferrous and ferrous), lead-acid batteries, and solar battery scrap.
Gio Recycling Company	Previously collected and exported plastics, waste oil, cardboard, and e-waste, but that was put on hold due to the uncertain market situation. Scrap-metal recovery and export operations continue. Stations in both Tongatapu and Vava'u Islands.
Local initiatives	
Tonga Waste Management and Recyclers' Association	Established with support from J-PRISM II. An interim executive, consisting of a president, secretary, and treasurer, has been established. Gio Recycling is the President, while Sustainable Resources Management holds the Secretary position. The association is planning its official launching before the end of the year.
Secondary Schools Recycling Competition	A competition on the Tongatapu island to promote recycling in Tonga, coordinated and organized by the Waste Authority Limited.

Key findings:

- Tonga is a signatory to numerous international and regional environmental agreements, but not the Noumea convention.
- There is currently no integrated waste management strategy to guide overall resource recovery.
- The two most relevant pieces of legislation addressing solid waste management, waste minimisation, and pollution control are the *Waste Management Act* and the *Environment Management Act*. This led to the establishment of the Waste Authority Limited (WAL).
- There is a 10 percent levy on the import of plastic bags.

4. Situation analysis – Waste management

4.1 Waste management services overview

Municipal solid waste management in Tonga effectively began in 2006, with the establishment of Waste Authority Ltd (WAL), a government public enterprise. WAL is the operating agency responsible for waste collection, landfill management, and awareness programs. The Department of Environment, under MEIDECC, is the government regulation agency overseeing operational activities. When WAL commenced operations in 2006, the main focus was the island of Tongatapu. The provision of waste services to the other islands was the responsibility of the Ministry of Health. With improved institutional arrangements and in collaboration with the Asian Development Bank (ADB), Australian Aid (AUSAID), and JICA (through J-PRISM II), WAL's operations were extended to Vava'u in 2018, and Ha'apai and 'Eua in 2020. The remaining islands are the responsibility of the Ministry of Health, with expectations that WAL will take over in the future.

4.1.1 Collection schedule

WAL provides a user-pays collection service for domestic and commercial waste on Tongatapu, Vava'u, Ha'apai, and 'Eua islands. A mixture of rubbish compactors and open dump trucks is used for waste collection from households, businesses, and organizations.

Tongatapu

Household waste is collected once a week with an estimated collection coverage of 97 percent for households and 80 percent for businesses and organizations. Household waste is stored in rubbish bags, sacks, or cardboard boxes, and placed on a raised platform, in a rubbish bin, or taken out of the premises just before collection. Around 130 m^3 of household waste is collected on a daily basis. The amount of commercial waste collected is approximately 20 m^3 per day. Some businesses and households self-haul excess waste to the landfill.

Vava'u

The collection covers about 80 percent of households in 25 villages, with 10 prefectures or subordinates. Households on the 10 small outer islands are not covered, owing to geographical access issues. Household and commercial waste is collected once a week from Monday to Thursday; collection in Neiafu, as the central and administration area, is on Friday. Waste storage at households

and businesses is similar to Tongatapu. Approximately 220 tonnes of household waste are collected per day.

Ha'apai

Household and commercial waste is collected once a week, from Monday to Friday, with public places serviced on Saturdays. Approximately 80 percent of households and 100 percent of commercial premises have a collection. The amount of waste collected from households is 10 tonnes per day and 4 tonnes per day for commercial premises.

'Eua

Collection services cover 889 households from Monday to Friday, while public areas are serviced on Saturdays. The same waste storage systems used in other areas are also used in 'Eua.

Figure 2:
Examples of receptacles placed out for waste collection in Tonga

Figure 3:
Collection compactor and open waste disposal trucks during their operations in Tongatapu

Table 5: Waste collection services in Tonga

Area	Collection coverage (%)	Service provider	Waste covered	Collection receptacle	Fee charged (AUD)	Frequency	Collection vehicle	Destination
Tongatapu	90–100%	WAL	Household	Bags Sacks Bins	$15/month	Once a week	5 x rubbish compactor trucks 2 x open trucks Truck with Hiab lifter	Tapuhia Landfill
			Commercial	Bags 240–300 L bins	Small business/retail - $50/month	Once a week		
					Accommodation (guest house) - $80/month	Once a week		
					Restaurant - $128 / month	Once a week		
					Large business - $200–$800/ month	Daily – twice a week		
					Hospital waste - $390/month	Once a week		
					Bulky waste per pickup service - $100 (2 tonne truck)	When requested		
					- $150 (>2 tonne truck)	When requested		
					Demolition waste - $50/$m^3$	When requested		

Area	Collection coverage (%)	Service provider	Waste covered	Collection receptacle	Fee charged (AUD)	Frequency	Collection vehicle	Destination
Vava'u		WAL	Household	Bags Sacks Bins	$15/month	Once a week	2 x compactor trucks (6m^3). 1 x open dump truck (4m^3)	Kalaka Waste Landfill
			Commercial	Bags 240–300 L bins	Small business/retail - $50/month Accommodation (guest house) - $80/month Restaurant - $128 month Large business - $200–$800/ month Hospital waste - $390/month Bulky waste per pickup service - $100 (2 tonne truck) - $150 (>2 tonne truck) Demolition waste - $50/m^3	Once a week Once a week Once a week Daily – twice a week Once a week When requested When requested When requested		
Ha'apai*		WAL	Household	Same as Vava'u	$15/month	Once a week	1 x rubbish compactor 1 x open dump truck	Faleloa disposal site
			Commercial		Same as Tongatapu and Vava'u	Same as Tongatapu and Vava'u		
'Eua*		WAL	Household	Same as other islands	$15/month	Once a week	2 x open dump trucks	Angaha disposal site
			Commercial		Same as Tongatapu and Vava'u	Same as Tongatapu and Vava'u		

* Currently, collection fees are not enforced in Ha`apai and 'Eua

Figure 4:
Waste collection services in Vava'u

Figure 5:
Waste collection services in outer islands of Vava'u

Figure 6:
Waste collection service in 'Eua

4.1.2 Waste types

Plastics

Plastics are generally not separated, stockpiled, or recycled in Tonga because it is not deemed economically viable. Plastic recycling was attempted under a Global Environment Fund (GEF) small grant community project in Ha'apai, with a pilot CDS involving a 5 cent refund for every returned plastic bottle. The returned bottles were then filled with sand and cemented together to be used as a seawall for coastal protection. The Ministry recognized that this creates the potential for leachate and microplastic pollution, and therefore the project is currently on hold.

Figure 7:
Bottles filled with sand to be used in seawall construction

Green waste

WAL discourages the use of collection services to dispose of green waste to try and reduce the total amount disposed at landfill. However, WAL continues to collect any mixed waste placed out by households for collection containing green waste. WAL provides advice and educational materials through its Facebook page, on managing green waste through composting or mulching practices for home gardens.

Figure 8:
Green waste placed outside for collection along with general mixed waste

Glass

Glass bottles are mostly placed in the household waste collection, as no special collection system is provided. Glass for recycling purposes is considered economically unviable and as a result there are no glass recycling operations in Tonga. In Ha'apai, there is a small glass crusher on the island which is being used to convert a small amount of glass into particles for use as a sand substitute. A national secondary schools' competition coordinated by WAL encouraged inventive options for reusing glass bottles in handicrafts (Figure 9).

Figure 9:
Reuse of glass bottles as handicrafts

Scrap metals and bulky waste

In May 2019, WAL implemented a special government-supported collection initiative for end-of-life vehicles (ELVs), with the aim of improving visual amenity. More than 300 ELVs were collected by WAL during the year-long initiative. The collected ELVs were handed over to the Sustainable Resources Management (SRM) recycling company under an agreement between WAL and SRM. SRM currently stockpiles ELVs. Similar recovered recyclable items are stockpiled at the Tapuhia Waste Landfill, including aluminum cans, used lead-acid batteries (ULAB), and other high-value metals such as stainless steel, copper, and bronze.

Figure 10:
WAL truck collecting ELVs in Tongatapu

Figure 11:
Metal stockpile in Tongatapu

Figure 12:
Aluminum cans collected in Vava'u (left); metal stockpiling at Tapuhia (right).

Healthcare waste

WAL provides general waste collection services to hospitals for US$390 per month. All hospitals in Tongatapu, Vava'u, Ha'apai, and 'Eua have incinerators for healthcare waste, however there is no coordinated national collection for healthcare waste from hospitals and healthcare facilities. Incinerators were provided under the PacWaste project for the Vaiola Hospital in Nuku'alofa for Tongatapu Island. Vava'u, Eua, and Ha'apai islands also received incinerators for their hospitals.

Figure 13:
Vaiola Hospital incinerator facility

E-waste and white goods

There is no organized collection service for e-waste in Tonga. E-waste from households is generally mixed with the general solid waste and is collected under WAL's collection services on all four islands. Large items such as refrigerators, televisions, and computers are transported by householders and businesses to the disposal facilities. Tapuhia Waste Landfill, on the main island of Tongatapu, has a potential stockpile area for recyclables. Gio Recycling collected e-waste in the past, storing material in shipping containers before transporting it overseas. These operations have now ceased.

Waste oil (used lubricating oil)

As one of the importers of oil into Tonga, the Pacific Energy Company has its own arrangements for waste oil recovery from customers. Waste oil is shipped to Fiji as part of its corporate green initiative. This initiative also covers Tuvalu and other countries in the region. Other oil importers do not have waste arrangements with customers and there is little information on collection and storage.

A reuse program for used cooking oil is currently run by commercial food and beverage businesses in Tonga. Businesses either provide staff with used oil for home use or sell the product as part of the reuse program. Anecdotally, approximately 30 percent of used oil is sold and 70 percent of used oil is taken home by staff.

4.2 Waste management infrastructure

Waste management in Tonga is through disposal to landfills on islands with waste management services. Recycling in Tonga is mainly driven by two local family businesses.

4.2.1 Landfills and dumpsites

Tongatapu, Vava'u, Ha'apai, and 'Eua islands have officially designated waste disposal sites. Little information is available about end-of-life disposal of waste on Tonga's other islands.

Table 6: Disposal sites – Available equipment and resources

Item	Tapuhia Landfill, Tongatapu Island	Kalaka Landfill, Vava'u Island	Faleloa Dumpsite, Ha'apai Island	'Eua Island
Area	6 ha	1.6 ha	1.6 ha	TBC
Land ownership	Government	Government	Private	TBC
Facilities type	Complete engineered, aerobic waste landfill with lined system, leachate collection, etc.	Rehabilitated waste landfill with some incorporated engineering components for leachate collection	Open disposal site with some monthly maintenance operations.	Open disposal site with some maintenance operations.
Available facilities	One-stop disposal facilities for solid waste, sewage, bulky waste Leachate collection	Partly leachate collection in place	Nil	Nil
Site office	Yes	Yes	No	No
Separate areas for different waste streams	Yes	Solid waste and sewage	Solid waste and sewage	Solid waste and sewage
Gate and fence	Yes	Gate only	No	No
Maintenance equipment	Waste Landfill Compactor Excavator.	Excavator	Excavator (Hire Basis).	Excavator (Hire basis)
Maintenance frequency by heavy equipment	Daily	Once a week or month	When required	When required
Environmental monitoring	Yes, for leachate	Yes for leachate	No	No
Site supervisor	Yes	Yes	No	No
Onsite supporting staff and workers	Yes	Yes	No	No

Item	Tapuhia Landfill, Tongatapu Island	Kalaka Landfill, Vava'u Island	Faleloa Dumpsite, Ha'apai Island	'Eua Island
Operation schedule	Monday to Saturday Closed on public holidays	Monday to Saturday Closed on public holidays	Monday to Saturday Closed on public holidays	Monday to Saturday Closed on public holidays

Tapuhia is the only sanitary landfill in Tonga. It is situated in Nuku'alofa Tongatapu, surrounded by farmland, and is run by WAL. The landfill area is approximately 6 hectares (200 m x 300 m), consisting of four cells, with 2.5 cells still remaining. Built in 2006, it was designed with a lifespan of 60 years. At the current rate of waste generation, the estimated lifespan is 30 years. It is lined, has leachate control, and daily soil cover.

Figure 14:
Entrance to the Tapuhia Waste Management Facility, Tongatapu

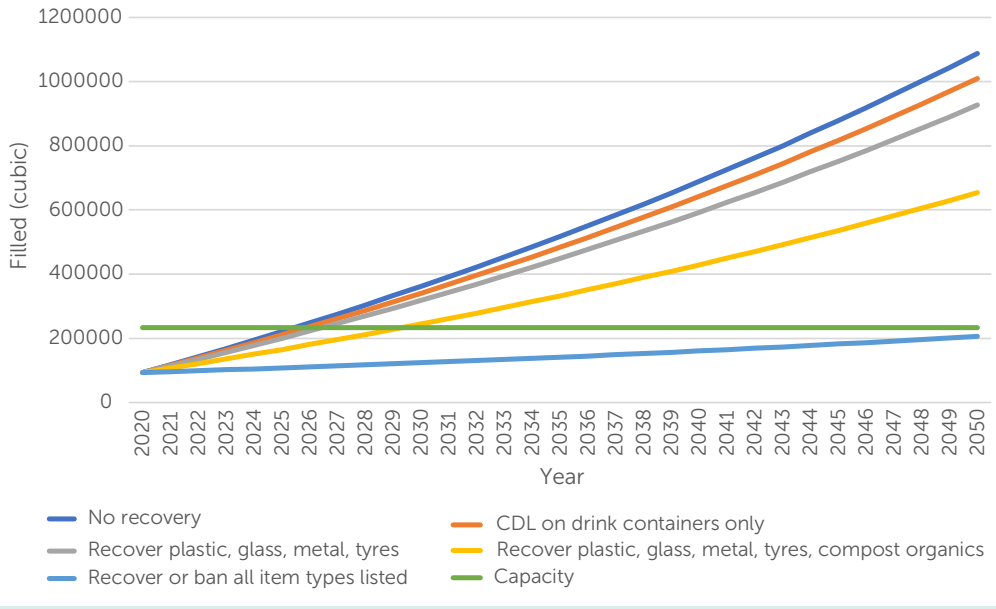

Figure 15:
Tapuhia estimated lifespan

Figure 16:
Tapuhia Waste Management Facility tip face, Tongatapu

The government-owned Kalaka Waste Landfill is the only disposal site in the Vava'u group. The site has reached capacity and should cease operation. Although potential sites have been identified, selection of an alternative is yet to be finalized. It is approximately 4 acres (1.6 hectares) and is situated adjacent to coastal mangroves. Kalaka has a security and gate office, two waste disposal cells, and one septic bed area for sewage. Soil cover is implemented regularly when needed. Burning of any kind at the site is not allowed due to past fire incidences. The site was rehabilitated in 2011 and 2013 by the Government of Japan and responsibility was given to the Ministry of Health until April 2018. During this time, the area was lined using compacted clay, and leachate collection pipes were installed, including a treatment system using coconut husks, coral stones and sand. WAL is not responsible for the maintenance of the site but has carried out some repair works to the installed leachate treatment system.

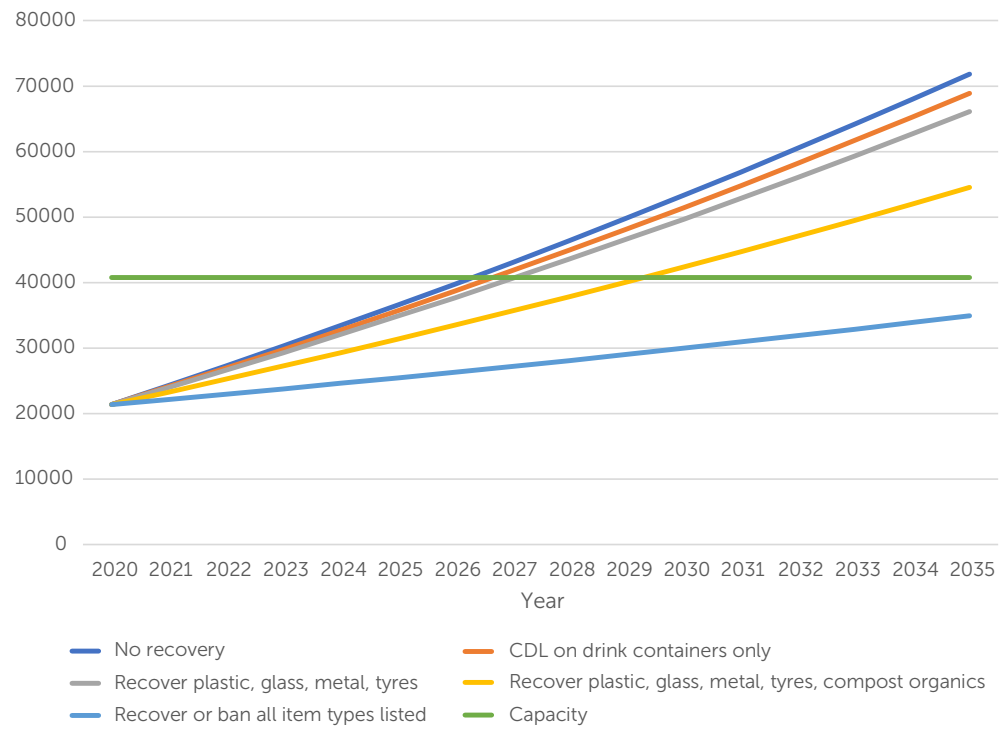

Figure 17:
Kalaka estimated lifespan

Figure 18:
Kalaka waste landfill

Faleloa is a private disposal site in Ha'apai, approximately 4 acres (1.6 hectares) in size, with 3,699 m^3 of free space (1,233 m^3 filled). It is unfenced and surrounded by unoccupied land and coastal areas. There is no lining, no leachate control, and four septic beds. No monitoring or security is in place. Presently, an excavator is hired for provision of maintenance services, with future plans by WAL to have its own equipment. The site has been in operation since 2017. Discussions are currently ongoing to climate-proof the site. 'Eua is also an open disposal site, which is now being used to dispose of waste collected by WAL.

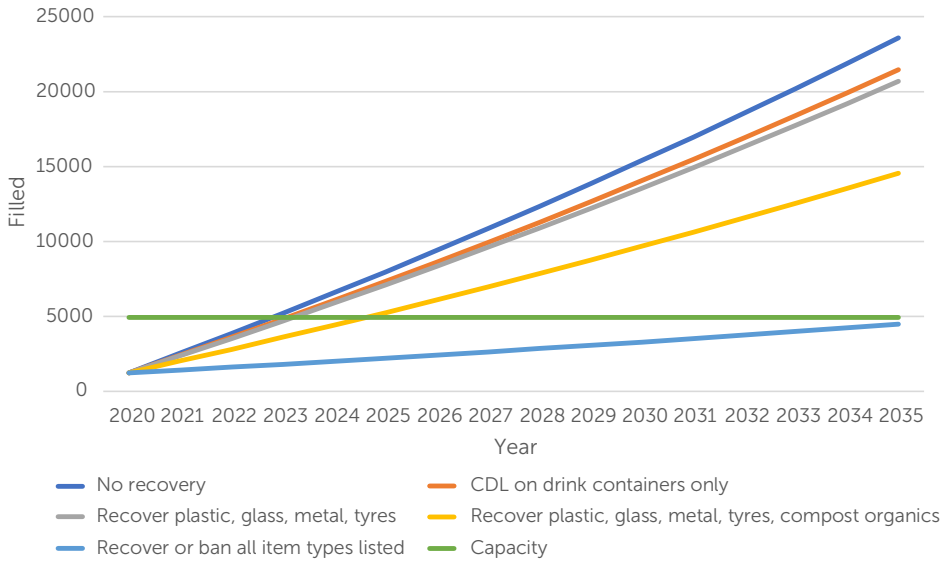

Figure 19:
Ha'apai estimated lifespan

Figure 20:
Angaha disposal site, 'Eua (left) and Faleloa disposal site, Haápai (right)

Other waste streams

Table 7: Other disposal facilities

	Tongatapu	Vava'u	Ha'apai	'Eua
Sewage and sludge	Engineered system	Open ditch	Open ditch	Open ditch
Waste oil	Waste oil from clients of Pacific Energy Ltd is shipped to Fiji for use by Bluescope	No	No	No

	Tongatapu	Vava'u	Ha'apai	'Eua
Healthcare waste	Through incineration at the hospital incinerator	Through incineration at the hospital incinerator	Through incineration at the hospital incinerator	Through incineration at the hospital incinerator
	Solid Waste to Tapuhia Landfill	Solid waste to Kalaka Landfill	Solid waste to Faleloa site	Solid waste to Angaha site

4.3 Waste-data collection and monitoring

The Department of Environment collects waste data from the Waste Authority Ltd (WAL). There is currently no distinction between waste streams. No data collection on landfill methane emissions takes place. Authorities are aiming to collect waste information to distinguish between different categories of waste in the near future. Because regular waste assessments are not undertaken, no reliable data is available regarding the amounts and types of municipal solid waste (MSW) generated on Tongatapu.

4.4 Current financial mechanisms

Waste management services provided by WAL are funded through a number of key financial mechanisms.

4.4.1 Plastic bag levy

Tonga introduced a plastic bag levy (10 percent of the cost of imported plastic bags), and a cruise-ship levy, as part of the mechanisms to support waste management in the country. WAL received approximately T$302,638 during the FY2017–2018 from levies.[9] About 17 percent of the forecast annual revenues come from waste levies.

4.4.2 Waste collection fees

The waste user-pays fees generate most of WAL's revenues based on what was earned in the FY2017– FY2018, which was T$1,691,523. With the improvement of WAL's systems under the combined monthly fees collection with the Tonga Power Agency, WAL estimated the revenue forecast from waste user-pays fees, outlined below. Based on this, more than 58 percent of revenue comes from domestic waste fees, 13 percent from commercial waste fees, 2.8 percent from churches and educational institutions, 4.7 percent from septic tank servicing, and 1 percent from the Tapuhia Waste Landfill gate fees.

- FY2018–2019 at T$1,758,994 and FY2019–2020 at T$1,934,894
- FY2020–2021 at T$2,128,383 and FY2021–2022 at T$2,341,221

9 WAL Business Plan 2018–2022.

Table 8: Current rates for waste collection in Tonga

Type	Fees (TOP)/type/payment interval	
Residential/household collection and disposal	15	Per month
Small business/retail disposal	50	Per month
Large business disposal	200–800	Per month
Restaurants	128	Per month
Accommodation	Individualized rates 80	Hotel Guest houses
Hospital waste disposal	390	Per month
Septic waste disposal	180 280	Households Businesses
Bulky waste	100 150	WAL truck 2 tonne or less WAL truck over 2 tonnes
Latex paint waste disposal	150	Per cubic meter
Demolition waste disposal	50	Per cubic meter

4.4.3 Hire and sale of waste bins

The hire and sale of waste bins is one of WAL's revenue sources, generating less than 1 percent of the overall revenue. As WAL plans to promote the use of waste bins, it is likely more revenue will be generated when householders and businesses support the idea in the future.

4.4.4 Waste budgets and expenditure

Table 9 shows WAL's budget forecast from 2019 to 2022, which indicates that 28 percent of the annual budget supports salaries and other management costs, followed by waste collection and disposal services expenses at 16 percent.

Table 9: Forecast budget of WAL (TOP)

Details	2019	2020	2021	2022
Management, accounting, and staff	599,010	658,911	724,803	797,283
Revenue collection cost	12,750	13,025	13,328	13,660
Communication cost	35,860	39,446	43,391	47,730
Board cost	78,574	85,431	92,975	101,272
Finance management services cost	38,875	41,763	47,439	50,933
Office expenses	276,515	304,167	334,583	368,041
Community expenses	29,700	32,670	35,937	39,531
Waste disposal sites operation and management cost	334,415	367,857	404,643	445,107
Total operational costs	**2,125,940**	**2,335,533**	**2,568,587**	**2,822,196**
Total revenue	**2,862,316**	**3,148,548**	**3,463,403**	**3,809,743**

4.4.5 Development partners

A number of projects have been funded by various development partners since the early 2000s to support better waste management in Tonga.

Table 10: Projects funded by development agencies in Tonga

Details	2019
AusAID	The solid waste management system was developed under the Tonga Solid Waste Management Project, funded by AusAID from 2004 to 2008.
ADB and AusAID	Under the Nuku'alofa Urban Development Sector Project (NUDSP), funded by ADB and the Australian Aid Programme, WAL received T$360,000 in investment, focusing on improving WAL's capacity for liquid waste treatment, and additional investment in site infrastructure at Tapuhia: - New sewage drying beds (T$160,000) - Three public toilets (T$200,000)
NZ High Commission	Funded the Tapuhia Student Tour Upgrades Project about T$11,417. The project provided a better area for students to learn about waste management, including the Tapuhia Waste Landfill Facilities.
JICA (through the J-PRISM program)	A number of activities have been funded through the J-PRISM program. These include: - Rehabilitation of Vava'u Waste Landfill - Development of the Waste Management Plan for Vava'u - Excavator for Vava'u Waste Landfill - Training for staff and workers in Japan and within the region - Technical support to WAL with the planning of the extension of service to Vava'u, Ha'apai and 'Eua - Donating five waste trucks - Developing monitoring system for the collection service - Training of WAL staff and workers
SPREP (through PacWaste and PacWaste Plus)	- Four healthcare waste incinerators and training of staff and workers - Development of ARF system
GEF Islands	- Improvement of Ha'apai and 'Eua disposal sites - Local staff.

4.5 Recycling in Tonga

Recycling in Tonga is driven mainly by the private sector and led by two family-owned local businesses: Gio Recycling Company and Sustainable Resource Recovery Company. The Gio Recycling Company has been operating for almost 20 years. Its longevity is due, in part, to its other business operations which has allowed it to maintain activities in Tonga when commodity markets for recycling activities are unfavorable. Both operations also collect materials such as ULABs and scrap metal, which have retained market value in the recent years.

Table 11: Recyclers in Tonga

Recycling aspect	Gio Recycling Company	Sustainable Resource Recovery Company
Years of operation	More than 20	5
Location of operations	Nuku'alofa, Tongatapu Neiafu, Vava'u	Nuku'alofa, Tongatapu Ha'apai (small base)
Waste streams covered	Scrap Metals Used lead-acid Batteries Waste oil (prior to 2018) Plastics (prior to 2018) Cardboards (prior to 2018) E-waste (prior to 2018) ELVs	Scrap metals Used lead-acid batteries
Overseas markets	New Zealand for cardboards (prior to 2018) China for plastics (prior to 2018) India for waste oil (prior to 2018) Australia for e-waste (prior to 2018) Australia and Asia for scrap metals	Australia and South Korea for scrap metals
Available equipment	Metal balers Cardboard balers Plastic balers Electric saws Forklifts Pallet weighbridge Trucks	Metal balers Electric saws Forklifts Pallet weighbridge Trucks
Available land area	Has private land used by other business activities which are also used to support recycling operations	Large area currently used for stockpiling ELVs

4.6 Initiatives and opportunities

Tonga has some major initiatives and projects for the future of waste management and recycling, including:

Key findings:

- Waste Authority Ltd (WAL) is responsible for the provision of collection services in Tongatapu, Vava'u, Ha'apai, and 'Eua. Remaining outer islands do not have official collection services.
- Collection is provided to 70–90 percent of households and commercial premises.
- Fees and charges for collection support the current collection services.
- Although adequately managed, the landfills on the three islands lack appropriate equipment and are reaching capacity.
- No sustainable financing mechanisms currently exist to support resource recovery.

5. Waste audits

5.1 Sampling methodology

The Secretariat of the Pacific Regional Environment Program's (SPREP) Waste Audit Methodology: A common Approach Audit (SPREP, 2020) was used by APWC to undertake the audit. The full breakdown of the methodology and the project-planning process is provided in the Appendices.

An integrated management system was used during audits, which covers quality, health, safety, and environment (QHSE). This system has been developed to be consistent with the requirements of the international standards ISO9001 (Quality), ISO14001 (Environment) and AS4801 (Occupational Health and Safety). No injuries or incidents were reported during the audit.

A remote online training session was conducted with local Department of Environment and Waste Authority Limited staff in relation to collecting waste samples, conducting waste audits, conducting interviews, and landfill assessments (Appendix B).

5.1.1 Waste sampling distribution and collection

The samples were stratified by population, household distribution, income category, as well as ability to sample safely and within the time frame during the COVID-19 pandemic. The waste data sampling was undertaken in March–April 2021, with a wide range of data collected from households and commercial premises through audits and interviews. In addition, landfill and stockpile audit assessments were undertaken.

Table 12: Tonga household sampling distribution

Urban/ Rural		Income category	Samples collected	Total*	Collection systems	Collection frequency
Urban	Tongatapu	Low	11	53	Yes – Door-to-door/ set collection points	Once a week depending on village schedule
		Middle	21			
		High	21			
	Vava'u island	Low	10	25	Yes – Door-to-door/ set collection points	Once a week
		Middle	8			
		High	7			
	Ha'apai island	Low	12	30	Yes – Door-to-door/ set collection points	Once a week
		Middle	10			
		High	8			

Rural	Tongatapu	Low	14	54	Yes – Door-to-door/ set collection points	Once a week depending on village schedule
		Middle	20			
		High	20			
	Vava'u island	Low	7	26	Yes – Door-to-door/ set collection points	Once a week
		Middle	9			
		High	10			
	Ha'apai island	Low	4	18	Yes – Door-to-door/ set collection points	Once week
		Middle	5			
		High	9			

*Sampling represents 1.1 percent of the overall household numbers in Tonga that were sampled

The project plan (see Appendix A) was developed by the in-country team following their online audit training, to ensure the smooth implementation of the waste audit operations. Samples were collected on Tongatapu, Vava'u, and Ha'apai islands, all of which have a collection system in place. All samples were therefore collected as per the collection methodology.

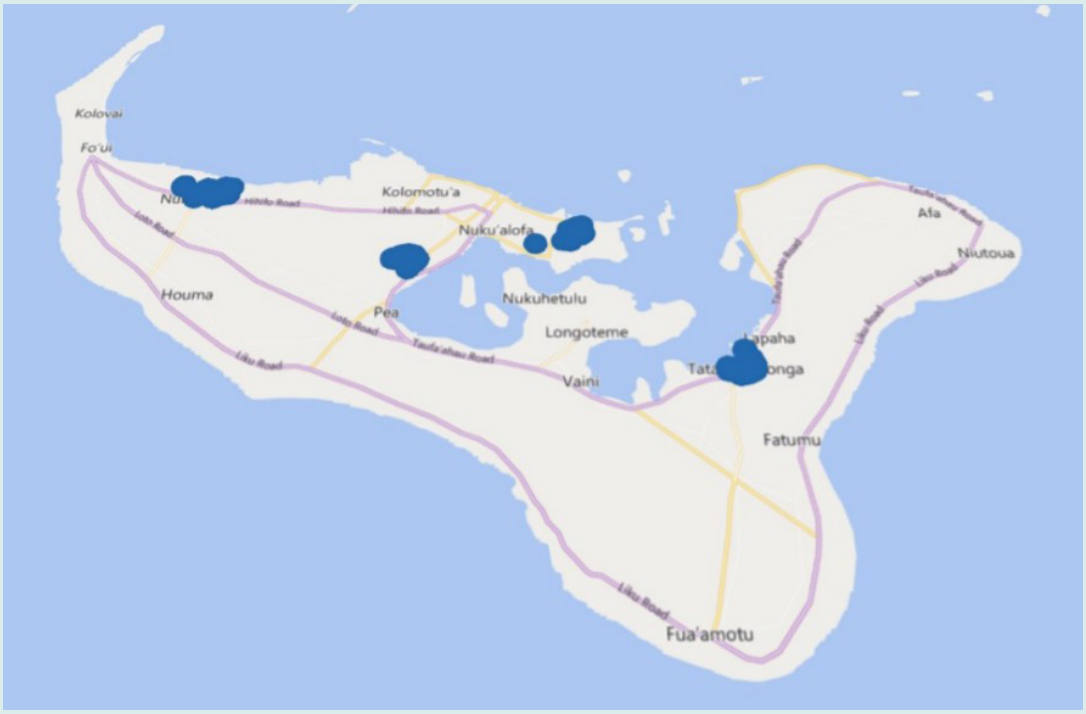

Figure 21:
Map of collection area on Tongatapu

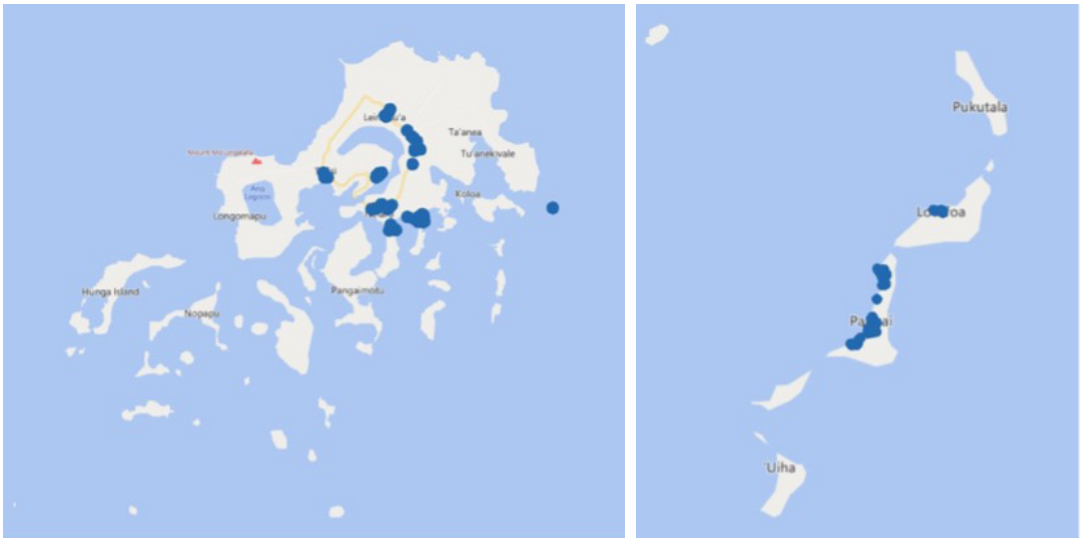

Figure 22:
Map of collection areas on Vava'u (left) and Ha'apai (right)

An online tool was used to capture data as the samples were collected. A collection sheet is provided in Appendix C.

Figure 23:
Platform for storing waste prior to collection (left); in-country audit team collecting samples (right)
(Photo: In-country team, March 2021)

Impact of COVID-19

Due to a pause on all international travel arising from the COVID-19 pandemic, a remote methodology was applied to the training and supervision of the in-country team. The team was recruited from the Department of Environment, and Waste Authority Ltd, in Tonga.

Air travel to outer islands was arranged by in-country team members, as they were aware of any pending internal travel restrictions. Fortunately, regular flights were available to the outer islands chosen for the audit, so any delays or cancellations were not a significant setback for the team.

Commercial premises

A total of 49 commercial premises were sampled simultaneously with households across all three islands. Commercial premises on Tongatapu have collections twice a week, and businesses on both Vava'u and Ha'apai have once-a-week collections. The methodology for commercial collection is described in Appendix B.

Table 13:Commercial samples collected

Sample type	Samples required	Samples collected	Interviews	Destination
Food outlet (TBU)	10	6	6	Tongatapu – Tapuhia Landfill Vava'u – Kalaka Landfill Ha'apai – Faleloa Dumpsite
Food outlet (HPA)		1	1	
Food outlet (Vv)		3	3	
Admin/office (TBU)	10	7	7	
Admin/office (HPA)		1	1	
Admin/office (Vv)		2	2	
Supermarket (TBU)	10	6	6	
Supermarket (Vv)		4	4	
Hotel (TBU)	10	5	5	
Hotel (HPA)		1	1	
Hotel (Vv)		3	3	
Retail (TBU)	10	10	10	
TOTAL	50	49	49	

Landfill samples

Although the household waste generation audit covers the waste generated through everyday consumption of products, a landfill audit was also undertaken to collect data on materials that are not usually found in household bins, for example, bulky, commercial, and construction waste.

Table 14: Landfill samples collected

	Sampling days	
Collected	**Tapuhia**	**Kalaka**
	14 days	7 days

Two of the three disposal sites on Tongatapu, Vava'u, and Ha'apai islands were assessed during the audit period in March–April 2021: Tapuhia Landfill (Tongatapu) and Kalaka Landfill (Vava'u). Tapuhia Landfill was chosen as the audit site for 14 days, as it is located on the main stretch of the island and accommodates the majority of the population. Kalaka Landfill, on Vava'u, is the second largest disposal

site and was chosen to be audited for seven days. Tapuhia Landfill is open from 8.30am to 4.30pm, Monday to Saturday; Kalaka Landfill is open from Monday to Friday, 8.30am to 4.30pm. The in-country team followed stringent health and safety requirements while conducting the landfill audit, including being equipped with appropriate personal protective equipment (PPE) (see Appendix B).

Figure 24:
In-country team conducting visual assessment at Tapuhia Landfill
(Photo: In-country team, March 2021)

5.2 Interviews

5.2.1 Household and commercial

Interviews were conducted with households and commercial operators to assess self-reported waste disposal behaviors. Interviews also sought to understand what happens to uncollected waste, why certain waste is disposed of using municipal waste collections, and the reason for these behaviors. Further information can be found in Appendix B.

Figure 25:
In-country team completing household (left) and commercial interviews (right)
(Photo: In-country team, March 2021)

5.2.2 Producer interviews

There are numerous producers and water-refilling companies located in Tonga (Table 15). Three of these companies were interviewed to obtain a more accurate understanding of plastic waste generation rates in the country.

Table 15: List of producers interviewed in Tonga

Producers
Tonga Water Limited
Cocker Enterprise Water Factory
Jin Xian Water

As well as collecting data from the producers, interviews were also conducted with currently operating recyclers to determine the amount of recyclable material collected in Tonga. An audit was taken of all material currently stockpiled. The size and location of each stockpile was audited and the data was recorded for analysis.

5.3 Sample analysis

All samples from Tongatapu were transported to an area at Tapuhia Landfill for sorting. In both Vava'u and Ha'apai, the Waste Authority Ltd (WAL) provided the team with a sort site at their office.

Bag tags were used to identify all samples to avoid misidentification. The collected samples were lined up to ensure none were missing. All samples were cross-referenced with the collection sheet to ensure consistency between sample

collection and sorting. Each waste sample was opened and the individual materials within each bag sorted into different trays according to the pre-defined categories. Separated materials were weighed using an electronic scale and the weight recorded in a sorting sheet on KoBoToolbox using digital tablets/smart phones. Due to the COVID-19 pandemic, the usual pre-calibrated electronic scales from Australia could not be used for weight analysis. The in-country team therefore sourced accurate calibrated scales on Tongatapu.

Figure 26:
In-country team referring to material categories while weighing and recording
(Photo: In-country team, March 2021)

A separate count of beverage containers for all general waste samples was also undertaken. Containers were stored and labelled to ensure no cross-contamination took place. Containers were sorted by size, packaging material, and product type. All sort data was added to the sorting form on the tablet using the categories listed in Appendix D.

5.4 Results of 2021 waste audit

During the waste audit in Tonga in March to April 2021, a wide range of data was collected.

Table 16: Data collected for audit

Sample type	Number of samples from Vava'u	Number of samples from Tongatupu	Number of samples from Ha'apai
Household samples	51	107	48
Commercial samples	12	34	3
Landfill samples	7 days – Kalaka Landfill, Vava'u	14 days – Tapuhia Landfill, Tongatapu	
All island stockpiles	All stockpiles located at multiple sites around the island		

5.4.1 Waste generation and disposal

The aim of the waste audit was to determine the total amount of material being disposed of in various parts of Tonga so that the quantities to be collected, compacted, and moved can be projected as accurately as possible. A model of waste disposal rates was constructed based on the household and commercial data collected. It also included available disposal data to determine what the data revealed about waste disposal characteristics and how it varies with households or the commercial sector. The following features were investigated as predictors of household waste disposal.

Household-level predictors:

- Total monthly household income (from all employed members of the household)
- Monthly household spending on groceries
- Number of people in the house
- Number of children in the house
- Household rating of collection service.

Town-level predictors:

- Whether or not there is a collection service in the house area
- How often waste is collected, if there is a service
- Average household income for the town where the house is located
- Average grocery spending for the town where the house is located
- Population of the town where the house is located.

The islands of Tongatapu and Vava'u disposed of household waste at a similar rate to other centers with similar population density, where the city and district population respectively were used as a measure of population density.

$$\text{Household waste generation} \left(\frac{\text{kg}}{\text{hh} \cdot \text{day}} \right) = 0.36 \ln(\text{settlement population}) - 1.8$$

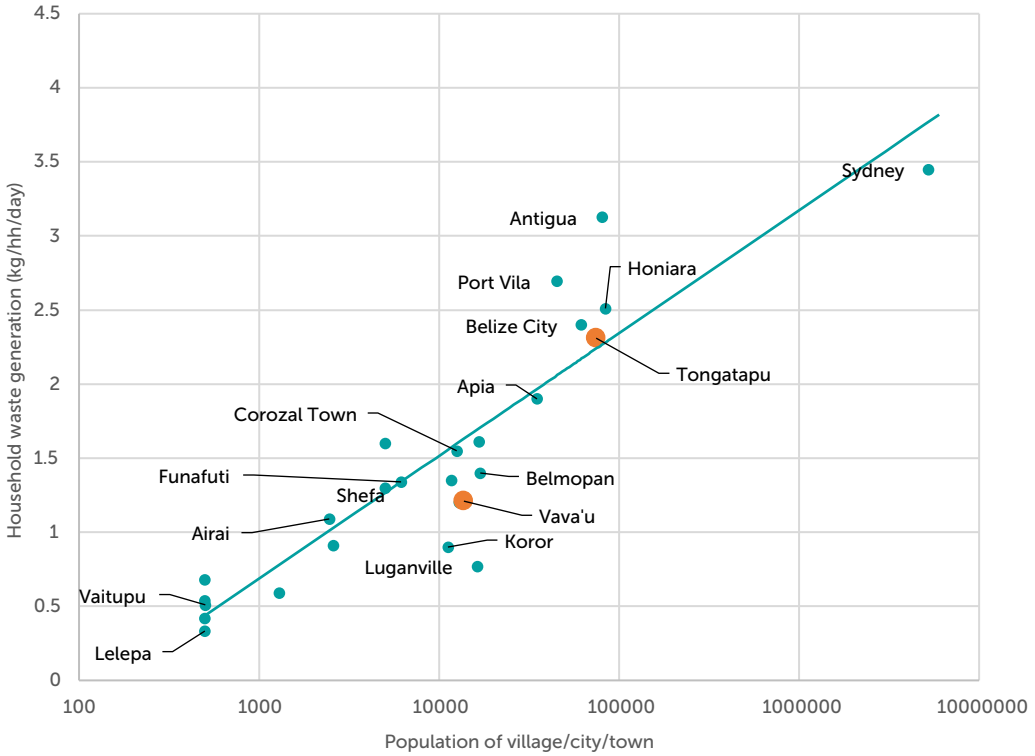

Figure 27:
Household waste and population density comparison to other SIDS (Tonga population centres highlighted in orange)

Figure 27 outlines the household waste generated and population density of Tongatapu and Vava'u in Tonga (plotted in orange) compared with other cities within the Pacific Region, Caribbean Region and South Africa where similar audits have been conducted.

The total waste generated, as opposed to just the household waste, was found to be closely related to the GDP per capita and was modelled by the following equation:

$$\text{Total waste}\left(\frac{\text{kg}}{\text{person}\cdot\text{day}}\right) = 0.0001\ \text{GDP per capita (US\$)} + 0.51$$

Figure 28 suggests that non-household waste generation is more closely related to a country's GDP than the amount of waste generated by households.

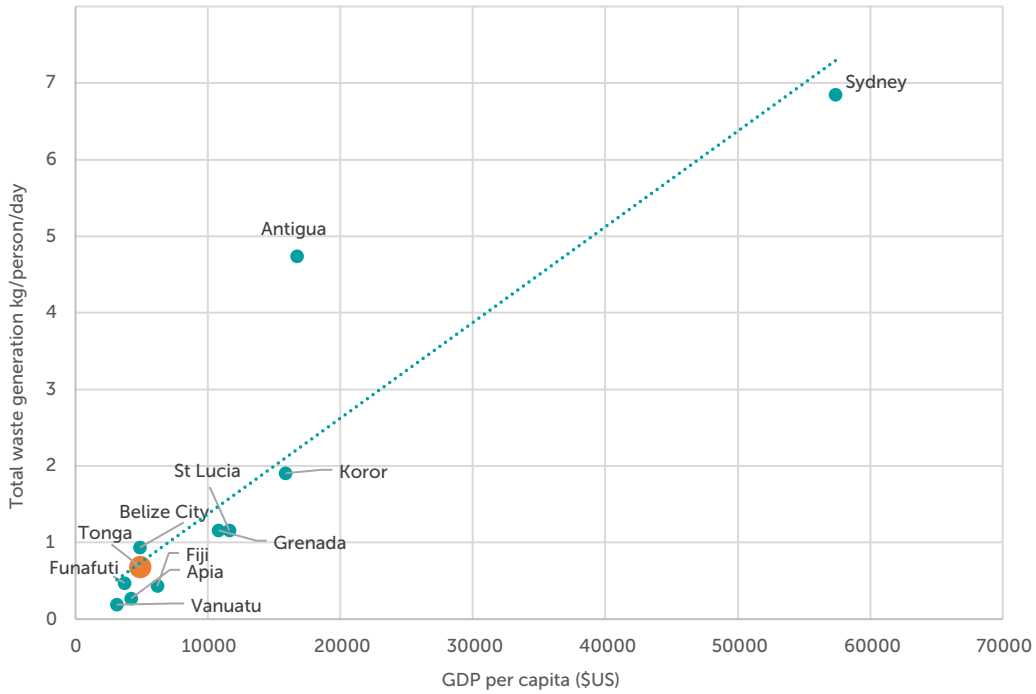

Figure 28:
Total waste generation vs GDP per capita in Tonga

When comparing the overall waste generation rate in Tonga with the generation rate in other island nations, it was found that:

- The household waste generation rate depends strongly on the population density of the area where the household is situated
- The overall waste generation rate depends strongly on the GDP per capita of the country.

The generation rate of household waste was not closely related to GDP per capita. Countries with higher GDP tend to produce much more non-household waste.

Table 17: Average waste disposal and household numbers in islands of Tonga (household waste only)*

Area	Average per person waste disposal (grams/capita/day)	Generation 95% credible interval* (grams/capita/day)	Average number of people in a household
Tongatupu	271	226–316	5.7
Vava'u	185	113–257	5.0
Ha'apai	185	113–257	5.1
Other islands	185	113–257	5.3

* Based on household waste audits only

Table 18: Waste generation from all sources in Tonga*

Area	Per capita waste from households Grams/person/day	Per capita waste from commercial premises Grams/employee/day	Overall waste generation in Tonga Grams/capita/day
Tonga overall	254	628	505

* Taking into account household audits, commercial audits, and averaging across the whole country

Analysis of audit data found that the overall waste disposal rate in Tonga is 0.51 kilograms per person per day, higher than other Pacific islands in the region. This is represented by households at 0.25 kilograms per person per day, and commercial and institutional premises at 0.63 kilograms per person per day.

5.4.2 Investigating high waste generation rates in Tonga

The estimated amount of waste disposed of is more than the estimated imports of waste material from customs data for consumables such as plastic, aluminum, or glass drinking containers. This is obviously not an accurate result. There are two possibilities:

a) The disposal rate was overestimated

b) The quantity of material imported was underestimated

Disposal rates in Tonga are high compared with other Pacific nations. Tonga has a higher coverage of waste collection services than Vanuatu and Samoa, and the per-capita disposal rate is about double the rate for these two countries. It is comparable with the rate in Kiribati and Fiji, as shown below:

- Kiribati: 0.37 kg/person/day
- Tonga: 0.51 kg/person/day
- Fiji: 0.43 kg/person/day
- Vanuatu: 0.19 kg/person/day
- Samoa: 0.2 kg/person/day

In addition to landfill audits, disposal rates were estimated from interviews with landfill managers. The disposal rates calculated from landfill audits are similar to estimates obtained from landfill interviews:

- Tapuhia: 125 m^3 per day calculated from audits, versus 150 m^3 per day obtained from interviews
- Kalaka: 5.2 tonnes/day calculated from audits (excluding end-of-life vehicles, which are stockpiled), versus 4.01 tonnes/day obtained from interviews
- Ha'apai: 2.3 tonnes/day calculated from audits (excluding ELVs), versus 1.4 tonnes/day obtained from interviews

While the landfill quantities estimated were accurate, landfills may have been audited in a high-traffic period. Audits were conducted over 14 days to avoid bias that might result from weekly collection cycles, but this may not account for longer waste disposal cycles.

5.4.3 Composition of waste – Household and commercial

Data analysis from household audits in Tonga shows the composition of waste by weight. Analysis shows that 39.4 percent of the waste (7316 tonnes per year) was organic (food and garden waste), 21 percent (3937 tonnes per year) was paper and cardboard, with plastics representing 17 percent (3048 tonnes per year) of total waste. Single-use plastic items, single-use plastic bags, and PET represented the largest components of the plastic waste generated in Tonga. This indicates that the 10 percent import tax on plastic bags is not stemming usage of single-use plastic bags.

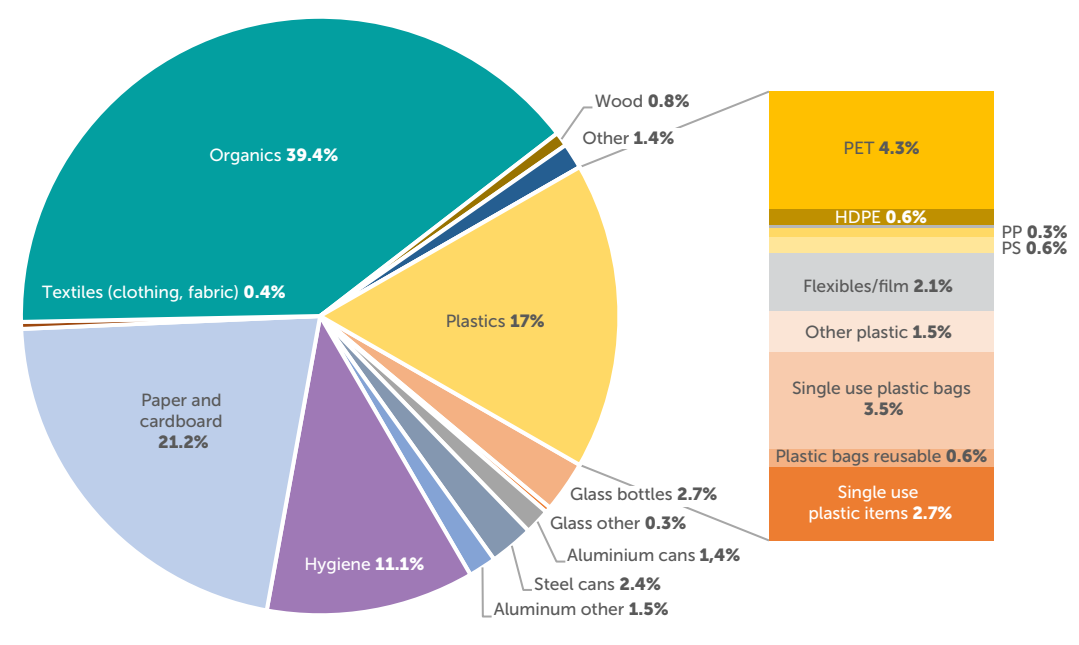

Figure 29:
Composition of waste by weight, Tonga

Almost 11 percent (2062 tonnes per year) of the overall waste collected is made up of hygiene items, including nappies (diapers) and feminine hygiene products.

The composition analysis indicates a higher-than-expected percentage of plastic waste in Tonga at 16 percent. By comparison, in Kiribati the percentage of plastics is 6 percent of overall waste generated.

Further investigation was therefore undertaken to understand the higher than usual percentage of plastic waste in Tonga. Data reveals that only about 20 percent of the households audited placed their organic waste out for the collection

service with the remaining 80 percent of the households using this material for beneficial reuse activities like feeding animals and composting. As a result, organic waste forms only about 34 percent of the overall waste generated in Tonga (as compared to 63 percent in Kiribati). The analysis was therefore undertaken again with an updated organic waste amount assuming all organic waste generated was placed out for collection. This resulted in a plastic waste percentage of 6.3 percent of overall waste, which is what was expected and comparable to other countries like Kiribati. Therefore, the reason for higher-than-expected plastic waste percentage is due to a smaller amount of organic waste, that is generally heavier, being used for other beneficial reuse activities in Tonga.

5.4.4 Houshold behavior

A 2019 study noted that the availability of organized waste collections contributed to a reduction in households burning waste as a disposal method (TSD, 2019). It also noted 90 percent of household and commercial premises on Tongatapu were using collection services provided. The data from this audit indicates that the uptake of general waste collection services had increased to 99 percent for households (on all islands audited) and 96 percent of commercial business.

In 2011, nearly all households (90 percent) in Ha'apai reported burning waste as a disposal method. Weekly waste collection services were introduced in 2020 and this audit ascertained that 99 percent of general waste and 99 percent of plastic waste was collected by the new collection service in Ha'apai.

Household interviews conducted with residents in Tongatapu, Vava'u, and Ha'apai for this audit provided insights into waste management practices in Tonga. Twenty percent of households interviewed were placing their organic waste out for collection, 88–94 percent were using food waste for feeding animals, and 55–68 percent placing hygiene waste (nappies/diapers) out for collection. Almost 50 percent of the households practiced composting and about 20 percent burn organic waste.

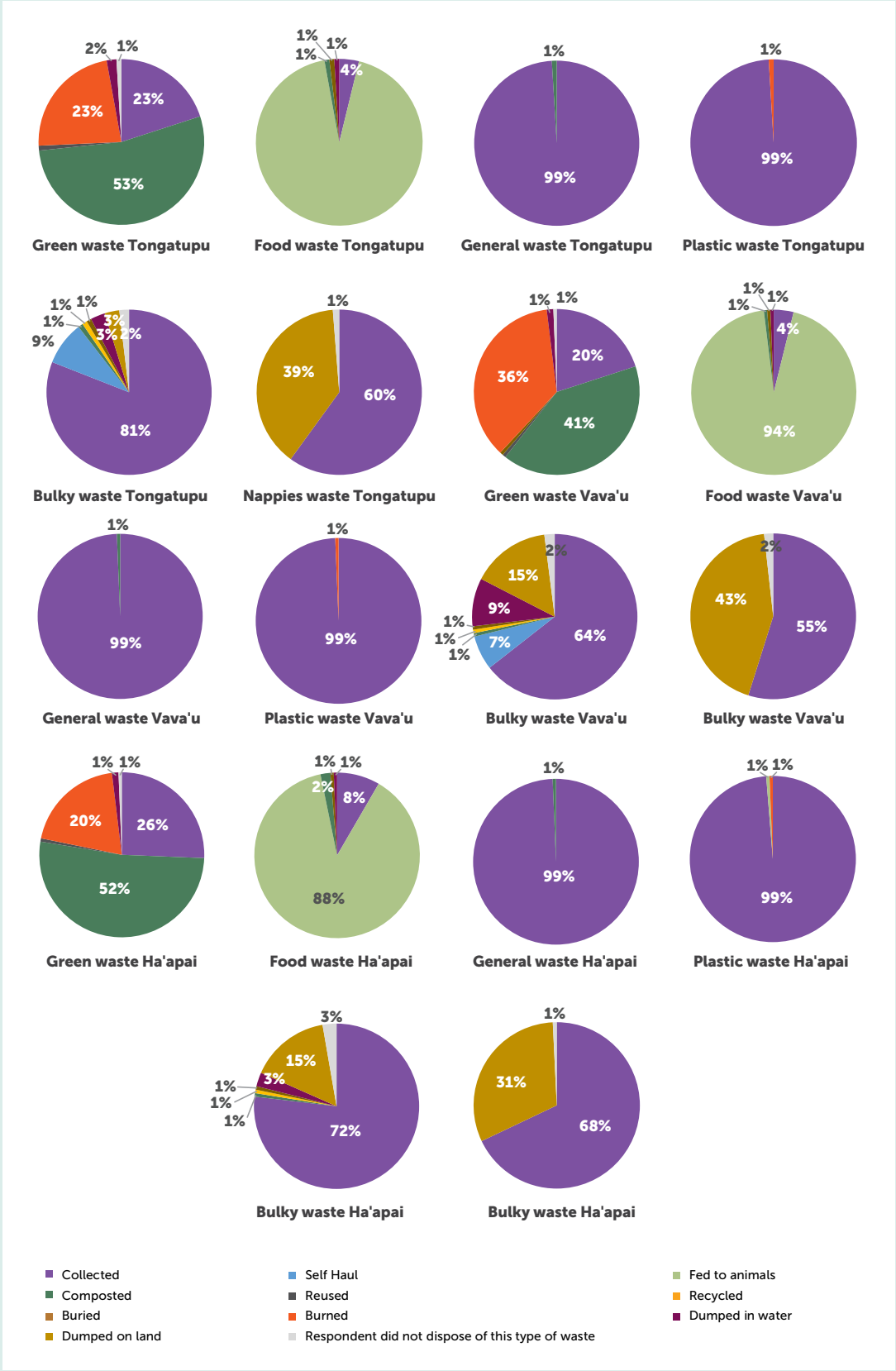

Figure 30:
Household waste disposal behavior

Tonga is highly reliant on imported materials. Previous audits using the same methodology found outlying islands are more likely to generate lower quantities of plastic, paper, and metal waste in comparison to organics (Tuvalu, PRIF 2019). This pattern was evident for Tonga, with 23.6 percent of the waste in Tongatapu being paper and cardboard, compared to only 15 percent and 7 percent of waste in Vava'u and Ha'apai, respectively.

However, the outer islands audited had more plastic waste (16 percent in Tongatapu versus 19 percent in Vava'u and 21 percent in Ha'apai), and a smaller quantity of organic matter (40.8 percent in Tongatapu versus 34 percent and 35 percent in Vava'u and Ha'apai, respectively) in the waste stream (See Figure 31). This is of interest because the islands of Vava'u and Ha'apai both have collection services that have recently commenced. Also, it is generally accepted that the households have more space to manage their organics on the outer islands and are therefore less likely to place their organics out for collection.

A larger percentage of nappy waste was also found on the outer islands of Vava'u (12.2 percent) and Ha'apai (14.5 percent), as compared to Tongatapu (10.6 percent).

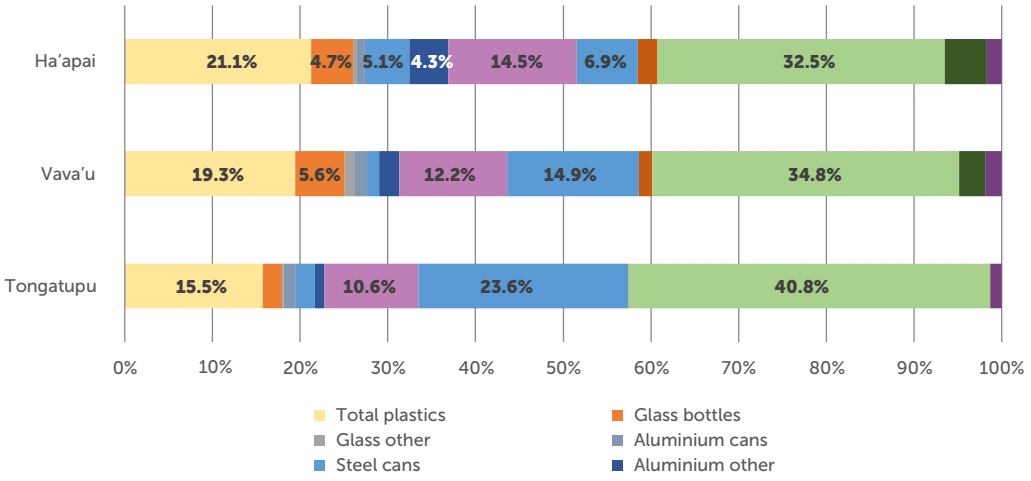

Figure 31:
Waste composition by island

5.4.5 Stockpile audit results

The study focused on an audit of current stockpiles situated on the islands of Tongatapu, Ha'apai, and Vava'u. The quantities stockpiled were estimated via visual audit and interviews with two current recycling facility operators.

It was considered important to conduct an analysis of current stockpiles because if measures are implemented to extract recyclable materials of interest as a result of this study, stockpiles represent immediately available material, and no additional measures will be required to extract the quantities of materials presented below.

Table 19: Stockpile quantities in Tonga

Waste type	Volume of stockpile (liters)	Number of items in stockpile	State/island	Detailed location of stockpile
Tires	300L	Not provided	Tongatapu	Mui'i Sopu
Tires 2	100L	80	Tongatapu	Ha'ateiho RSM
Cars	110,000L	100	Tongatapu	Pili Quarry
Cars 2	1,000,000L	500	Tongatapu	Haateiho RSM
PET bottles	200L	Not provided	Tongatapu	Mui'i Sopu
Heavy machinery	10,000L	6	Tongatapu	Ha'ateih RSM
Heavy machinery 2	10,000L	6	Tongatapu	GIO Recycling
Gas bottles – acetylene	1000L	12	Tongatapu	GIO Recycling
Iron roofing material	400L	Not provided	Tongatapu	Mui'i Sopu
Iron roofing material 2	850L	20	Tongatapu	Pili Quarry
Iron roofing material 3	1000L	300	Tongatapu	Ha'ateiho RSM
Aluminum cans	100L	Not provided	Tongatapu	Mui'i Sopu
Copper wire	800L	100	Tongatapu	GIO Recycling
Aluminum cans 2	30L	40	Ha'apai	Tongoleleka
Aluminum cans 3	350L	78	Ha'apai	FOA Village
PET bottles 2	20,000L	Not provided	Ha'apai	Tongoleleka
PET bottles 3	400L	102	Ha'apai	FOA Village
Steel cans	50L	100	Ha'apai	Tongoleleka
White goods	1400L	4	Ha'apai	FOA Village
Textiles	120L	Not provided	Vava'u	Makave
Cars 3	3000L	Not provided	Vava'u	Makave
PET bottles 4	60L	Not provided	Vava'u	Makave
Aluminum cans 4	100L	Not provided	Vava'u	Makave

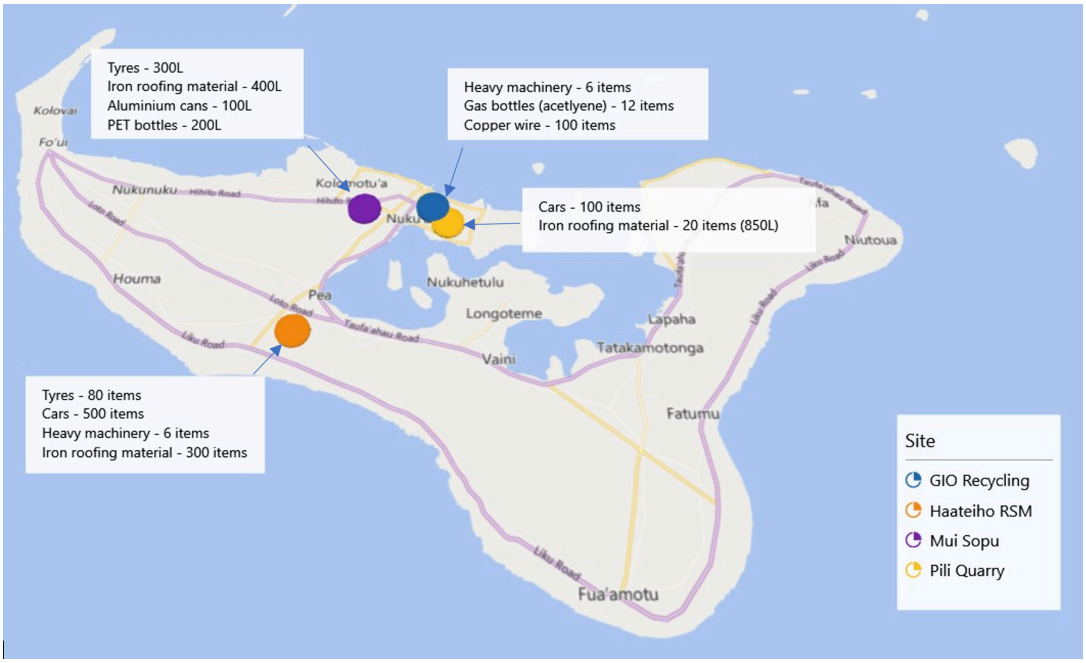

Figure 32:
Map of stockpile locations, Tongatapu

Figure 33:
Map of stockpile location, Vava'u

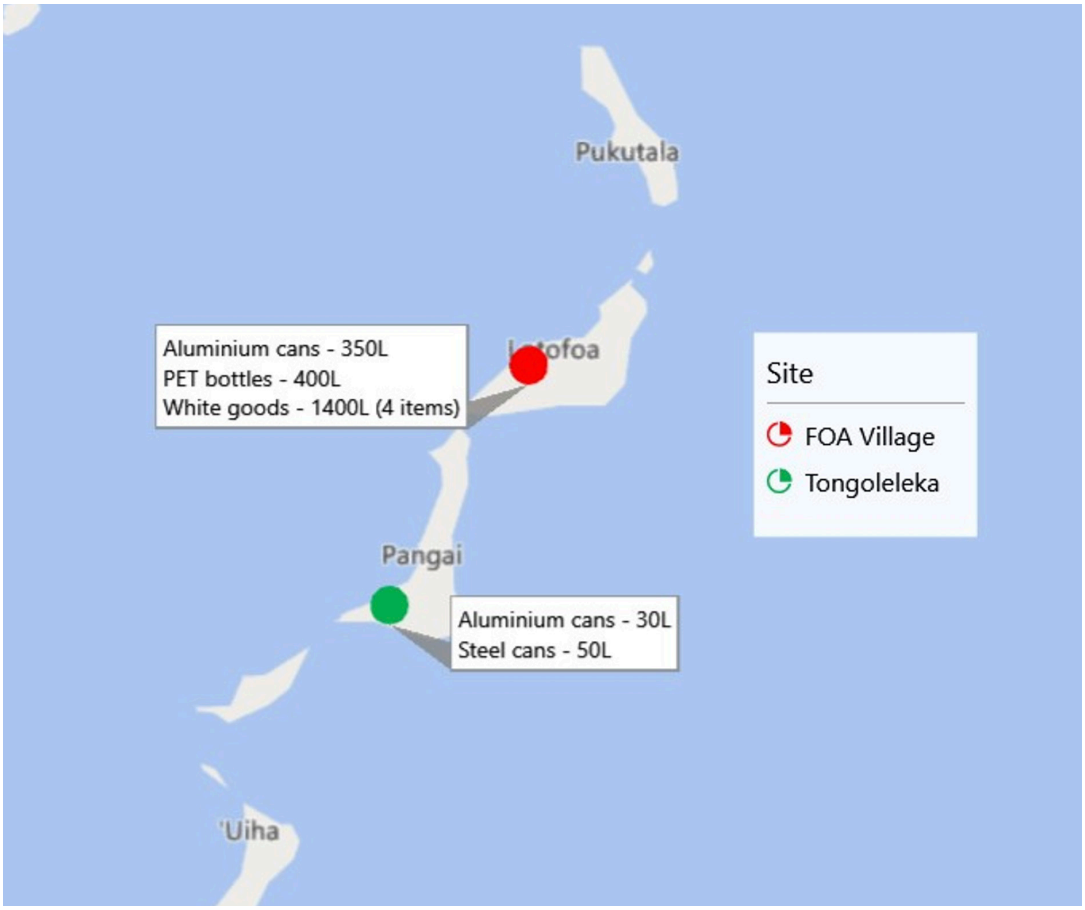

Figure 34:
Map of stockpile locations, Ha'apai

Table 20: Material imports, disposal, stockpile, and recycling

	Customs imports T/y	Total waste disposal T/y	Stockpile total (tonnes)	Recycling T/y
PET	261.5	794	13.94	4
HDPE	224.8	114	0	
LDPE	113.9	20	0	
PP	292.8	62	0	
PVC	90	5.6	0	15
PS	201.6	106	0	
Flexibles/film		393	0	
Other plastic	890.9	279	0	
Single-use plastic bags		658	0	
Plastic bags, reusable		119	0	
Aluminum cans	7.7	252	0.17	3

	Customs imports T/y	Total waste disposal T/y	Stockpile total (tonnes)	Recycling T/y
Steel cans	33	436	0	0
Aluminum other	477	275	0	103
Metal other	3082	14	6.41	554
End-of-life vehicles (inc. heavy machinery)	1768	*	3230.09	
E-waste	484.2	100	0	10
Lithium-ion batteries	8.6	0.3	0	
Other batteries	18.6	2.5	0	
Used lead-acid batteries	48	0	0	346
White goods	171.1	1.4	0	
Tires	87.7	15	0.51	0
Wood	1320.5	141	0	0
Construction (cement, clean fill, plasterboard, rocks, tiles)	3719.8	43	0	0

* End-of-life vehicle disposal was unable to be estimated from landfill audits

5.4.6 Material recycled in Tonga

The quantity of recovered materials in Tonga was estimated via interviews with recycling facility operators.

Table 21: Material recycled in Tonga

Material	Collected	Exported	Material	Collected	Exported
Uhia and Sons, GIO RECYCLING			**Sustainable Resources Management – SRM RECYCLING**		
Metal	500 kg/week	400 kg	Aluminum	30 tonnes/year	28 tonnes
Aluminum	100 kg/day	15,000 kg	A/C coils	3 tonnes/year	2 tonnes
A/C coils	150 kg/week	300 kg	Cast Aluminum	5–10 MT/year	9 tonnes
Cast aluminum	700 kg/week	500 kg	Brass	1–2 tonnes/year	2 tonnes
Brass	5 kg/week	20 kg	Copper	10 MT/year	10 tonnes
Copper	800 kg/day	500 kg	insulated copper	2 tonnes/year	2 tonnes/year
Car radiators	300 kg/month	150 kg	Car radiators	4 tonnes/year	4 tonnes
Electric motors (cars)	300 kg/month	300 kg	Alternator	5 tonnes/month	5 tonnes
Lead	100 kg/month	100 kg	Electric motors (cars)	20 tonnes/year	18 tonnes
Stainless steel	100 kg/month	100 kg	Lead	200 tonnes/year	180 tonnes

Material	Collected	Exported	Material	Collected	Exported
Uhia and Sons, GIO RECYCLING			**Sustainable Resources Management – SRM RECYCLING**		
Batteries	1440 (count)/ month	1,440 (count)	Stainless steel	6 tonnes/year	5 tonnes
PVC	400 kg/week	297 kg	Mother boards	4 tonnes/year	4 tonnes
E-waste	2 tonnes/year	2 tonnes	Iron	250 tonnes/year	
			E-waste	4 kg/week	4 tonnes
			Aluminum cans	3 tonnes/year	3 tonnes
			Vehicle chassis	2,000 (count)	
			Other – fridge compressor, power tools, generators, catalytic convertor, transformers	50 tonnes/year	40 tonnes

Key findings:

- Waste disposed of by the Kingdom of Tonga is 0.51 kg/person/day. Households generate 0.25 kg/person/day. Commercial and institutional generation rate is 0.62 kg/person/day.
- Municipal waste is not being deposited at the landfill and if deposited, it is not being recorded.
- Organics, paper and cardboard, plastics, and hygiene products are the top waste categories in Tonga.
- 99 percent of households use the collection services for general household waste and more than 90 percent feed food waste to animals.
- Only about 20 percent of the organic waste is collected through the collection services.
- 3.5 percent of overall waste is single-use plastic bags, indicating that the implementation of a customs levy on plastic bags is not having the desired effect.

6. Conclusion

Onsite visits, meetings with officials, audits, and a review of the current legislative framework suggest Tonga has the potential to contribute clean recyclable material for future recycling activities at the regional level. Additional technical, monetary, and human resource support will be required for this participation to ensure efficiency and efficacy. In addition, if pending policy measures are legislated, the quantity of materials separated at source is expected to increase by 13,173 tonnes per year, at an 80 percent recovery rate.

To ensure the private and public sectors in Tonga can successfully undertake the activities associated with recycling at a regional level, current challenges must be factored into decision-making, including land barriers, the small private sector presence, limited technical capacity, and a number of regulatory constraints. Modifications to current infrastructure and implementation of additional appropriate equipment and other resources will also need to be investigated. A needs assessment should be undertaken to determine if Tonga is able to participate in any regional waste management initiatives.

6.1 Sustainable financing mechanisms

Sustainable financing systems, such as the advance recovery fee and deposit (ARFD),[10] are seen by many PICs as a solution for long-term management of low-value recyclable materials. The ARFD represents a funding mechanism designed to facilitate recycling and recovery of waste. The fundamental principle is that the purchase price of an item includes the costs associated with that item's disposal. Such systems provide financial security for the recovery, dismantling, sorting, packing, and shipment of materials to recovery and recycling markets.

ARFD legislation is building on the success of CDS and waste levy systems currently operating in five Pacific countries. In addition to beverage containers, these systems allow for the inclusion of other problematic items, such as vehicles, white goods, and solar batteries.

6.2 Organics including paper and cardboard

Across all islands included in this audit, organic waste, and paper and cardboard are the most significant waste streams by weight. These materials should be prioritized for future resource-recovery activities in Tonga. Organic matter in the waste stream is already being reused at the household level.

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10 An ARFD starts with a product being levied when it arrives in country by customs. This sum is paid by the importer but then may be passed on to the retailer and ultimately the consumer through the purchase price. The product or container is either taken to a returns facility or put on the roadside for collection after use. If the item is returned, the returnee can be paid a refund. If the item goes to curbside for collection, the deposit is effectively forfeited and is held by the body administering the ARFD.

The current commodity value for paper and cardboard is low and finding a market for recycling will be challenging, therefore an on-island rather than an overseas (export) solution for the organic waste stream in Tonga would be highly beneficial.

If a ban on single-use plastic items is introduced, most alternative materials on the market are compostable. These would add further material to Tonga's organic waste stream.

6.3 Hygiene items including nappies (diapers)

Nappies (diapers) are a problematic waste, and disposal practices require urgent attention. Nappy bans are coming into force around the world, with the Vanuatu government in 2018 announcing an extension of the plastics ban to include plastic-containing nappies. Tuvalu has included a deposit on plastic nappies and Kiribati also instituted a ban on nappies in 2020.

Solutions must be formulated with caution. Reforming nappy consumption and disposal practices in Tonga could have adverse impacts on a highly marginalized cohort of the population. Lower income families and those living on the poverty line are more likely to have a larger number of children in disposable nappies. Access to water for washing and sanitation facilities is also a consideration. For legislative changes to be effective – especially a nappy ban – reusable and compostable nappies must be made available to communities at an affordable and competitive cost, commensurate with that of traditional plastic-containing nappies. Compostable nappies, if introduced, will need to be compostable at a community scale and sufficient infrastructure must be in place for successful implementation of a ban. It is highly recommended a full feasibility study be conducted prior to embarking on any projects.

6.4 Landfill life

The landfill capacity and current fill rates at Tapuhia, Kalaka, and Ha'apai landfills were taken from interviews with local service providers. Given the lifespan of each landfill (Tapuhia was opened in 2017 and Kalaka in 2013), the space currently occupied was broadly consistent with an average density of around 1,000 kg/m^3. An assumption was made that the total quantity disposed of at each landfill is increasing by 2 percent every year, in line with Tonga's GDP growth.

The capacity of Tapuhia was estimated from interview statements, suggesting the landfill was just under half full (40 percent). Without additional recovery, Tapuhia is estimated to reach capacity around 2026, although given the rough estimate of total capacity this figure is uncertain. A CDL on beverage containers would add two years to lifespan and the recovery of beverage containers, plastics, tires, and organics would add an extra eight years.

Without additional recovery, Kalaka is estimated to reach capacity around 2026. Recovery of plastics, glass, tires, and organics would extend the lifespan to almost 2030. Better compaction would also deliver lifespan improvements. Ha'apai landfill is estimated to reach capacity around 2023 without additional recovery.

6.5 Key conclusions

- Approximately 18,553 tonnes of waste are generated annually in Tonga
- Organic matter is the most abundant material in the waste stream
- Plastics pose a major problem to waste management and are generally not separated, stockpiled, or recycled
- Waste disposal rates are higher in Tonga compared to other PICs
- There are four designated disposal sites and three of these will reach capacity by 2028 if not action is taken to reduce input
- There is a need to develop a national waste policy and strategy
- Tonga has the potential to contribute to regional recycling activities.

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8. Appendices

Appendix A: Project Plan for Tonga

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Agency	Contact person	Contacts
1. Waste Authority Ltd	Mr Tevita Toli	tevita.toli@gmail.com
2. Ministry of Tourism	Ms Meleoni Vakapuna	mvakapuna@tongatourism.gov.to
3. Civil Society Tonga	Ms Sesimani Lokotui	sesimanilokotui@gmail.com
4. Gio Recycling	Ms 'Ofa Tu'ikolovatu	Uihanson.gio@gmail.com
5. No Pelesitiki	Ms Eleni Leveni Tevi	etevi@finance.gov.to

SAMPLING PLAN – DATA REQUIRED TO BE COLLECTED IN TONGA

Households (collect and sort waste – conduct same number of interviews)

Scheme	Error at 80% Confidence	Error at 90% Confidence
80 Tongatapu, 70 other	26%	33%
70 Tongatapu, 40 on two other islands	23%	29%
100 Tongatupu, 50 on two other islands **1.** Tongatapu – 100 Houmakelikao 25 Nukunuku 25 Tatakamotonga 25 Tofoa 25 **2.** Vava'u – 50 Ta'anea 10 Taoa 10 Makave 10 Leimatu'a 10 Talau 10 **3.** Ha'apai – 50 Holopeka 10 Lotofoa 10 Koulo 10 Pangai 10 Tongaleleka 10	22%	28%
80 Tongatapu, 40 on three other islands	20%	25%

Note: grey shaded is the chosen sample split

Businesses (collect and sort waste – conduct requested interviews)

	Samples	Interviews
Admin/office **1.** Tongatapu – 7 ANZ Bank NPI Office FISA MEIDECC STT Office ATS Tonga Post **2.** Vava'u – 2 TCC Lulutai Airlines **3.** Ha'apai – 1 Ministry of Tourism	10	10
Food outlet **1.** Tongatapu – 6 Wave's Café Mum's Café Little Italian Restaurant CTR Restaurant Emerald Restaurant HI 5 Delight **2.** Vava'u – 3 Banda Belavista 'Isime'eli Restaurant **3.** Ha'apai –1 Market Takeaway	10	10
Supermarket **1.** Tongatapu – 6 Molisi Si'I Kae Ola Luna'eva Chi Long Star Fish Costlow **2.** Vava'u – 4 MBf Chinese Supermarket Peter Chinese Supermarket Chie Supermarket Luke Supermarket	10	10

	Samples	Interviews
Hotel **1.** Tongatapu – 6 Kahana Resort Vakaloa Resort Meida Hotel Papiloa Motel Ishadora Hotel Waterfront Lodge **2.** Vava'u – 3 Emerald Hotel Porta Wine Flying Annie **3.** Ha'apai – 1 Fifita Guesthouse	10	10
Retail **1.** Tongatapu – 10 Nukunuku 2 Tofoa 3 Houmakelikao 2 **-** Tatakamotonga 3	10	10

Landfill (collect and sort waste, conduct requested interviews)

Understandable	7 days – Kalaka Landfill, Vava'u
Desirable	14 days – Tapuhia Landfill, Tongatapu

Bottling companies – local manufacture of plastic (gather data around plastics manufacturing – use data sheet provided)

List of bottling/water refill companies in Tonga

Tasilo
Tonga Water
Water Vai

Recyclers (gather data around materials recycled currently and current recycling markets – use data sheet provided)

1) Gio Recycling
2) Vuki Recycling

Customs (request data around import and export of materials)

To be sent on 15 March 2021

Municipal services provision sheet (request data around current legislation, collection, and disposal services)

Sent on 11 March 2021

COLLECTION OF WASTE AND SORTING ARRANGEMENTS

Sort site

ISLAND	CONTACT
Tongatapu	Tapuhia Landfill Contact: Ms Charlynn Lautaha +676 27827
Vava'u	WAL Office Mr Tevita Toli +676 7863860 +676 70704
Ha'apai	WAL Office Mr Ma'ali Folau +676 60234

**Will need a designated sort site on each island

APWC Work Health and Safety training

TASKS	Completed in country	Signed off by PM
APWC waste audit code of conduct	Yes	
APWC COVID response safety plan	Yes	
Electronic copies of SWMS/ JSEA*	Yes	
Training for staff and hard copy of training module	Yes	

Equipment required in country (Cont'd)

ITEM	Purchased/organized in country	Receipts provided to PM
2 * Tables	Yes	Yes
2 x electronic scales	Yes	Yes
2 * tablets	Yes	Yes
Inner gloves (7)	Yes	Yes
Outer gloves (7)	Yes	Yes
Masking tape and permanent markers	Yes	Yes
Garbage bags (100)	Yes	Yes
Masks/face shields	Yes	Yes
Safety vests (7)	Yes	Yes
Sorting tubs/aluminum trays	Yes	Yes
First Aid kits	n/a	n/a
Soap and hand sanitizer	Yes	Yes
SIM card (1)	Yes	no
SD card (2)	Yes	no
Marquee (*3)	required	no
Pickup truck for collections (*3)	required	no
Vehicle for the team (*4)	required	no
Safety boots	required	Yes
Electronic hanging scale (*1)	required	no
Garbage bags (200)	required	no

Work schedule

	February 2021					
Sun	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**
	1	2	3	4 Catch up meeting with Lupe, Erin and Faafetai	5	6
7	8	9	10	11	12	13
14	15	16 WB Waste Audit Training	17 WB Waste Audit Training	18 WB Waste Audit Training Quotes to purchase equipment sent	19 1st installment to purchase necessary equipment received	20
21	22 Equipment purchased	23 Equipment purchased 1st financial report sent	24	25	26	27

Work schedule

March 2021						
Sun	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**
	1	2	3	4	5 Purchase equipment Arrange Tevita's trip over to main Island	6
7	8 Tevita's travel arrangement confirmed	9 Tevita Toli arrived from Vava'u Team Planning Update Erin on messenger	10 Team Planning Update Erin on messenger Create chat group on messenger	11 Team Planning Conduct Practical training Sent official letter for CEO endorsement	12 Team Planning Work-plan and budget sent. Distribute letters to Vava'u and Ha'apai as well and participating businesses. Dispatch team to Houmakelikao to select 25 households (10H, 10M, 5L). Brief and interview. Renting of collection truck and vehicle for team use. Renting of tent. Tag plastic bags accordingly.	13

Work schedule

March 2021						
Sun	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**
14	15 Set up Tapuhia Landfill (Tevita) Team/safety briefing (All) Landfill data collection (Tevita) Household collection/ interview at Houmakelikao (Commercial (Retail) collection/ interview Office collection/ interview Sorting Team debrief Data entry and sent Daily report sent	16 Team briefing Landfill data collection Household collection/ interview at Nukunuku Commercial (Retail) collection/ interview Food collection/ interview Sorting Team debrief Data entry and sent Daily report sent	17 Team briefing Landfill data collection Household collection/ interview Tatakamotonga/ Tofoa Commercial (Retail) collection/ interview Sorting Team debrief Data entry and sent Daily report sent	18 Team briefing Landfill data collection Household interview Houmakelikao/ Nukunuku/ Tatakamotonga/ Tofoa revisit. Supermarket collection/ interview Sorting Producer interview Team debrief Data entry and sent Daily report sent	19 Team briefing Landfill data collection Hotel collection/ interview Recycling interview Sorting Prepare and pack equipment for Vava'u and Ha'apai Team debrief Data entry and sent Daily report sent	20 Team 1 depart for Vava'u Team 2 depart for Ha'apai
21	22 Waste Audit in Vava'u and Ha'apai (see below for details)	23 Waste Audit in Vava'u and Ha'apai	24 Waste Audit in Vava'u and Ha'apai	25 Waste Audit in Vava'u and Ha'apai	26 Waste Audit in Vava'u. Team 2 arrive from Ha'apai	27 Team 1 arrive from Vava'u
28	29 Team briefing on the Outer Islands audit. Progress report sent	30 Data input	31 Date input			

Work schedule

April 2021					
Thu	**Fri**	**Sat**	**Sun**	**Mon**	**Tue**
1 Data input	2 Data input completed	3	4	5 Progress report sent	6 Tonga Waste Audit completed.

WORK HEALTH AND SAFETY

Safety while travelling and working in Tonga:

a) **PRE-MISSION BRIEF:** In-country project team members to be provided with a copy of the mission brief, all documents and safety while travelling/ working briefing and audit training. Team also briefed of all in-country requirements, safety, local conditions and data to be collected. In-country briefing to include details on accommodation, transport, money and timekeeping. Team will be provided with a copy of an attendance sheet that must be signed confirming that all training, briefing and safety documents have been read and understood. A copy of this document must be sent to the Project Manager. BRIEF AND SIGNED COPY OF ATTENDANCE SAVED IN PROJECT DROPBOX. Once this has been completed, please fill out the table below.

	Date/Signed by in country team	**Received and saved by PM**
Mission brief	✓	✓
Work, Health and Safety	✓	✓
Audit training	✓	✓

b) **POST-MISSION BRIEFING:** After completion of in-country mission, review of all processes and learnings. All learnings to be recorded by PM and reflected in future project planning. A copy of the review process to be saved in project dropbox.

Project Team

Team Leader	Position	Training
Ms. Mafile'o Masi	Chief Environmentalist, DoE	Landfill and stockpile assessments, interviews, collection and sorting: Waste audits Material identification and classification Plastic resin and product identification Household interviewing skills Data entry skills
Audit Team	**Position**	
Ms. Lupe Matoto	Director, DoE	
Mr. Filimone Lapao'o	Senior Environmentalist, DoE	
Ms. Sulieti 'Ofa	Conservation Officer, DoE	
Mr. Siosiua Hakaumotu	Environment Trainee, DoE	
Mr. Joshua Latu	Environment Trainee, DoE	
Mr. Tevita Toli	Landfill Operation Manager, Waste Authority Ltd	

MEDICAL: 933

Paramedic Ambulance: 933

Search and Rescue: 911

EMERGENCY DENTAL: 933

ELECTRICAL FAULTS: 944

FIRE: 999/ 927/ 928

MEDICAL EMERGENCIES:933

POLICE: 922

OFFICE OF DISASTER PREPAREDNESS: 28004/ 280

Appendix B: Project methodology

Impact of COVID-19

Due to a pause on all international travel arising from the COVID-19 pandemic, a remote methodology was applied to the training and supervision of the in-country team recruited from Department of Environment and Waste Authority Ltd in Tonga.

Air travel to outer islands was arranged by the in-country team members as they were most aware of any pending internal travel restrictions. Fortunately, regular flights were available to the outer islands chosen for the audit, so any delays or cancellations were not a significant setback for the team.

Data collection

Household samples

This section provides information on how the waste data collection works were undertaken over the period March to April 2021 in Tonga.

Household samples to be collected

Scheme	Error at 80% Confidence	Error at 90% Confidence
80 Tongatapu, 70 other	26%	33%
70 Tongatapu, 40 on two other islands	23%	29%
100 Tongatapu, 50 on two other islands	22%	28%
80 Tongatapu, 40 on three other islands	20%	25%

* Schemes highlighted in orange represent the targeted samples prior to commencing the audit

Using the calculations provided above, it was assumed that the minimum number of samples required was 150 and the maximum number was 200. A total of 108 samples were collected in Tongatapu, 51 were collected on Vava'u, and 48 on Ha'apai. Therefore, the total sample size in Tonga was 207, bringing the number to an acceptable level of confidence needed for decision-making purposes.

Tonga household sampling distribution

Urban/ rural		Income category	Samples required	Samples collected	Total	Collection systems	Collection frequency
Urban	Tongatapu	Low		11	53	Yes – door-to-door/set collection points	Once a week depending on village schedule
		Middle		21			
		High		21			
	Vava'u island	Low		10	25	Yes – door-to-door/set collection points	Once a week
		Middle		8			
		High		7			
	Ha'apai island	Low		12	30	Yes – door-to-door/set collection points	Once a week
		Middle		10			
		High		8			
Rural	Tongatapu	Low		14	54	Yes – door-to-door/set collection points	Once a week depending on village schedule
		Middle		20			
		High		20			
	Vava'u island	Low		7	26	Yes – door-to-door/set collection points	Once a week
		Middle		9			
		High		10			
	Ha'apai island	Low		4	18	Yes – door-to-door/set collection points	Once week
		Middle		5			
		High		9			

Household samples collected

Income category	Urban	Rural	Total
Low income	33	25	58
Middle income	39	35	74
High income	36	39	75
Total	108	99	207

The World Bank consultant team provided a project plan template to the in-country team following the online training provided by the Project Manager (See Appendix A). The plan was discussed by the in-country team and the Project Manager during the online training to ensure the smooth implementation of the waste audit operations. Samples were collected on Tongatapu, Vava'u, and Ha'apai islands. All islands have a scheduled collection service. Samples were therefore collected as per the collection methodology below.

Household waste samples were collected from Tongatapu, Vava'u, and Ha'apai islands based on the required sampling method. The methodology requires collection of household samples across the low-, medium- and high-income streams.

The locations of the households where samples were collected were marked using the GPS coordinates. The sample collection team arrived prior to the arrival of the waste collection truck on the day of the collection and procured the sample before the truck could visit the households. The spread of samples is shown in the following figures.

The collection team consisted of the three key members with separate functions. The World Bank consultant team engaged and trained up to eight waste management staff, kindly provided by the Department of Environment and Waste Authority Limited (WAL) to undertake the in-country work for this project. The in-country team used their local knowledge and experience in the waste industry to develop the collection routes on each of the islands. Knowing the areas well, the team was able to answer questions posed by locals regarding why they were collecting waste from their household bins instead of the regular contractor. The in-country team used an online tool to capture all data as the samples were collected. A collection sheet is provided in Appendix C.

Collections were carried out in the following way:

- A collection supervisor and recorder marked the location of a sample using the GPS coordinates, photographed the premises for follow-up interviews, and inserted notes on the nature of the collected samples (e.g. bin fullness, how much waste collected for sampling, what proportion and contents description of was left behind, types of waste, etc.).
- The second member of the team assessed the types of the waste presented and provided information to the recorder. Samples were collected using garbage bags by emptying the contents of the bins into these bags and placing them in the truck for transportation to the sorting area at the landfill.
- The third member of the team conducted the interview with the resident of the household. If the resident was not home, a note was made of the address and the corresponding sample number collected for easier identification later during follow-up interviews. The household numbers recorded by the recorder must correspond to numbers written on the garbage bags.

Commercial premises

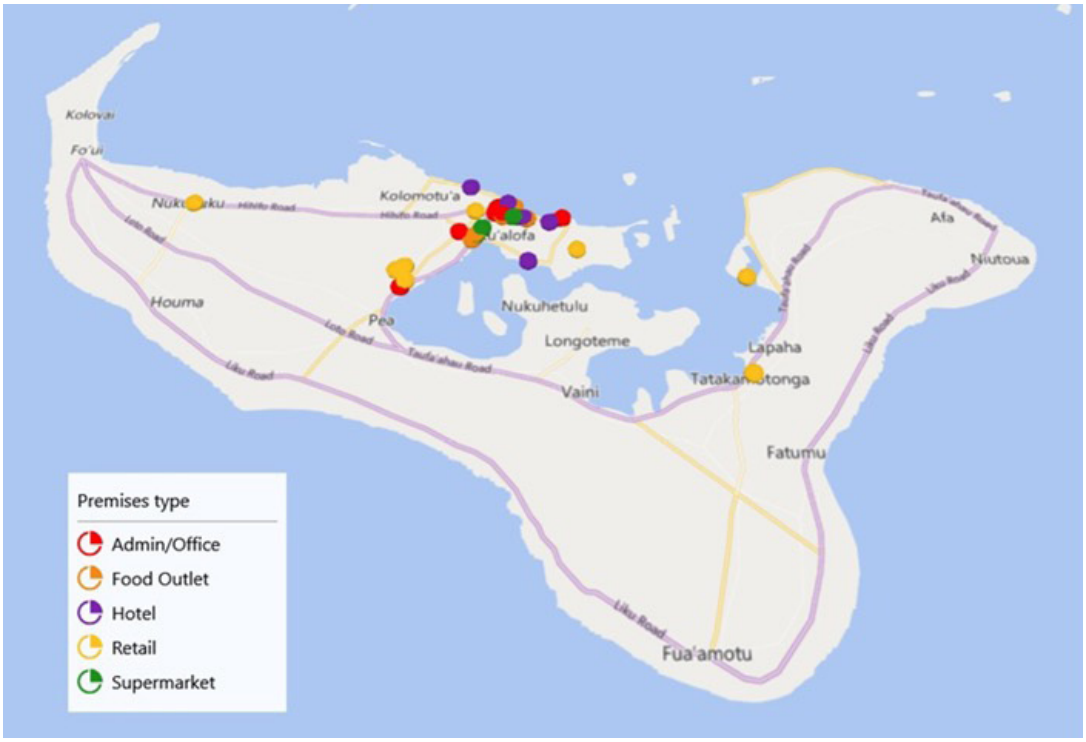
Commercial samples were required to be distributed as follows:

Commercial samples collected

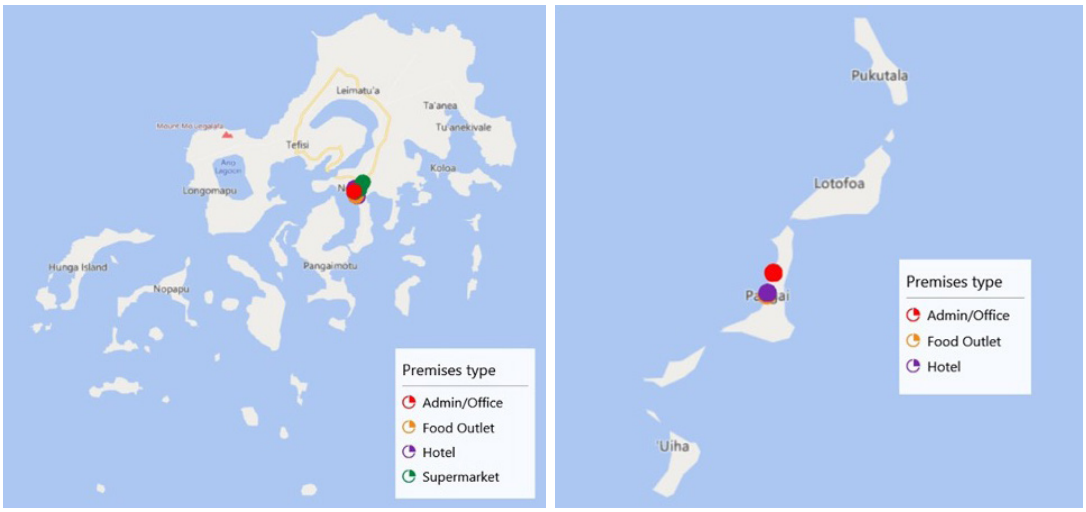
Sample type	Samples required	Samples collected	Interviews	Destination
Food outlet (TBU)	10	6	6	Tongatapu – Tapuhia Landfill Vava'u – Kalaka Landfill Ha'apai – Faleloa Dumpsite
Food outlet (HPA)		1	1	
Food outlet (Vv)		3	3	
Admin/office (TBU)	10	7	7	
Admin/office (HPA)		1	1	
Admin/office (Vv)		2	2	
Supermarket (TBU)	10	6	6	
Supermarket (Vv)		4	4	
Hotel (TBU)	10	5	5	
Hotel (HPA)		1	1	
Hotel (Vv)		3	3	
Retail (TBU)	10	10	10	
TOTAL	50	49	49	

A total of 49 commercial premises were sampled simultaneously with households across all three islands. Commercial premises on Tongatapu have a waste collection twice a week, and business on both Vava'u and Ha'apai have a collection once a week.

The commercial samples from small shops, offices, businesses, and hotels were collected at the same time as the household samples. The team member was required to speak directly to the person in charge of waste management at the premises in order to collect a sample, therefore the interview was completed at the same time rather than the team returning at a later date.



Map of commercial samples collected, Tongatapu



Map of commercial samples collected on Vava'u (left) and Ha'apai (right)

Landfill samples

The team visited a disposal site on each of the islands during the audit period, however only sites on Tongatapu (Tapuhia Landfill) and on Vava'u (Kalaka Landfill) were assessed. Faleloa Dumpsite on Ha'apai is an unmanned dumpsite and was deemed unsafe for the team to assess. Tapuhia Landfill is open 8.30am to 4.30pm. Monday to Saturday and Kalaka Landfill is open Monday to Friday 8.30am to 4.30pm.

Landfill audit statistics

Statistics		
Landfill visual audit	**Tapuhia Landfill**	**Kalaka Landfill**
Number of days of visual audit	14 consecutive days (excluding Sunday)	7 consecutive days (excluding weekend)
Number of vehicles audited	484 vehicles	91 vehicles

The in-country team conducted a snapshot audit so that the composition of the different types of materials could be understood. This composition could then be applied to the overall volume of incoming material to determine the content.

Auditors were equipped with mobile phones, high-visibility safety vests, gloves, protective glasses, sunscreen, wet-weather gear, and safety boots (with steel base to prevent any penetration). Paper data sheets were used at the landfill instead of tablets, as multiple entries often had to be made at once. These sheets were then scanned and sent to the data-entry office based in Australia to be entered into KoboToolbox. The categories and information recorded for each vehicle is provided at Appendix H.

All data was recorded in a consistent manner (in liters) on a standard data sheet. Space was provided on the form so that if significant quantities of any other items were found they could be appropriately recorded. Sheets were pre-numbered to ensure all recording sheets are accounted for after the audit.

The following information was recorded on each load:

- Date and time of vehicle arrival
- Registration number
- Vehicle type
- Volume of vehicles load in liters
- Composition and volume of load in liters
- Degree of compact
- Photographs of specific loads of interest.

Interviews

Household and commercial

The methodology assesses the amount of waste requiring immediate management, that is, the general municipal waste being placed in bags. It also assesses self-reported household behaviors based on interviews in order to understand what happens to uncollected waste or why certain waste is not placed in bags, including the reason for these behaviors.

All interviews were conducted by the in-country team. The team conducted the interviews for both households and commercial premises at the same time as sample collection. As the team often had to meet with the business owner in order to collect a waste sample for commercial premises, interviews were conducted immediately in order to precisely match samples. When completing the household collections/interviews, if the residents were not home, the team member took note of the address and sample ID, and returned at another time. The interviews cover the following areas:

- Demographic information
- Income levels
- Disposal behavior by material type
- Willingness to pay for collection/disposal systems
- Current recycling behaviors including further source separation
- Level of awareness about the current waste service
- Type of premises
- Access to amenities (electricity, sanitation, stormwater infrastructure, etc.)
- Consumption habits.

The questionnaires are designed specifically for each country and are based on the local conditions, language, and culture (if they cover the above criteria). The questionnaires in English and interpreters were used when required. The use of interpreters was chosen over local language translation because it had been previously demonstrated that translated questionnaires can be misleading and answers may not reflect the questions asked.

Producer interviews

There are three companies in Tonga producing bottled water and other packaged products. The companies were interviewed to obtain a more accurate understanding of plastic waste generation rates.

List of producers in Tonga

Producers
Tonga Water Limited
Cocker Enterprise Water Factory
Jin Xian Water

As well as collecting data from the producers, interviews were also conducted with recyclers currently operating in Tonga to determine the amount of recyclable material collected. The teamalso conducted an audit of all current stockpiled material. The size and location of each stockpile was audited, and the data was recorded for analysis.

Sample sorting

All samples from Tongatapu were transported to an area at Tapuhia Landfill for sorting. Waste Authority Ltd (WAL) provided the team with a sort site at their office in both Vava'u and Ha'apai.

Bags tags were used to identify all samples to avoid misidentification. The collected samples were lined up to ensure none were missing. All samples were cross-referenced with the collection sheet to ensure consistency between sample collection and sorting. Each waste sample was opened and the individual materials within each bag sorted into different trays according to the pre-defined categories. Separated materials were weighed using an electronic scale and the weight measurement recorded in a sorting sheet on KoBoToolbox using digital tablets/smart phones. Due to the global COVID-19 pandemic, the pre-calibrated electronic scales from Australia were unavailable. The team members sourced their own calibrated scales on Tongatapu.

A separate count of beverage containers for all general waste samples was also undertaken. Beverage containers from the samples were stored and counted separately. Containers were stored and labelled to ensure no cross-contamination took place. Containers were sorted by size, packaging material, and product type.

All plastic bags were sorted into different types. Cigarette butts, coffee cups, and takeaway containers were also segregated. All sort data was added to the sorting form on the tablet using the categories listed in Appendix D.

Work health and safety

The study has an integrated management system used during audits covering quality, health, safety, and environment (QHSE). The system has been developed to be consistent with the requirements of the international standards ISO9001 (Quality), ISO14001 (Environment) and AS4801 (Occupational Health and Safety).

The following steps were undertaken to ensure the safety of personnel:

- Site-specific safe work method statements (SWMS) were developed
- A pre- and post-work commencement risk assessment was undertaken
- A collection and sorting supervisor undertook QHSE inductions for project staff
- All staff were trained in the Waste Audit Code of Conduct developed by (APWC), which includes a requirement to sign a confidentiality agreement prohibiting staff from removing anything from the material they sort or from revealing any information they might obtain while sorting or auditing
- Adjustments were made to ensure safety of staff based on local conditions. APWC's collection and sorting supervisor had full control over local safety requirements to ensure all work was being conducted in a manner protecting the health and safety of the staff.

To comply with best-practice COVID-19 health and safety requirements, wearing masks was mandatory when completing collections and sorting. The teams were required to abide by the nationally implemented social-distancing rules and to be vigilant about their personal health as well as that of the public. The in-country consultant responsible for supervising the fieldwork was given an extra briefing on safety and hygiene during a pandemic by the project manager before commencing work. This message was shared to the whole team by the in-country consultant.

Staff training

As much as possible during the project, training was provided to local university student volunteers in collecting waste samples, conducting waste characterizations, conducting interviews, and in landfill assessments, as outlined below.

Training received by in-country team in Tonga

Team Leader	Position	Training
Ms. Mafile'o Masi	Chief Environmentalist, DoE	Landfill and stockpile assessments, interviews, collection and sorting: Waste audits Material identification and classification Plastic resin and product identification Household interviewing skills Data entry skills
Audit Team	**Position**	
Ms. Lupe Matoto	Director, DoE	
Mr. Filimone Lapao'o	Senior Environmentalist, DoE	
Ms. Sulieti 'Ofa	Conservation Officer, DoE	
Mr. Siosiua Hakaumotu	Environment Trainee, DoE	
Mr. Joshua Latu	Environment Trainee, DoE	
Mr. Tevita Toli	Landfill Operation Manager, Waste Authority Ltd	

Due to the COVID-19 international travel restrictions, a remote training method was developed to instruct local volunteers and Department of Environment and Waste Authority staff members via a series of Zoom video meetings.

The online training was organized across three sessions with the whole team. In preparation for these sessions, one-on-one virtual meetings were held between the country coordinator and the project manager (PM). During these meetings the PM provided an overview of the project activities, methodology used, and the different processes involved in the audit work. The PM and the country coordinator worked through any existing queries prior to the training sessions with the whole team.

In-country team during the remote training provided by World Bank consultants (APWC)
(Photo: In-country team, 2021)

The full team training sessions were approximately three to four hours and took place over three consecutive days via Zoom in one of the conference rooms at the Department of Environment Office. The first session gave an overview of the project, which instructed the team on different sorting categories used during the audit, with specific attention paid to understanding the detailed plastic categories. The PM used interactive games and memory-oriented techniques to help the team familiarize themselves with the categories so they would be more confident when sorting. At the end of the session, the team was taken through a step-by-step process of downloading and installing the different KoboToolbox forms used for data collection to their devices.

The second session began with the team reviewing the sorting and plastics categories from the previous day and working through any questions that may have arisen. A more practical approach was taken for the remainder of the session in order to familiarize the team with how to use the Kobotoolbox platform. The team practiced interview techniques, entering the responses into KoboToolbox and submitting the forms upon completion. The team also went

through the landfill entry and tip-face sheets, in preparation for the visual audit that would be undertaking.

The third session allowed the team to receive an overview of the remaining audit processes for the landfill and stockpiles components of the project, along with all health and safety protocols required, including those specific to the COVID-19 pandemic.

Following the three days of the training, the team undertook a practical training session to practice the collection and sorting process, from waste characterization to using the scales and the input of data into the KoboToolbox form. The team completed several days of this practical training, contacting the PM with any queries or concerns throughout the process to ensure that all challenges were addressed prior to commencing the actual audit work.

Food outlets sampled

Business name	Location
Wave's Café	Tongatapu
Mum's Café	Tongatapu
Little Italian Restaurant	Tongatapu
CTR Restaurant	Tongatapu
Emerald Restaurant	Tongatapu
HI 5 Delight	Tongatapu
Banda	Vava'u
Belavista	Vava'u
'Isime'eli Restaurant	Vava'u
Market Takeaway	Ha'apai

Admin/office outlets sampled

Business name	Location
ANZ Bank	Tongatapu
NPI Office	Tongatapu
FISA	Tongatapu
MEIDECC	Tongatapu
STT Office	Tongatapu
ATS	Tongatapu
Tonga Post	Tongatapu
TCC	Vava'u
Lulutai Airlines	Vava'u
Ministry of Tourism	Ha'apai

Admin/office outlets sampled

Business name	Location
ANZ Bank	Tongatapu
NPI Office	Tongatapu
FISA	Tongatapu
MEIDECC	Tongatapu
STT Office	Tongatapu
ATS	Tongatapu
Tonga Post	Tongatapu
TCC	Vava'u
Lulutai Airlines	Vava'u
Ministry of Tourism	Ha'apai

Supermarkets sampled

Business name	Location
Molisi	Tongatapu
Si'I Kae Ola	Tongatapu
Luna'eva	Tongatapu
Chi Long	Tongatapu
Star Fish	Tongatapu
Costlow	Tongatapu
MBf Chinese Supermarket	Vava'u
Peter Chinese Supermarket	Vava'u
Chie Supermarket	Vava'u
Luke Supermarket	Vava'u

Hotels sampled

Business name	Location
Kahana Resort	Tongatapu
Vakaloa Resort	Tongatapu
Meida Hotel	Tongatapu
Papiloa Motel	Tongatapu
Ishadora Hotel	Tongatapu
Waterfront Lodge	Tongatapu
Emerald Hotel	Vava'u
Porta Wine	Vava'u
Flying Annie	Vava'u
Fifita Guesthouse	Ha'apai

Retail outlets sampled

Location	Number
Nukunuku, Tongatapu	2
Tofoa, Tongatapu	3
Houmakelikao, Tongatapu	2
Tatakamotonga, Tongatapu	3

Appendix C: Collection sheet

	Date[11]	Auditor		Weather			
	Sample number	GPS location recorded?	Photo?	Interview sheet provided?	Interview sheet returned?	Bags provided?	Comments
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							

[11] Please note that the consultant team used an online tool but collected the below information..

Appendix D: Sorting categories

Material categories, definition and source of data

C	Category	Description	EOL Source	Incoming
Metal	Aluminum cans	Alcoholic sodas and spirit-based mixers, beer and soft drink, food cans, pet food cans, aerosols, industrial cans	H, C, L	Cu, D
	Aluminum recyclable	Steel packaging	H, C, L	Cu, D
	Steel containers	Alcoholic sodas and spirit-based mixers, beer, soft drink, food cans, pet food cans, aerosols, industrial cans, clean/ empty paint cans	H, C, L	Cu, D
	Metal other	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	H, C, L	Cu, D
Fishing	Fishing/ seafood, metal		H, C, L	
	Fishing/ seafood, plastic		H, C, L	
	Fishing/ seafood, wood		H, C, L	
Paper and cardboard	Cardboard	Cardboard without corrugation (glossy and non-glossy), cereal boxes, business cards	H, C, L	
	LPB	Soy milk cartons, some fruit juice cartons, UHT/long-life milk	H, C, L	
	Composite	Composite paper items for which the weight of the paper is estimated to be greater than the weight of the other materials	H, C, L	
	Paper	Office paper, writing pads, letters, envelopes, books, newspapers, newspaper-like pamphlets, paper, magazines, brochures, wrapping paper, labels, paper packaging (no plastic or wax coating)	H, C, L	

C	Category	Description	EOL Source	Incoming
Plastic	PET containers	(Polyethylene) – soft drink, flavored water, fruit juice, sports drinks, plain water (carbonated/non-carb), food containers, mouthwash containers, detergent bottles	H, C, L	Cu, D
	HDPE containers	(High-density polyethylene) milk and flavored milk bottles, bleach bottles, oil containers, food containers	H, C, L	Cu, D
	LDPE containers	(Low-density polyethylene) squeeze bottles	H, C, L	Cu, D
	PVC containers	(Polyvinyl chloride) clear cordial and juice bottles, detergent bottles	H, C, L	Cu, D
	PP	Bottles and containers	H, C, L	Cu, D
	EPS	Yoghurt and dairy containers, vending cups, clam shells	H, C, L	Cu, D
	PS	Meat and poultry trays, vending cups, fragile-item packaging	H, C, L	Cu, D
	PP	Bottles and containers	H, C, L	Cu, D
	Flexibles/film	No shopping bags, just chip packets and other MLM packaging	H, C, L	Cu, D
	Other plastic		H, C, L	Cu, D
Single-use plastic items	Beverage containers	Total count from the beverage container sort	H, C, L	Cu, D
	Cigarette butts		H, C, L	Cu, D
	Cigarette packets		H, C, L	Cu, D
	Straws		H, C, L	Cu, D
	Coffee cups		H, C, L	Cu, D
	Bags – heavy, glossy typically branded carry bags		H, C, L	Cu, D
	Bags – supermarket-type light-weight carry bags		H, C, L	Cu, D
	Takeaway containers plastic other than EPS		H, C, L	Cu, D
	Takeaway containers styrofoam		H, C, L	Cu, D
	Takeaway containers paper		H, C, L	Cu, D
	Takeaway container lids		H, C, L	Cu, D
	Bottle lids		H, C, L	

C	Category	Description	EOL Source	Incoming
Batteries	Non-rechargeable batteries	Common batteries, AAA, AA, etc. single-use	H, C, L	
	Rechargeable batteries	Common batteries (rechargeable), AAA, AA, etc. rechargeable	H, C, L	
	Lead-acid batteries	Large batteries used in vehicles or other machinery	H, C, L	Cu, D
	Mobile phone batteries	Batteries used in mobile phones	H, C, L	Cu, D
	Power tool batteries	Batteries used in power tools	H, C, L	
	Lithium batteries	Small lithium batteries	H, C, L	
	Lithium ion batteries	Batteries used in electric cars	H, C, L	Cu, D
	Other batteries	All other battery types	H, C, L	Cu, D
E-waste	Computer equipment	Keyboard, monitor, hard drives, printers, etc.	H, C, L	Cu, D
	TVs	TVs	H, C, L	Cu, D
	Mobile phones	Mobile phones, phones, pads, charges, car kits, Bluetooth	H, C, L	Cu, D
	Electrical items and 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	H, C, L	Cu, D
	Toner cartridges	Printer and toner cartridges	H, C, L	Cu, D
Glass	Glass bottles	Recyclable (all colors) – beer bottles, wine bottles, spirit cider/fruit-based, flavored water, fruit juice, sports drinks, plain water	H, C, L	Cu, D
	Glass jars	Non-beverage containers (all colors) – sauce bottles, jam jars, vegetable oils, other food containers	H, C, L	Cu, D
	Glass fines	Mixed glass or glass fines < 4.75 mm	H, C, L	Cu, D
	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)	H, C, L	Cu, D
Hygiene	Feminine hygiene	Used disposable feminine hygiene products	H, C, L	
	Pharmaceutical		H, C, L	
	Nappies (diapers)	Used disposable nappies/diapers	H, C, L	
	Medical waste	Sharps, human tissue, bulk bodily fluids and blood, any blood-stained disposable material or equipment	H, C, L	
	Other sanitary waste		H, C, L	

C	Category	Description	EOL Source	Incoming
Organics	Food	Vegetable/fruit/meat scraps	H, C, L	
	Wood/timber		H, C, L	
	Garden organics	Grass clippings, tree trimmings/prunings, flowers, tree wood (< 20 mm diameter)	H, C, L	
	Other organics	Animal excrement, mixed compostable items, cellophane, kitty litter	H, C, L	
Hazardous	Paint	Containers containing paint (dry or wet)	H, C, L	
	Fluorescent tubes	Fluorescent tubes; compact fluorescent lamps (CFLs)	H, C, L	
	Household chemicals	Containers containing bleach, cleaning products, unused medical pills	H, C, L	
	Asbestos	Asbestos and asbestos-containing products or building materials	H, C, L	
	Clinical (medical)	Sharps, human tissue, bulk bodily fluids and blood, any blood-stained disposable material or equipment	H, C, L	
	Gas bottles	Gas bottles	H, C, L	
	Mercury	Mercury used in medical applications	H, C, L	Ministry of Health, hospitals
	Hazardous other	Any other hazardous material	H, C, L	
	Textiles	Wool, cotton and natural fiber materials	H, C, L	
	White goods		H, C, L	Cu, D
	Ceramics		H, C, L	
	Containerized used oil		H, C, L	Cu, Retail
	EOL renewable energy equipment	Includes EOL solar panels	H, C, L	Cu, Power company, installers
	End-of-life vehicles		H, C, L	Cu
	Tires		H, C, L	Cu
	Please describe			

Codes used:

H = Household audit

C = Commercial audit

L = Landfill audit

Cu = Customs

D = Distributors

Appendix E: High-level sorting sheet

APWC: HOUSEHOLD_____
Collection date: _____
Sorting Date: _____

		Material Type	Grams	Volume	Count (where possible)
Metals	Aluminum cans				
		Aluminum recyclable			
		Steel containers			
		Metal other			
		Fishing/seafood metal			
		Fishing/seafood plastic			
		Fishing/seafood wood			
		Paper			
		Cardboard			
		Composite (mostly paper)			
		Liquid paperboard			
		PET containers			
		HDPE containers			
		LDPE containers			
		PVC containers			
		PP			
		EPS			
		PS			
		PP			
		Flexibles/Film			
		Other plastic			
		Beverage containers			
		Cigarette butts			
		Cigarette packets			
		Straws			
		Coffee cups			
		Bags – heavy glossy typically branded carry bags			
		Single use plastic items			
		Bags – supermarket light weight carry bags			

		Material Type	Grams	Volume	Count (where possible)
		Takeaway containers plastic other than EPS			
		Takeaway containers paper			
		Takeaway container lids			
		Bottle lids			
		Glass			
		Glass bottles			
		Glass jars			
		Glass fines			
		Glass other			
		Hygiene			
		Feminine hygiene			
		Pharmaceutical			
		Nappies (diapers)			
		Medical waste			
		Other sanitary waste			
		Organics			
		Food			
		Wood/timber			
		Garden organics			
		Other organics			
		Textiles			
		Ceramics			
		Hazardous			
		Paint			
		Fluorescent tubes			
		Household chemicals			
		Asbestos			
		Clinical (medical)			
		Gas bottles			
		Hazardous other	specify		
		Batteries			
		Non-rechargeable batteries			
		Rechargeable batteries			
		Lead-acid batteries			
		Mobile phone batteries			

		Material Type	Grams	Volume	Count (where possible)
		Power tool batteries			
		Lithium batteries			
		Lithium ion batteries			
		Other batteries			
		E-waste			
		Computer equipment			
		TVs			
		Mobile phones			
		Electrical items and peripherals			
		Toner cartridges			
		Other (specify)	specify		

Appendix F: Detailed list of container categories

BEVERAGE CONTAINER ONLY FURTHER SORT			
	<500	500-1500	>1500
Alumimium			
Alcoholic sodas & spirit-based mixers			
Beer/cider			
Water			
flav water/soft drink (carbonated)			
flav water/soft drink (non-carb)			
Food (human)			
Food (dog and cat)			
Other			
Steel			
Alcoholic sodas & spirit-based mixers			
Beer			
cider/fruit based etc			
flav water/soft drink (carbonated)			
flav water/soft drink (non-carb)			
Other			
LPB			
milk			
flavoured milk			
fruit juice (>90% fruit &/or Veg juice)			
fruit drink			
flav water/sports drink, non-carb			
Beauty and personal care			
Home care (including cleaning)			
Other			
PET			
milk			
drink pouches			
flav. Milk			
flav water/ sports drink etc (non-carb)			
flav water/soft drink (carbonated)			
plain water (carbonated or non-carb)			
fruit juice (>90% fruit &/or Veg juice)			
fruit drink			
Beauty and personal care			
Home care (including cleaning)			
Other			
HDPE			
milk			
drink pouches			
flav. Milk			
flav water/ sports drink etc (non-carb)			
flav water/soft drink (carbonated)			
plain water (carbonated or non-carb)			
fruit juice (>90% fruit &/or Veg juice)			
fruit drink			
Beauty and personal care			
Home care (including cleaning)			
Other			
Other Plastic			
milk			
drink pouches			
flav. Milk			
flav water/ sports drink etc (non-carb)			
flav water/soft drink (carbonated)			
plain water (carbonated or non-carb)			
fruit juice (>90% fruit &/or Veg juice)			
fruit drink			
wine bladders			
Beauty and personal care			
Home care (including cleaning)			
Other			
Glass			
Alcoholic sodas/spirit-based mixers			
Beer			
Cider/fruit based etc			
Flav water/soft drink (carbonated)			
Plain water (carbonated or non-carb)			
fruit juice (>90% fruit &/or Veg juice)			
fruit drink			
Wine (glass only)			
Wine cooler			
Spirit			
Beauty and personal care			
Home care (including cleaning)			
Other			

Appendix G: Landfill gate entry sheet

Date							
Time	**Type of vehicle**	**Waste type**	**Company**	**Premises type**	**Location**	**Size**	**Plate#**
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr / W /M / Mat/Ti/WG/ Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr / W /M / Mat/Ti/WG/ Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		
	F/P/V/ C/S/O	Tr /W/M/Mat/ Ti/WG/Gr/B/O		Hhl/Shop/Acc/C&D/ Of/Caf/PWC/Ch/E/M	1/2/3		

F = Flatbed **P** = Pickup **V** = Van **C** = Compactor (dump truck) **S** = Sedan **O** = Other **Hhl** = Household self-haul
Shop = Any commercial store including shopping centers **Acc** = Resort, hotel, apartments **C&D/Of** = Office **Caf** = Food outlet
PWC = Private waste collector **Ch** = Charity **E** = Educational institution **M** = Municipal waste **Tr** = Trash **W** = Wood **M** = Metal
Mat = Mattresses **Ti** = Tires **Gr** = Green waste **WG** = White goods **B** = Batteries

Appendix H: Landfill audit sheet

Date	Time	Location		
Time				
Plate number				
Type of Vehicle	F/P/V/C/S/O	F/P/V/C/S/O	F/P/V/C/S/O	F/P/V/C/S/O
Size of load				
Source	Hhl/Shop/ Acc/C&D/ Of/Caf/PWC/ Ch/E/M	Hhl/Shop/ Acc/C&D/ Of/Caf/PWC/ Ch/E/M	Hhl/Shop/ Acc/C&D/ Of/Caf/PWC/ Ch/E/M	Hhl/Shop/ Acc/C&D/ Of/Caf/PWC/ Ch/E/M
Compaction (Circle)	**H M L**	**H M L**	**H M L**	**H M L**
Green bags of rubbish				
Other bags of rubbish				
Paper - recyclable				
Paper - non-recyclable				
Cardboard				
Food / kitchen				
Nappies (diapers)				
Dead animals				
Vegetation / garden				
Stumps, logs (10 cm diameter +)				
Wood - furniture, painted wood				
Wood - chipboard, MDF				
Wood - pallets				
Wood - board/pole, untreated				
Wood - board/pole, treated				
Covered furniture				
Carpet and underlay				
Textiles - clothing / cloth				
Textiles - composite (shoes, bags)				
Mattresses - spring				
Rubber - tires				
Rubber / foam				

Glass - containers recyclable				
Glass - plate / other				
Plastic - containers recyclable				
Plastic - plastic bags and film				
Plastic - polystyrene foam				
Plastic - other				
Metals - recyclable containers				
Metals - ferrous (steel)				
Metals - non-ferrous				
Concrete / cement				
Bricks				
Tiles				
Plasterboard				
Clean fill				
Rock / dirt / soil/sand				
Asphalt				
Sludge				
Toner cartridges vol				
Electrical large i.e. white goods				
Electrical medium i.e. televisions				
Electrical small i.e. blender				
Insulation				
End-of-life vehicles				
EOL renewable energy equip				
Paint				
Gas bottles				
Containerized used oil				
Other - organic				

Appendix I: Stockpile Assessment Sheet

Date

Location of stockpile

Photo taken

Material type	☐ Cars ☐ Heavy machinery ☐ Solar Panels ☐ Boats ☐ Gas bottles – acetylene ☐ Gas bottles – oxygen ☐ Gas bottles – cooking ☐ 44 gallon drums ☐ Containers (20 ft) ☐ Containers (40 ft) ☐ Used oil ☐ Iron roofing material ☐ Aluminum cans ☐ Plastic water tanks
Volume of stockpile	
Number of items in stockpile	
Weight of one item (if possible)	
Comments	

Appendix J: Key assumptions and limitations of the study

Time frame	• The audits were carried out to cover one week's waste from selected areas and two weeks at the landfill as a minimum. The data was then extrapolated using mathematical models to obtain the waste disposal and generation rate for the whole of the country. • Seasonal trends (e.g. warmer weather leading to increased consumption of beverages; Easter, Christmas) and weather events (e.g. high rainfall leading to grass growth) may change waste generation over time. • The results of this audit should be treated with caution when comparing the results with reports based on data taken at different times of year. Where weighbridge data was available, the changes in material quantities and times were used to ensure seasonal influences were taken into account.

Representative sample	• APWC audits are carried out using strict random sampling, stratified by geographic area, and population distribution to minimise the chance of this situation occurring. There is always a small probability of inadvertently collecting waste from atypical households, resulting in non-representative data. • The sample for this audit is necessarily small due to the high per-capita cost and resource-intensive nature of waste auditing. However, based on waste audits undertaken across the Pacific, three sample sizes with an estimated error range were provided by the statistician to the field team. The team chose the sample plan that could be achieved with the most success based on operational limitations of time and funds. • Substantial variation was found between disposal rates between rural and urban areas even after accounting for factors like income and consumption. This adds additional uncertainty when using the data we collected to estimate disposal rates for regions we were unable to cover. Modelling has been undertaken and where higher than expected sampling error was found, it was reported.
Sample size limitations	• All surveys carry an element of sampling error, which is the mathematical error associated with using a sample to represent a total population. The error rates associated with sampling are presented in the report.

Weight-based analysis and results

- The collection of data for this audit was recorded by weight. Weight-based analysis has been used in this audit because it is a standard procedure and is the most accurate way to collect data on a number of different types of materials.
- This type of collection may cause some materials to appear to be present in quite small proportions due to their comparatively low densities (e.g. plastic beverage containers). They, however, take up large volume and for considerable part of the waste stream. Volumetric data has been provided in the supporting spreadsheets.
- This study used waste auditing to determine the amount of material imported, waste generated, material recycled and exported. Leakage estimates have not been made but can be undertaken with further analysis of existing data.

Collection method

- For areas with collection services, a household's regular rubbish load was picked up. If households were disposing of any rubbish via other means, this was not picked up in the survey. The numbers collected may be a reasonable estimate of waste going to landfill, but are unlikely to be a reasonable estimate of waste generation rates.
- For areas without collection services, the households were given a bag into which to put three days worth of rubbish. Some households may have taken this opportunity to dispose of extra rubbish, with nappies being a particular concern.

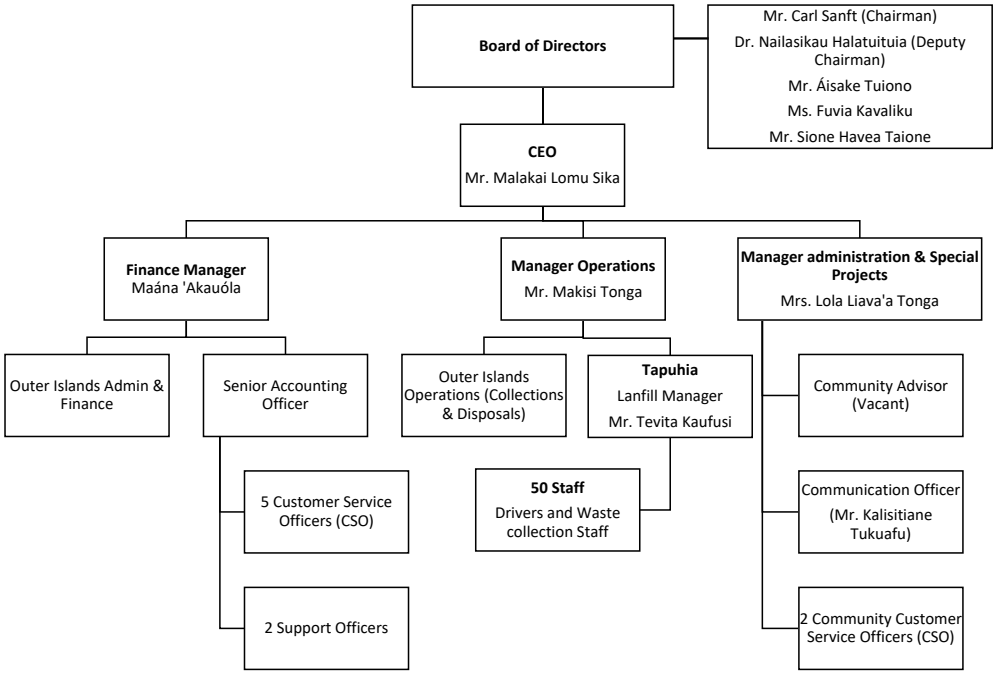
Model assumptions

- The study estimates the waste disposal rates for different islands based on the audit data collected. In order to do so, it was assumed that they displayed a similar pattern of variation to sites we did sample.
- Relationships between variables were assumed to be linear.

Customs data	• Customs data was used to understand the total amount of material arriving in the country. The lifespan of materials was then used to determine the quantities that should be found in waste. This was benchmarked against the waste audit results to ensure accuracy and robustness of analysis as well as the sample collection methodology.

Appendix K: Waste Authority Limited

Waste Authority Limited (WAL) is the implementing agency for waste management services and has seven branches/offices around Tonga. Its main office at Tongatapu has 10 staff, the finance department has six staff, and there is one staff member at the customs office. Branch offices are located at Tapuhia (45 staff), Vava'u (27 staff), Ha'apai (12 staff), and 'Eua (13 staff).



Appendix L: Materials available for recovery

A number of data sources were used to establish the total quantity of material imported, disposed of at landfill, and recycled.

APWC data from March–May 2021 waste audits	Other sources of data
Household audit results	
Commercial audit results	Data available from WAL for overall household waste collection in m^3
Landfill audit results	Import data
Interview results (household, commercial premises, recyclers, producers)	Data recorded manually from the landfill
Stockpile audit results	

The composition of general household and commercial waste for this audit was determined by collecting waste from premises and conducting a detailed audit on the sample contents. A visual audit of waste entering the landfill was also carried out to determine the contribution of larger items and special waste types that do not usually show up in audits of general waste. Both sources of data were combined to determine the overall generation rate of waste in Tongatupu and Vava'u. Ha'apai dumpsite was not audited, so the quantity of special waste types on Ha'apai and other islands was assumed to be the same as on Vava'u.

In summary:

- Detailed audits of household and commercial/office premises waste were conducted to find the composition of bagged waste from each of these locations
- Visual audits were conducted of incoming waste to the landfill for 14 days to determine the composition of waste entering the landfill by source
- The volumetric data from visual audits was converted to weights using density figures for many categories of waste provided by the US EPA, APWC data from past audits, and the Western Australian Waste Authority
- Overall weight compositions determined from visual audits were combined with detailed compositions of bagged waste to get an overall waste composition figure for each source of waste
- The disposal rate was calculated from a landfill entry audit that counted the number of vehicles entering the landfill for 14 days and estimated the quantity of waste on each day. The waste disposal quantities generated using this method were presented as the overall generation rates.

Appendix M: Imports of materials

The process for determining the quantity of imports for Tonga differed from the process carried out for other countries. The customs data provided contained only monetary values for imports and no measure of quantity. Owing to the extra processing involved in the Tonga customs data, these figures are likely to be less accurate than customs figures for previous countries.

- Several hundred HS codes were assigned to around 30 broad categories representing more than 80 percent of imports by value
- From data provided by Samoa and Kiribati, the provided quantities and values were used to estimate a dollar per kilogram ($A/kg) conversion rate for each import category
- The averaged value for each country was converted to Tongan currency to derive a value-to-weight conversion factor
- Since Tonga only provided import figures by value not weight, this conversion factor was used to estimate the tonnage of Tongan imports from the provided value
- For each broad category, the proportion of the imported material eventually ending up as waste was estimated, including what proportion was consumable (for example, it was estimated that PET water bottles are 99.5 percent consumable and 0.5 percent PET waste)
- A combination of predictive models and educated guesses was used to convert all import records that were in volumes or units into weights, and to detect outliers in the raw customs data. Even after this, it is believed some figures were unreliable. In particular, it was found that imports of aluminum cans were far too low and imports of tires were far too high. Import quantities in other categories are believable.

Appendix N: Potential recovery of additional recyclable materials

Imports, generation, and recovery of metals

The estimated imports of aluminum cans (7.7 tonnes imported versus 252 tonnes disposed) and steel cans (33 tonnes imported versus 436 tonnes disposed) were well below the estimated disposal rate. The import data provided for Tonga may be less reliable than other countries assessed because it included dollar values only.

The imports of 'other metals' (3082 tonnes) were substantially higher than the disposal (14 tonnes) and recycling (554 tonnes) rates. It is considered typical that 'metal other' imports exceed disposal and recovery estimates by a significant margin. This is because many imported metals are used in construction. The large differences between imports and disposal likely reflect that metals have a long lifespan within the economy.

Recovery of e-waste, white goods, and batteries

Recovery (346 tonnes) of used lead-acid batteries was much higher than the estimated import rates (48 tonnes per year). Customs data was investigated for omissions but none were found. It was concluded that customs data estimates are unreliable. It is also possible that the lead acid batteries were stockpiled for a few years prior to being exported for recycling.

Disposal (1.4 tonnes) of white goods was 12 percent of estimated imports (171 tonnes) and disposal (100 tonnes) of e-waste was 36 percent of estimated imports (484 tonnes). These figures are more reliable than the figures for batteries and drink containers.

Recovery of plastics

As with metal cans and lead-acid batteries, disposal of plastic drink containers far exceeded imports of plastics of any type.

Other items

Tires were found to be disposed of in larger quantities than imports. Wood disposal rates were 60 percent of imports. This is higher than expected, given modeling typically under-accounts for growth of stocks in items such as wood. Construction disposal rates were 17 percent of imports. A low fraction here is expected, as modeling typically under-accounts for growth of stocks in long-lived items.

Material availability for potential recovery based on situation analysis

The data collected identified a number of recyclable items, such as e-waste, white goods, and containers other than drink containers present in the waste stream that are not currently subject to a levy or a recovery scheme. There is an opportunity for these to be considered in the upcoming review of the CDS as well as for resource-recovery initiatives.

Table 21: Materials available for recovery

	Tonga				Tongatapu				Other islands			
	100% recovery t/y	80% recovery t/y	60% recovery t/y	Percentage volume savings @ 80% recovery (m^3)	100% recovery t/y	80% recovery t/y	60% recovery t/y	Percentage volume savings @ 80% recovery (m^3)	100% recovery t/y	80% recovery t/y	60% recovery t/y	Percentage volume savings @ 80% recovery (m^3)
PET drink bottles	754	603	452	3.7%	529	423	318	2.6%	225	180	135	4.9%
PET cleaning products	659	527	395	3.2%	462	370	277	2.3%	196	157	118	4.3%
All glass drink bottles	423	338	254	1.3%	269	216	162	0.8%	154	123	92	2.1%
Aluminum cans	252	202	151	2.9%	210	168	126	2.4%	42	33	25	2.1%
Single-use plastic bag ban, 20% substitution	658	527	395	1.8%	505	404	303	1.4%	153	123	92	1.8%
Nappies (diapers)	2062	1649	1237	12.7%	1587	1270	952	9.8%	475	380	285	13.1%
Organics	7316	5853	4389	27.5%	6113	4890	3668	22.9%	1203	962	722	20.1%
E-waste	100	80	60	0.5%	93	74	56	0.4%	7	6	4	0.2%
Paper and cardboard	3937	3150	2362	31.8%	3540	2832	2124	28.6%	397	318	238	14.3%
Aluminum other than cans	275	220	165	3.2%	159	127	95	1.9%	116	93	70	6.0%
Ferrous metal	14	11	8	0.0%	12	10	7	0.0%	2	2	1	0.0%
Tires	15	12	9	0.0%	4	4	3	0.0%	10	8	6	0.1%
All of the above	16467	13173	9880	88.7%	13485	10788	8091	73.1%	2982	2386	1789	69.0%
All plastic, glass, metal, tires	3050	2440	1830	16.1%	2152	1721	1291	11.3%	899	719	539	21.4%
All plastic, glass, metal, tires, organics	10366	8293	6220	43.6%	8264	6612	4959	34.3%	2101	1681	1261	41.5%
All food containers only	1429	1143	857	7.9%	1009	807	605	5.8%	420	336	252	9.1%