Master's Research Report

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Municipal Solid Waste Material Flows and Waste Separation Attitudes of Urban Households in Fiji

By

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Certification Page

I, KONUSI Sagaitu Jotama (Student ID 51220627) hereby declare that the contents of this Master's Thesis / Research Report are original and true, and have not been submitted at any other university or educational institution for the award of degree or diploma.

All the information derived from other published or unpublished sources has been cited and acknowledged appropriately.

KONUSI, Sagaitu Jotama

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Abstract

Waste management in Fiji is a critical issue due to a number of problems including a lack of government recycling initiatives, landfilling and incineration of all municipal solid waste (MSW) materials from households and the absence of waste separation practices. In addition to this, Fiji does not have any rich MSW data characterizing the different types of MSW materials received at landfills or those which are produced from households. The absence of waste separation practice means that the underlying waste materials flows within Fiji's waste management system are difficult to determine. Thus, the appropriate long-term strategies to recycle MSW materials cannot be enacted. In order to shift Fiji towards a sustainable waste management system, this study investigates the underlying MSW materials that are produced at the urban household level and attitudes of urban household residents in the greater Suva region towards waste separation.

The software tool Substance Flow Analysis (STAN) was used to identify the MSW material flows and semi-structured interviews were implemented to ascertain the attitudes of household residents. MSW data was leveraged directly from household residents over a one-week period. Households were provided with rubbish bags, to separate waste into six different categories, and weight scales, to weigh all materials entering the household over the one-week period. The rubbish bags were then collected at the end of the week and weighed separately. This data was used to input into the STAN tool to create a material flow map of the household. Two semi-structured interviews were conducted with a single household representative before and after the data collection period. The pre-data collection interview focused on the household's basic information, such as the number of household members and the combined annual income, and the household representatives knowledge of MSW and

Fiji's environmental issues. The post-data collection focused on the waste separation experience of the households during the one-week period.

The material flow from STAN results show that organic waste had the largest quantity, with 64% of the total MSW, followed by paper/cardboard waste with 13%. The average amount of MSW leaving the households was 8kg over the one-week period. The interview results showed that all urban household residents were supportive of the waste separation practice. The main reasons for supporting waste separation were environmental protection and recycling of MSW. The main challenges for households were identifying different types of MSW material and coordinating with other household members to separate waste. Recommendations put forward by household representatives include legislation and policy to support waste separation in households, construction of recycling facilities to motivate residents to separate waste and awareness programs for waste separation in schools, households and workplaces.

Based on the results of the material flows in the household, policies to target organic MSW for alternative uses such as biogas production or composting need to be evaluated. In addition to that, cooperation with existing recycling companies in Fiji to utilize the remaining waste streams need to be examined. The results of the interviews show that a large-scale pilot test of waste separation at home with urban residents in the greater Suva region needs to be implemented. Alongside this, studies to investigate the economic feasibility of constructing material recovery facilities (MRF) to support waste separation practices at home need to be conducted.

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List of Abbreviations

AWPC	**Asia Waste Pacific Consultants**
CHP	**Combined heat and power**
COVID	**Coronavirus disease**
DOE	**Department of Environment**
EU	**European Union**
FJD	**Fiji dollars**
GHG	**Greenhouse gas**
GWh	**Gigawatt hours**
JICA	**Japan International Cooperation Agency**
J-PRISM	**Japanese Technical Cooperation Project for Promotion of Regional Initiative on Solid Waste Management in Pacific Island Countries**
LCA	**Life cycle assessment**
MFA	**Material flow analysis**
MRF	**Material Recovery Facility**
MSW	**Municipal solid waste**
OHS	**Occupational Hazard Safety**
PRIF	**Pacific Regional Infrastructure Facility**
SIDS	**Small Island Develop States**
SPREP	**South Pacific Regional Environment Programme**
STAN	**Substance Flow Analysis**
UN	**United Nations**

Chapter 1: Introduction

1.1 Research Background

Municipal solid waste (MSW) management in Fiji poses a serious challenge due to a number of factors including collection and treatment infrastructure, a lack of incentive programs and a lack of policy to support waste separation in households. Fiji is located in the Pacific region and is composed of over 300 islands with a total geographical area of 18,000 square kilometers. Fiji is a small island developing state (SIDS) that imports a number of goods and products, which after their end-of-life must be treated as waste domestically (Eckelman et al., 2014). Fiji has a single sanitary landfill in Naboro, located near the capital of Suva (Pacific Regional Infrastructure Facility, 2017). A sanitary landfill is an engineered facility where waste is collected, stored and leachate from the accumulation of waste is collected and disposed (Mani & Harvey, 2016). Landfills, which are managed dump sites, and open rubbish dumps, which are non-managed dump sites, are currently the main method of waste treatment. The Naboro landfill has an operational cost of $3 million Fiji dollars (FJD) per year (The Fiji Government, 2019), which heavily burdens the economy of Fiji and blocks necessary funding for a more sustainable short to medium term solution. The Naboro landfill, in addition to seven other dump sites located around town and suburban areas in Fiji, account for an estimated 155,000 tons of MSW every year (Pacific Regional Infrastructure Facility, 2021). However, a significant amount of waste is unaccounted for as it is common for waste to be disposed of in individual households through incineration or illegal dumping (Asian Development Bank, 2014). There are currently no government recycling programs in place but there are 16 private recycling companies operating in the country providing recycling services for the reuse of different materials such as lead acid batteries, paper and

scrap metal (Pacific Regional Infrastructure Facility, 2017). The government cannot enact targeted recycling and reuse initiatives for different types of waste due to the lack of data on the composition and quantity for different streams of waste. The absence of waste separation in Fijian households makes it difficult to determine the quantity of different waste streams. Thus, the need for the implementation of waste separation in the future will be key to enacting recycling and reuse initiatives. These initiatives can support the shift away from the use of landfills, to a circular model whereby MSW materials are recycled, and reduce the dependency on landfills by increasing the material and energy recovery, and minimizing the amount of MSW to be landfilled.

There is no approved MSW quantity and composition analysis available from a Fijian authority. However, there are several waste audits being conducted by the Japan International Cooperation Agency (JICA), Asia Waste Pacific Consultants (AWPC) and Pacific Regional Infrastructure Facility (PRIF) throughout Fiji to gather accurate waste composition data (Pacific Regional Infrastructure Facility, 2021). The MSW audits are complementary to each other and plan to showcase the broader picture of Fiji's MSW quantity and composition. Waste material data is vital in understanding the underlying quantities and composition of different waste types[1]. It can also help identify the potential for alternative uses. Waste in this aspect is all material that has been disposed of or discarded that is of no use or does not serve a purpose to the user. The practice of material flow analysis (MFA) can help to identify waste material types. MFA in its simplest terms is the preservation of energy and matter in an isolated system within set boundaries of space and time, adhering to the basic mass-balance

[1] The JICA funded waste audit for the greater Suva region was discovered after the data collection period had been completed, thus the overlap in the research objectives of this study and the waste audit.

principle (Brunner & Rechberger, 2015). This method can be used to analyze waste streams in various sized systems, ranging from small communities to an entire country. MFA leverages the input, output and process data from within a system to create material flow map for the system. It is able to support waste management and acts as a key decision making tool assessing the waste material flow and connecting key stakeholders (Allesch & Brunner, 2015).

Despite the clear need for a long-term MSW management solution, there are no government incentives in place to do this. However, material flow analysis can be utilized to address Fiji's persistent waste management issues. At the household level waste material data can be leveraged directly from household residents. MSW material composition at the household level can serve as an indicator to the overall composition of MSW in Fiji. What are the waste material flows within households? This paper will use MFA to identify the material flows within Fiji's urban households and outline the quantity, composition and sources of these waste materials. In addition to this, waste separation can be introduced to Fijian households. What do household residents think about the practice of waste separation? This paper will also seek to ascertain the attitudes and opinions of household residents on waste separation.

1.2 Research Questions and Objectives

1.2.1 Research Questions

1. What are the MSW material flows for households located in Fiji's greater Suva region?
2. What are the perceptions and attitudes of urban household residents towards waste separation?

1.2.2 Research Objectives

1. Quantify MSW materials, their various material flows and identify their sources.

2. Ascertain the opinions of urban residents on the practice of waste separation.

3. Provide policy recommendations for Fiji's MSW management system.

1.3 Research Scope and Structure

The research scope is focused on urban areas within Fiji. 55% of Fiji's population now reside in urban areas (Fiji Bureau of Statistics, 2018) and thus makes this a reasonable area to research. The urban area that will be focused on is the greater Suva region. This area is demarcated by Figure 1. The city of Suva is the capital of Fiji. The area surrounding the city is commonly referred to as the greater Suva region. This area is home to the second largest urban population in Fiji (UN-Habitat, 2012). The greater Suva region was selected for this research because of its large urban population. The region's population is estimated to be 93,870 which accounts for 10% of the Fiji's total population of 884,887 and 20% of its total urban population (Fiji Bureau of Statistics, 2018). Thus, the results from this study can be a general representation of urban household patterns in the region.

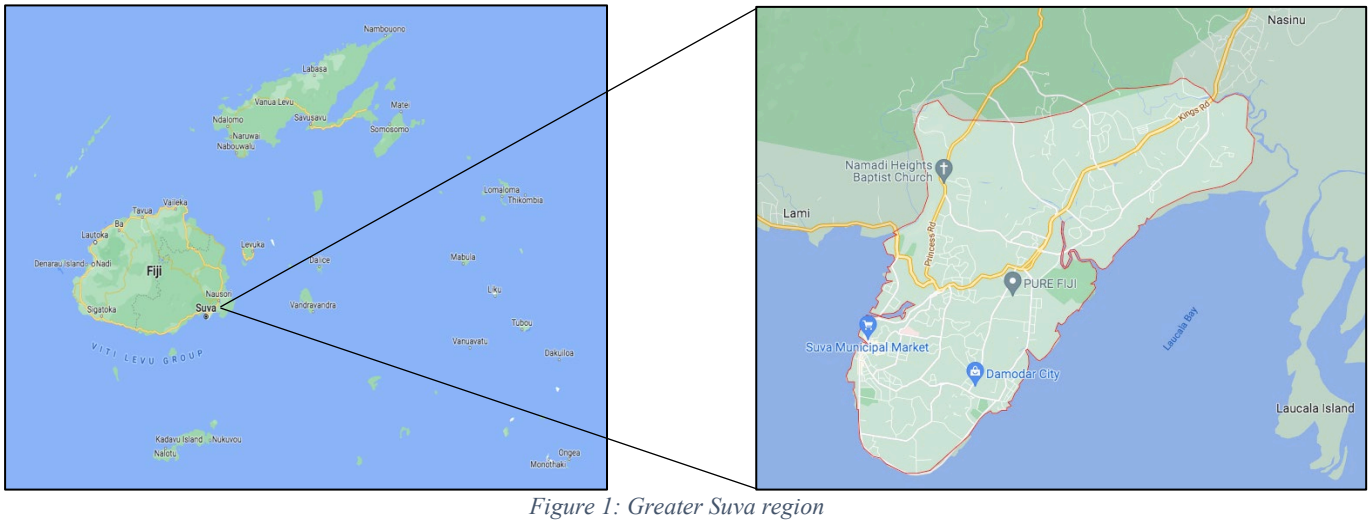

Figure 1: Greater Suva region
(Source: Google, 2022)

This paper is structured as follows. Chapter 1 has highlighted the issues with Fiji's waste management and the need to have MSW composition data to implement effective policies and infrastructural changes. It also introduces how MFA can enable this with waste separation practice and support policy decision making for waste management. The research question, objectives and scope of the research are also included.

Chapter 2 contains a review of Fiji's waste management system. The structure and system of Fiji's waste management, waste situation in households and current issues within the system.

Chapter 3 discusses the current literature around MFA studies. MFA applications, regions for its application and uses as a tool to support decision making in waste management will be outlined. From this, the contribution of this study towards the body of literature will be identified.

Chapter 4 will introduce the methodology for the study. Substance Flow Analysis (STAN) as a framework for the data collected from households for the MFA will be described. The use of semi-structured interviews to attain basic household information and obtain the perspectives of household residents will be outlined. The method of selecting the households, period of data collection and the process of the data collection for the material flow analysis will be discussed.

Chapter 5 presents the results of the material flow analysis of the households, semi-structured interviews with the household representatives and a discussion section on the implications of the results.

Lastly, Chapter 6 outlines policy recommendations, the significance and limitations of the research and the conclusion.

Chapter 2: Waste Management in Fiji

2.1 Institutional Structure

Waste management in Fiji at the national level is the responsibility of the Department of Environment at the Ministry of Environment and Waterways (Ministry of Environment and Waterways, 2020). Under the Department of Environment (DOE), the Waste and Pollution Control Unit is tasked with the authority for solid waste management. Outside of the DOE there are four other institutions that have responsibility and authority. These four institutions are the Ministry of Health, the Ministry of Fijian Affairs, the Ministry of Labour and the Ministry of Local Government (Ministry of Local Government, Housing, Urban Development and Environment, 2011). The Ministry of Health is given authority through the Public Health Act and deals directly with hospital waste management. Health inspectors help coordinate this effort in rural and urban areas. The Ministry of Fijian Affairs is given authority through the Fijian Affairs Act which is vested in the Provincial Councils who oversee waste management in the villages. The Ministry of Labour is given authority through the Occupational Health Safety (OHS) regulations that were implemented in 2007. This authority is vested in the OHS unit under the Ministry of Labour which enforces the safe handling of hazardous waste material by industries and companies. Lastly, the Ministry of Local Government through the Local Government Act are charged with the responsibility of waste management in the cities and towns. Coming down from the national level to the regional level, there are now the provincial councils and municipal town and city councils who manage the collection and disposal of MSW. The provincial councils are charged with the rural areas and the municipal town and city councils with the urban areas (Ministry of Local Government, Housing, Urban Development and Environment, 2011). In both rural and urban areas, waste collection is either serviced by the provincial and municipal councils or

private contractors whose services are outsourced. The disposal of MSW is then taken to a landfill or open dump site.

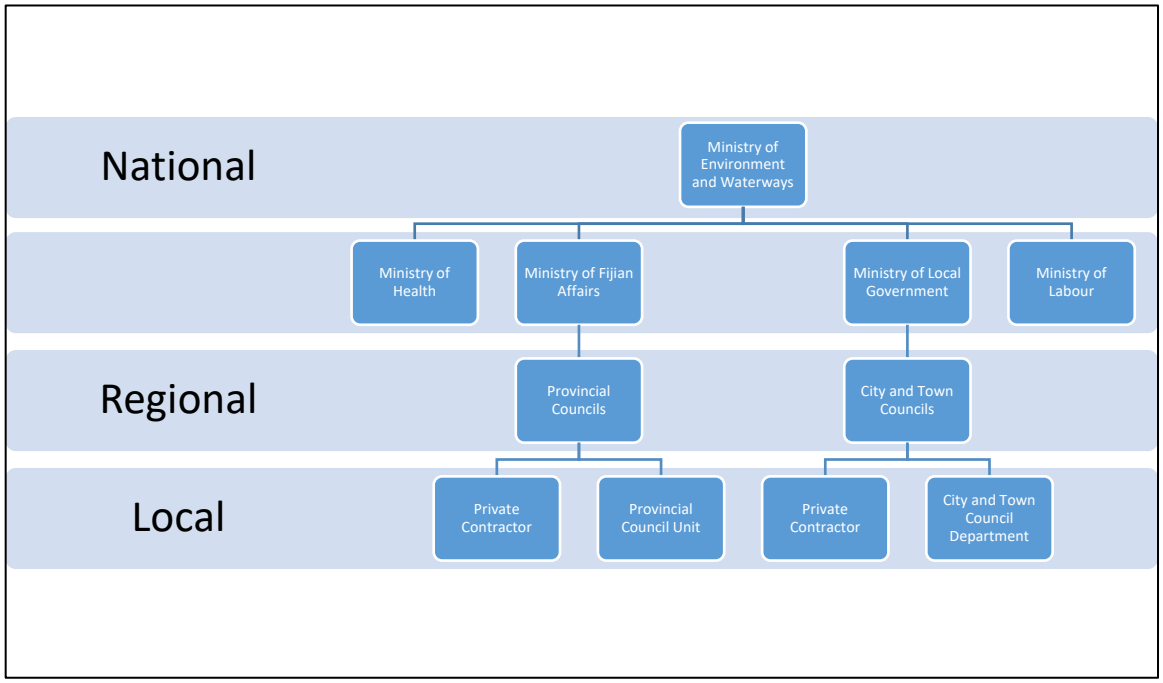

Figure 2:Fiji Waste Management Institutional Structure.
(Source: Ministry of Local Government, Housing, Urban Development and Environment, 2011)

2.2 MSW Collection and Disposal in Households

MSW collection and disposal for all households are the responsibility of the city, town or provincial councils (Ministry of Local Government, Housing, Urban Development and Environment, 2011). Households that do not have access to collection and disposal services often dump their waste into the natural environment or incinerate it (Asian Development Bank, 2014). Waste collected from households are not segregated into different categories. They are collected in a single waste bag before waste disposal services collect them. In the greater Suva region, the disposal services for households collect waste three times a week for general rubbish, including organics, PET bottles, plastics and paper, and once a month to collect green waste, such as grass clippings and tree branches (Ministry of

Local Government, Housing, Urban Development and Environment, 2011). Households with backyard gardens often use organic waste from the household as a fertilizer to add nutrients into the soil which help with crop growth (Asian Development Bank, 2014). This practice is common in rural areas and in urban households with backyard gardens.

2.3 Existing Recycling Programs and Service Providers

2.3.1 Government Programs

The DOE currently runs a composting program to encourage the use of organic waste within households (Secretariat of the Pacific Regional Environmental Programme, 2016). The program is operated by the city and town municipal councils in Suva, Lautoka, Sigatoka, Nadi and Ba. The program initially ran under the Japan International Cooperation Agency (JICA) program J-PRISM but was later adopted by the DOE. The objective is to avert organic wastes being transported to landfill and open dumpsites. The reduction in waste being treated at the disposal sites reduces the economic impact for expenses being spent on landfill operations and environmental burden on the surrounding areas as a result of the increased greenhouse gas (GHG) emissions. The organic wastes are now diverted at the household level where it is utilized through subsidized compost bins. The compost is then used as fertilizer for backyard gardening. Composting is beneficial for Fiji as there is no source separation or large-scale use of organic MSW in anaerobic digestion units. The organic waste would then accumulate at the landfill and form harmful methane gas. Fiji's sanitary landfill in Naboro does not have a methane recovery system (Mani & Harvey, 2016). From a GHG emissions perspective, in the absence of an anaerobic biogas digestion unit, composting is a better alternative as it avoids the production of methane and generates carbon dioxide instead.

2.3.2 Private Recycling Companies

There are currently 16 recycling companies operating within Fiji (Pacific Regional Infrastructure Facility, 2017). All recycling companies in Fiji must have a permit from the DOE to operate. From the 16 recycling companies that are operating, 9 of them deal directly with scrap metal.. Table 1 shows a list of the recycling companies that currently operate within Fiji.

Table 1 Recycling Companies in Fiji

Company Name	Recycled Material
J.P.T Enterprise	Scrap metal, White Goods, PET bottles, Aluminum Cans, Office Papers
Ace Recycling Ltd	Scrap Metal
South Pacific Metal Limited	Scrap Metal
Pacific Scrap Metal Buyers	Scrap Metal
Waste Recyclers	Scrap Metal, PET bottles, Aluminum Cans, Waste Office papers
Fletcher Pacific Steel (Fiji) Ltd	Waste Oil
Pacific Batteries Ltd	Lead Acid Batteries
Coca Cola Amatil	Recycle own products (PET bottles and Aluminum Cans)
Recycling & Composting	Waste from sugar cane industry and poultry farmers
Sun & Bright	Scrap Metal
Sun & Moon Company Ltd	Scrap Metal
City Worldwide Ltd	Scrap Metal
South Pacific Metal Ltd	Scrap Metal
South Pacific Waste Recyclers	Waste Office Papers
Asia Pacific Engineering	N/A

(Source: Japan International Cooperation Agency, 2013)

2.3.3 International and Regional Projects for MSW

There are currently three separate initiatives being run in Fiji through a collaboration of different stakeholders. The first project is called J-PRISM II. The overarching goal of this project is to strengthen sustainable waste management capacity in the Pacific (Secretariat of the Pacific Regional Environmental Programme, 2016). The project is a collaboration between JICA and the Secretariat of the South Pacific Regional Programme (SPREP). J-

PRISM II is currently conducting a waste audit for MSW in Suva. The aim of the waste audit is to quantify underlying waste composition for all MSW produced in the region in support of initiating recycling practices for Fiji (Pacific Regional Infrastructure Facility, 2021).

The second initiative that is active in Fiji is the PacWastePlus Organics Project. This project is targeted at Fiji's rural area and agriculture sector to effectively utilize organic wastes that are produced at homes as organic fertilizer for agricultural crops (Secretariat of the Pacific Regional Environmental Programme, 2021). The Organics Project comes under the PacWastePlus program which aims to build cost-effective sustainable management of solid waste, hazardous waste and waste water (Secretariat of the Pacific Regional Environmental Programme, 2020b). The PacWastePlus program is funded by the European Union (EU). The Organics Project is in its initial stages and is currently collaborating with the Ministry of Environment and Waterways, and iTaukei Affairs Board to identify communities that are willing to adopt the project. Figure 3 shows a snapshot of the project and its main objectives.

Figure 3: Fiji Organics Project Poster
(Source: Secretariat of the Pacific Regional Environmental Programme, 2021)

The third project that has been launched is the Moana Taka Partnership. The Moana Taka Partnership enables Pacific Island states to transport non-commercial recyclable material to overseas recycling facilities using empty containers aboard ships (Secretariat of the Pacific Regional Environmental Programme, 2020a). The initiative is implemented by SPREP and is a part of the broader PacWastePlus initiative. The Moana Taka Partnership has been active in Fiji since its inception in 2018 shipping out over 200 tons of waste from 2019-2020 (Secretariat of the Pacific Regional Environmental Programme, 2020a).

2.4 MSW Management Issues

2.4.1 Economic Aspect of Current MSW Scheme

Fiji currently operates a single sanitary landfill located in Naboro on the main island of Viti Levu (Pacific Regional Infrastructure Facility, 2017). The landfill was initially constructed in 2005 with a capital expenditure (CAPEX) of $14 million FJD, financed through a grant from the European Union (Ministry of Local Government, Housing, Urban Development and Environment, 2011). The DOE is in charge of the supervision of the landfill but the day-to-day operations are contracted to the private company H.G Leach. There are seven other sites of MSW disposal located in Savusavu, Rakiraki, Ba, Lautoka, Nadi and Vunato. The Naboro landfill accommodates the MSW for the large urban population located in the capital city of Suva and the neighboring urban areas of Nasinu, Nausori and Lami. These urban suburbs combined account for the single largest population center catered for by a sole disposal site. The total quantity of waste treated at the landfill annually is estimated at 70,000 tons (Mani & Harvey, 2016). The annual operational expenditure (OPEX) for the landfill is $3 million FJD (Fiji Government, 2019). In addition to this, the exponential increase in MSW output from Fiji's urban areas means that storage cells need to be constructed frequently to accommodate the increase in quantities of waste. The construction of new storage cells incurred a cost $5.2 million FJD in 2019 (Fiji Government, 2019). The lifespan of the Naboro landfill is expected to last until early 2040 but due to the exponential increase in waste production, this date is expected to be brought forward. The DOE outlined its budget in its Strategic Plan 2020-2024 as seen in Table 2. Given the current situation with the maintenance and expansion rate of landfill, the budget stated by DOE is unsustainable in the long term for the continued maintenance of the landfill. An average of 11 million FJD is budgeted per year for the next 3 years (2022-2025) for the DOE and 30% of the budget is spent on landfill operations in Naboro. The continued construction of new

storage cells and increasing amounts of waste from urban households will incur further expenses.

Table 2 Department of Environment Budget 2020-2024

Department	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Department of Waterways	20 million	22 million	25 million	25 million	28 million	120 million
Department of Environment	10 million	12 million	10 million	12.5 million	11 million	55.5 million

(Source:Ministry of Environment and Waterways, 2020)

2.4.2 Lack of Government Recycling Programs

The DOE currently runs a nationwide composting program in Suva, Lautoka, Nadi, Ba and Sigatoka (Secretariat of the Pacific Regional Environmental Programme, 2016). The objective of this program is to divert potential organic waste from landfills to reduce the overall environmental impact. The program has been operational since 2008 and was initially launched in Lautoka and Nadi (Fiji Government, 2019). It has now expanded to include three other towns and cities. However, this is the only program in place to practice recycling at the household and national level. The programs run by private sector companies and international and regional organizations play a much more active role in recycling programs. The programs and initiatives that are operational target other waste streams such as scrap metal, paper, PET bottles and plastic packaging. While the presence of the private sector company and regional organization programs are beneficial, the need for a coordinated and comprehensive national initiative is required to adequately address all MSW streams for recycling. The large expenditure of funds towards the Naboro landfill severely hinders the capacity for the DOE to maintain other ongoing programs such as the composting programs for households and limits investment into new recycling initiatives.

2.4.3 Absence of Waste Separation Practice

Waste separation is scarcely practice at any level of waste management in Fiji, apart from recycling companies that collect waste material from selected sources such a company offices, bottle collectors and scrap metal dealers. The Nasinu Town Council is looking to pilot waste separation as part of its waste management program in 2020 (The Commonwealth Local Government Forum, 2020). In a bid to reduce expenses from waste management services and decrease the amount of organic waste moving to landfills, the Nasinu Town council is looking to implement composting and waste separation programs in households. In addition to this, the regional intergovernmental organization, SPREP, is spearheading a project called PacWastePlus Organics Program in Fiji's rural areas (Secretariat of the Pacific Regional Environmental Programme, 2021). The program will also target the composting of organic MSW for fertilizer production and waste separation in rural households in an effort to reduce organic MSW going to landfills. Apart from these two programs, there are no other initiatives to implement waste separation. The absence of waste separation in households and within the waste management infrastructure means that accurate waste composition data cannot be compiled. The absence of this data reduces the ability of the DOE to implement effective recycling and material recovery initiatives. These initiatives will be key in incorporating various stakeholders from the public and private sectors to attract investment into Fiji's waste management infrastructure. The initiatives will reduce the waste materials flowing into the landfill and instead transform them into economic returns by reinvesting this material into the economy through alternative uses of the MSW material. Without these initiatives in place, the continued economic burden from the landfill operations will continue to debilitate progress for waste management in Fiji.

Chapter 3: Literature Review of Material Flow Analysis Studies

Understanding the material flows of MSW is essential to identifying sustainable waste management opportunities such as recycled material markets for consumers and renewable energy potentials through the use of organic waste to harvest biogas through anaerobic digestion units. Materials flows can be identified using the practice of material flow analysis (MFA). MFA has been conducted in many sectors and regions of the world and is a useful tool in identifying the material flows.

3.1 MFA in Countries of Similar Geography

When looking at countries of geographical similarities, the island nations of the Dominican Republic (Sarkar et al., 2011), Trinidad and Tobago (Millette et al., 2019) and the Galapagos islands located in Ecuador (Cecchin, 2017) have conducted MFA's. Sarkar et al (2011) addressed the issue of scrap tyre waste in the Dominican Republic by creating a material flow account of waste tyres on the island. The country is an island nation thus enabling vehicle import data and vehicle registration to be utilized as the baseline data to determine the accumulation of waste tyres on the island. The outcome of the study identified that 500 tons of tyres were produced per year and that expenditure for shredding and disposal of tyres was uneconomical. Alternatives to recycle whole tyres and export them are discussed. Millette et al (2019) quantified the plastic flows in Trinidad and Tobago, and used the results to better inform strategies towards a circular economy. Similarly to the study by Sarkar et al (2011), import data and domestic production was leveraged to create a material flow map for plastics in the country and identify potentials for diversion of plastic wastes or recycling and reuse opportunities. The study identified a majority of plastic wastes came from imported plastic packaging of products, highlighting the issue of limited demand for end-of-

life import products. The results indicated that the capacity to implement a national recycling program is feasible given the large quantity of plastic wastes and the results could be used to further guide circular economy and waste management decision making. The study used a benchmark of 200 tons for PET bottles, which was adopted from other studies, and the significant amount of LDPE film plastics, 45,000tons, as an alternative for cement production as indicators to further investigate the economic feasibility of these two options. Cecchin (2017) conducted a material flow analysis of the flow of goods in the island of Santa Cruz in Galapagos islands to determine the impact of policy implementations with regards to fossil fuel consumption and the agricultural sector. The policy recommendations from this study included the inclusion of MFA as part of the sustainable development toolbox for decision makers on the island. The inclusion would be able to quantify the flow of goods and products on the island which would support policy implementation and strategies for socioeconomic development on the island.

Within the Pacific vicinity, in the Republic of Palau, Owens et al (2011) carried out an MFA to address marine litter and waste management on the island. The MFA conducted in the Republic of Palau was conducted on one of its outer islands, Kayangel. It looked to determine spatial accounting flow and characterization of all non-burnable waste entering and exiting the island to help identify the main sources of litter into its marine environment. The results were then used to determine the relevant waste management approaches to reduce waste on the island and also identify the impact of marine waste on the island's overall waste production. It identified that over 50% of waste on the island was sourced from marine litter found in the sea while the most significant waste stream in terms of quantity were non-recyclable plastics. The study showed that for SIDS, a link between global waste output (marine litter) and local waste output (household waste) is present.

3.2 MFA at the Household Level

The current literature identified for household level MFA is very limited, with the research conducted by Leray et al (2016) and Ali & Mawlood (2021) being two of the few conducted. The research conducted by Leray et al (2016) was an extended MFA of six households located in Bangalore, India. The MFA conducted focused on the organic metabolic flows at the household level, namely food and drink purchases. The MFA helped to identify the sources, quantities and flows of materials within these urban households and helped formulate the metabolic profiles of each household. MFA was combined with a Social Practice Theory methodology introduced by the researcher to help formulate a metabolic profile for each household and identify individual, sociological and technological tendencies in household consumption. In this expanded MFA study, the results showed that commercial and retail infrastructure, availability of fresh food and sociocultural combined with economic conditions directly affected the varying food consumption practices identified in different households. In addition to this, the ability to effectively store food and avoid food waste were also affected. The study by Ali & Mawlood (2021) used MFA to assist with waste management strategy development for the city of Erbil in Iraq. The research profiled a single household and implemented waste separation practice for a week to collect input and output data for products arriving at the house and waste leaving the house. The outcomes of the study outlined the large generation of organic waste as covering 75% of total waste output while the remaining waste were split between combustible and non-combustible waste. Through this, the researchers were able to identify that use of organic waste in households could significantly decrease total waste output in the city.

3.3 Research Gap

The current body of academic literature lacks MFA studies that are conducted at the household level. In addition to this, there is only one MFA study conducted within the Pacific region. Thus, this study will contribute to the existing literature by conducting an extended MFA study at the household level for residents residing in the greater Suva region. This will address both the lack of literature at the household level and in the Pacific region. It will also address the clear lack of understanding on the quantity and types of MSW produced by individuals in their households. This information is vital in adopting long term strategies to recycle MSW at the household level. The extension of this MFA study includes the investigation into urban residents' attitudes towards waste separation. This will look to determine the perspectives of individuals on waste separation which will be essential to consider if waste separation is to be adopted in the future. The study not only contributes to the body of literature but addresses key environmental and economic issues for Fiji regarding its MSW management system.

Chapter 4: Research Methodology

The methodology for this research is divided into three components. These components are the use of the Substance Flow Analysis (STAN) tool, semi structured interviews and the data collection process. The MFA component using STAN uses the waste material data gathered during the data collection period to create a material flow map of the households. The semi-structured interviews are used to ascertain basic information from the households and garner the opinions from household residents regarding the practice of waste separation. The data collection process details the lead up to the data collection period, process during the data collection and post-data collection period. These three components will be discussed in detail in the following sub-sections.

4.1 Material Flow Analysis using STAN

The MFA is conducted with the use of the software system STAN. STAN is a software system created to support material flow analysis, assembling all the features of the analysis, graphic modelling, data calculations and graphical presentation of resulting material flows (Cencic & Rechsberger, 2008). The software will help identify the quantities and material flows of the materials in the household system. STAN uses the mass balance principle in order to account for all materials coming in and out of the system. The mass balance equation is show in Equation 1.

Equation 1: Balance Equation: $\sum inputs = \sum outputs + change\ in\ stock\ transfer$
(Source: Cencic & Rechburger, 2008)

STAN allows users to create a model MFA diagram tailored to the system they are studying. In this case, the system model is based on the households in this study. A graphical

interface allows users to enter data on materials entering the system as ‘inputs’ and materials exiting the system as ‘outputs’. These two categories of data entries were fulfilled using the data collected from the households. However, the data on materials remaining the system as ‘stocks’ or undergoing changes through ‘processes’ such as household consumption cannot be accounted for in this study. This is due to the fact that materials that came into house and remained as stocks and those that were consumed during the week from the materials entering the household were not differentiated during the data collection period. Any uncertainties regarding input, processes, stocks and outputs within the designed systems are accounted for by STAN using error propagation methods that have been designed into the program. At the conclusion of the data collection period for all households, MFA will be implemented using the input and output data from the households. To apply MFA in the context of this research, the following will need to be carried out:

i.) clearly define the scope and objective:
ii) to set the system's spatial and temporal boundaries:
iii) to select the relevant flows and processes
iv) to calculate the flows, stocks and to consider uncertainties
v) to interpret and present the results in an appropriate way

The scope and objective of the system have already been described. The systems temporal boundary is one-week and spatial boundary is the household of participants. The relevant flows encompass all materials entering the household and all waste materials exiting the spatial boundary of the household system. The materials entering and exiting the system are measured in kilograms. The processes in this study consist of the consumption of materials by household members and stocks of materials remaining in the household. Calculation of

materials flows were done using the data collected during the research week before the results are interpreted and presented as an MFA diagram using the STAN tool.

The qualitative data obtained from the semi structured interviews and quantitative data shown using STAN will paint a comprehensive picture of the waste material streams in households and waste separation practice issues faced by urban residents.

4.2 Semi-Structured Interviews and Data Collection Process

4.2.1 Pre-Data Collection

A sample size of 10 households within the greater Suva region were selected for the research. The sample size of 10 households took into consideration the time it would take to gather data within the four-month data collection period and validity of the results given the sample size relative to the population of the greater Suva region. The households were selected on the basis of being located within the greater Suva. The households were also selected in a manner to ensure a diversity in number of household members, locations in the greater Suva region and socioeconomic background. This was to ensure the sample of ten households represented a diversity backgrounds of households located in the region. Contact with the household acquaintance was first established to disseminate information about the research, determine the feasibility of participation of the household in the research and select a time period when the data collection for the research could take place. All meetings and contact with households were conducted online as the researcher was not present in Fiji to communicate directly with household participants. As a result of this, all groundwork with regards to the data collection and direct contact with household members were carried out via a research assistant who assisted with the data collection process. Contact with household acquaintances was established through online messaging platforms such as Messenger, Viber or WhatsApp depending on the convenience to the acquaintance. Information disseminated to

household representatives included aims and objectives of the research, and participant responsibilities during the data collection period. Feasibility aspects of households in participation ensured that a one-week period could be dedicated for data collection, all responsibilities of the households could be carried out and that no special events such as family gatherings or social events took place during the one-week period. The one-week period was determined as the minimum time period required to observe consumption patterns by households (Williams et al., 2012). A one-week time period was also adopted by Leray et al (2016) and Ali & Mawlood (2021) in their MFA studies for households. The requirement that no special events take place during the one-week data collection period was to ensure that household consumption patterns during the week replicated a typical week for the household. Any special event during the week would disrupt typical consumptions that would occur within the households.

Once participation of the household and the data collection time period were confirmed a pre-data collection meeting was organized. All meetings and interviews with household representatives were conducted via Zoom and recorded for data collection and analysis purposes. The aim of the pre-data collection meeting was to determine basic information about the household representative and household members, ascertain the understanding of the representative with regards to waste and environment issues, and give an overview of the data collection process during the data collection period. Within the pre-data collection meeting a semi-structured interview was implemented. The interview conducted before the data collection period was aimed at obtaining basic information about the household representative and members, and ascertaining the representatives understanding of waste and environment issues. The pre-data collection interview was split into two parts. The first part targeted household information related to number of members of the household, gender composition, education level and combined income of the household. The second part

aimed at determining the extent of the knowledge of the household representative with regards to local waste management activities, household waste production and national environmental issues. An overview of the one-week data collection period and household representatives and members responsibilities were explained directly to the household representative. The responsibilities for household members were as listed below:

1. Weigh all shopping items and products that are brought into the household with the provided weight scale.
2. Take a picture of all shopping items and products brought into the household.
3. Upload the pictures taken into the appropriate Google Drive folders that have been created.
4. Separate all waste into the appropriate waste bag provided as categorized below:

I. Organic Waste

II. PET bottles

III. Plastics

IV. Paper and Cardboard

V. Steel/Tin/Aluminum Cans and Glass

VI. Miscellaneous items (items which do not fit into any of the categories above)

The definition and categories for each of the waste material categories were determined according to the Waste Audit Methodology handbook published by the Pacific Regional Infrastructure Facility (2019). Organic materials are typically breakdown naturally in the environment without treatment. Organic materials include food waste such as vegetable, fruit and meat scraps, and garden wastes such as tree, grass and wood clippings. PET bottles are polyethylene material containers. These include soft drinks, sports drinks,

water bottles and detergent containers. Plastics come in a variety of forms including single-use plastics, polyvinyl chloride material and low-density polyethylene containers. Plastics include plastic straws, shopping bags, cigarette packets, detergent bottles and fragile item packaging. Paper and cardboard are composed of composite paper and hard cardboard material. These include office paper, cereal boxes and paper packaging. Steel/Tin/Aluminum and Glass materials include a variety of items including soft drink and alcoholic beverage cans, beer bottles, jar lids, food cans and assorted food containers. Miscellaneous items include any waste material that do not fit into the above categories.

All items entering the household needed to be weighed to account for the material coming into the household. The pictures taken by household members are to use as reference for the weight of materials coming into the house. The wastes during the week are divided into the six categories listed above. This is done to collect data on the waste stream coming out from the household. Any questions or issues on the part of the household representative were dealt with here before proceeding with the data collection week. At the conclusion of the pre-data collection meeting, household representatives were given access to a Google Drive folder which contained three items. The first was a document outlining the responsibilities of the household representatives and members during the data collection week (Appendix 1). This document was used as a reference by participants to remind them of the different tasks to keep track of during the week. The second was a waste audit booklet published by the PRIF titled Waste Audit Methodology: A Common Approach (Pacific Regional Infrastructure Facility, 2019). Within the booklet is a waste classification guide index. The guide was used as a reference for households to refer to in assistance of their waste separation activities during the data collection week (Appendix 2). The third item was a collection of folders titled with dates for each day of the relevant data collection week. In these folders, participants would be requested to upload photos of shopping and items

brought into the household during the week. A day before the beginning of the data collection week, a weight scale and rubbish collection bags were dropped off with the households to use during the week.

4.2.2 Data Collection Period

During the data collection week, the researcher contacted the households at the end of every day to clarify any issues or answer any questions from the household representatives with regards to data collection activities throughout the day. The researcher also used this time to ensure procedures were followed such as weighing of shopping and items coming into the household and uploading of pictures into the Google Drive files. Examples of pictures taken of shopping brought into the household, household members weighing the shopping and the setup of the waste bags are shown below in Figure 5, 6 and 7.

Figure 4: Picture of shopping taken by household member
(Source: The author)

Figure 5: Household member weighing material brought into the household (Source: The author)

Figure 6: Setup of waste separation bins (Source: The author)

At the end of the one-week period, the rubbish bags and weight scales were picked up from the household. The rubbish bags were then weighed and the weight information for each of the six waste categories was noted down. Due to the large rubbish bags and a small surface area of the scale, a bucket was used to store the bags in while taking the reading of the weight. The weight difference from the bucket and added rubbish bag was taken as the final

reading. The waste bags with their rubbish were then disposed of. A picture of the rubbish bag weighing process is shown in Figure 8.

Figure 7: Weighing rubbish bags
(Source: The author)

4.2.3 Post-Data Collection

After the data collection week, a post-data collection meeting was organized. The meetings were conducted one-on-one with the household representative. The aim of the post-data collection meeting was to ascertain the opinions and experience from household representatives and members about the practice of waste separation during the one-week period. A second semi-structured interview was implemented to obtain this information. The interview conducted after the data collection period was to gather feedback on the experiences and opinions on of the households on waste separation practice during the data collection period. The post-data collection interview investigated the experiences of the household members practicing waste separation. The questions targeted the household representatives' experiences, the challenges faced during the waste separation process and

recommendations that household members had to improve the waste separation practice. The interviews were semi-structured in nature. The reason for this was to allow participants to expand upon their understanding and experiences during the data collection period. This also allowed the researcher to ask follow-up questions to gain a deeper understanding on the thoughts and opinions of household representatives and members. At the conclusion of the meeting, all information obtained from the interviews were noted down and tabulated.

Table 3: Pre-Data Collection Interview Questions

Pre Data Collection
Basic Information
1. What is your full name?
2. What is your age?
3. What is your gender?
4. What is the total number of people in your household?
5. What is the gender of the other people in your household?
6. What is your education level?
7. What is the total income of the household per month?
Waste and Environmental Problem Knowledge
8. Do you know what is waste classification?
9. Do you know the final destination of your waste when you dispose of it?
10. Do you know how much waste you produce everyday? What would be your estimate?
11. In your opinion, what are Fiji's environmental problems?

(Source: The author)

Table 4: Post-Data Collection Interview Questions

Post Data Collection
Waste Separation Experience
1. What was your experience with separating waste over the one week period?
2. What are some of the challenges you faced while separating the waste?
3. Do you think waste separation should be implemented in households? If yes, why? If no, why?
4. What suggestions do you have for the types of wastes that should be separated?
5. Do you have any further recommendations or comments on the waste separation process?

(Source: The author)

Chapter 5: Results and Discussion

5.1 Pre-Data Collection

5.1.1 Household Information

Tables 5 and 6 display the basic household information with regard to each respondent. There were 7 questions asked to household representatives in this first part of the pre-data collection interview. The questions were regarding their full names, age, gender, number of people in their household, the gender composition of the household, the representatives level of education and the combined income of the household. Household representatives were sorted into three different age groups. The age groups are 18-25, 26-40 and 41-50. Eight household representatives came from the 18-25 age group, one from the 26-40 age group and one from the 41-50 age group. For the gender composition, eight of the household representatives were male and two were female. Looking at the number of people per household, the number varied greatly. The number of household members were between two to eight members. Two households contained 2 people, one household contained 4 people, one household contained 5 people, three households contained 6 people, two households contained 7 people and one household contained 8 people. The level of education for household representatives ranged between diploma to postgraduate degree studies. One representative had a diploma, eight representatives were undergraduate degree holders and one representative is currently undertaking their postgraduate degree studies. The combined income for households ranged from $0-$20,000 FJD to $80,000+ FJD. Two households had an income of $0-$20,000 FJD, two households had an income of $20,000-$40,000 FJD, three households had an income of $40,000-$60,000 FJD, one household had an income of $60,000-$80,000 FJD and two households had an income of $80,000+ FJD.

Table 5: Household Information for Respondents 1-5

Name	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5
Age	18-25 years old	18-25years old	18-25 years old	18-25 years old	18-25 years old
Gender	Male	Male	Male	Female	Female
People in Household	2 people	6 people	7 people	7 people	2 people
Gender Composition	1 male and 1 female	5 males and 1 female	2 males and 5 females	1 male and 6 females	1 male and 1 female
Education Level	Bachelors degree	Bachelors degree	Bachelors degree	Bachelors degree	Bachelors degree
Household Income	$0-$20,000	$80,000+	$40,000-$60,000	$20,000-$40,000	$20,000-$40,000

(Source: The author)

Table 6: Household Information for Respondents 6-10

Name	Respondent 6	Respondent 7	Respondent 8	Respondent 9	Respondent 10
Age	18-25 years old	26-40 years old	18-25 years old	18-25 years old	40-50 years old
Gender	Male	Male	Male	Male	Male
People in Household	6 people	5 people	8 people	4 people	6 people
Gender Composition	4 males and 2 females	4 males and 1 female	4 male and 4 female	3 males and 1 female	1 male and 5 females
Education Level	Bachelors degree	Postgraduate	Diploma	Bachelors degree	Bachelors degree
Household Income	$40,000-$60,000	$80,000+	$40,000-$60,000	$0-$20,000	$60,000-$80,000

(Source: The author)

5.1.2 Knowledge of Waste and Environment Issues

Table 7 and 8 displays the individual answers for each representative regarding questions 8 to 11.

Table 7: Waste and Environmental Problems for Respondents 1-5

Question Number	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5
8 **Waste Classification**	Yes	Unsure	Unsure	Unsure	Yes
9 **Destination of waste**	Yes	Yes	Unsure	Yes	Unsure
10 **Quantity of waste**	Unsure	Yes	Yes	Unsure	Yes
11 **Fiji's environmental problems**	Ocean pollution and public littering	Ocean pollution and public littering	Ocean pollution and public littering	Climate change	Public Littering

(Source: The author)

Table 8: Waste and Environmental Problems for Respondents 6-10

Question Number	Respondent 6	Respondent 7	Respondent 8	Respondent 9	Respondent 10
8 Waste Classification	Yes	Yes	No	Yes	Yes
9 Destination of waste	Yes	No	Yes	Yes	Yes
10 Quantity of waste	Unsure	Unsure	Yes	Yes	Yes
11 Fiji's environmental problems	Ocean pollution, public littering	Ocean pollution and public littering	Public littering	Poor waste management and climate change	Poor waste management

(Source: The author)

The questions in this part of the interview looked to ascertain the knowledge of the representatives on the term 'waste classification', the destination of waste once it leaves the household, quantity of waste produced daily in the household and Fiji's environmental issues. The range of answers for the first 3 questions ranged between 'Yes', 'Unsure' and 'No'. 'Yes' affirmed that the respondent fully understood and answered the question correctly.

'Unsure' shows that the respondent was somewhat aware but unable to fully divulge a clear answer. 'No' means the respondent was unaware and did not have any understanding of the question. Question 8 regarding waste classification showed that 6 respondents answered 'Yes', 3 respondents answered 'Unsure' and 1 respondent answered 'No'. Question 9 is regarding the destination of waste from the households to the disposal area. 6 respondents had answered 'Yes', 3 respondents had answered 'Unsure' and 1 respondent had answered 'No'. Question 10 asks respondents about their awareness with regards to the quantity of waste produced every day in the household. 5 respondents answered 'Yes', 4 respondents answered 'Unsure' and 1 respondent answered 'No'. Question 11 tried to determine what household representatives' thought Fiji's environmental problems were. Some respondents gave multiple answers while others gave a single answer. The most popular answer amongst respondents was 'Public Littering' which garnered 7 responses. The second most common issues mentioned was 'Ocean Littering' with 3 responses. The third most mentioned issues were 'Poor Waste Management' and 'Climate Change with 2 responses each. The final environmental issue mentioned was 'Plastic Overuse' with 1 response. The results for the answers of Question 11 are displayed below in Figure 9.

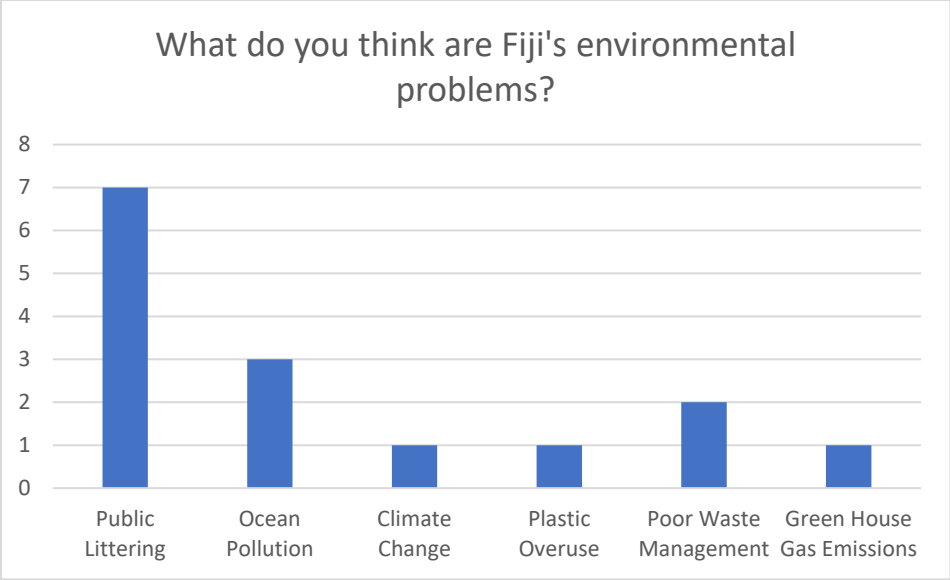

Figure 8: Fiji's environmental problems

(Source: The author)

5.2 Post-Data Collection

5.2.1 Waste Separation Experience

Table 9 and 10 outline the individual answers of household representatives and their experiences with waste separation during the week. Figure 10 to 15 and Table 11 display the results of the respondents to the interview questions. The post-data collection interview was composed of seven questions, 5 open-ended questions and 2 close-ended question. The questions asked looked to investigate the experiences of household representatives and the practice of waste separation during the week, challenges they faced with the practice and whether it was difficult or easy for them. Then it further looked into whether household representatives would implement this practice of waste separation, why they would or would not implement it, suggestions for the types of wastes that should be separated and some recommendation and final comments regarding the practice of waste separation.

Table 9: Waste separation experience respondents 1-5

Question Number	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5
1 **Overall Experience**	Increase awareness on waste produced and cross checking waste bags.	Increase awareness of waste produced and cross checking waste bags.	Collected all the waste in one bag before separating, labelled rubbish bags and increased awareness of waste produced.	Difficult at first became easier with practice and labelled rubbish bags.	More hygienic.
2 **Challenges**	Identifying types of waste material	Coordination with other household members and storage.	Coordination with other household members, storage, separating multiple material products and unhygienic.	None	Storage
3 **Difficulty Level**	Neither	Neither	Difficult	Easy	Easy
4 **Waste separation reasons**	Yes. Recycling and increases awareness of waste we produce.	Yes. Environmental protection and recycling.	Yes. Beneficial for areas that don't have frequent collection services and recycling.	Yes. More hygienic.	Yes. Increases awareness of waste we produce.
5 **Number of categories**	6 categories.	6 categories.	7 categories. Extra category for sanitary products. accommodate waste.	4 categories. PET/Plastics, Aluminum/Glass, Paper/Cardboard and Miscellaneous.	6 categories.
6 **Recommendations**	Provide tools at the household level to separate waste.	Waste categorization guide for households and methodology for separating waste.	Need to implement legislation.	Specific waste separation technique for organics and color coded bags for different waste.	Education in school on waste separation and change in attitudes of people.

(Source: The author)

Table 10: Waste separation experience respondents 6-10

Question Number	Respondent 6	Respondent 7	Respondent 8	Respondent 9	Respondent 10
1 Overall Experience	Increased awareness of waste produced.	Difficult at first became easier with practice and collected waste in a single bag before separating.	Cross checking the waste bags and difficult at first but became easier practice.	Helped with waste organization and more hygienic.	Difficult at first but became easier with practice and more hygienic.
2 Challenges	Identifying type of waste material, separation, coordination with household members and storage.	Identifying types of waste materials.	Identifying type of waste material and coordination with household members.	Identifying type of waste material.	Identifying type of waste material.
3 Difficulty Level	Difficult	Difficult	Easy	Easy	Difficult
4 Waste separation reasons	Yes. Environmental protection and recycling.	Yes. Environmental protection and recycling.	Yes. Increases awareness of waste we produce.	Yes. More hygienic.	Yes. Environmental protection and recycling.
5 Number of categories	5 categories. Plastic, PET, Aluminum/Glass, Paper/Cardboard and garden refuse/organics.	6 categories	3 categories. Organic waste, recyclable and non-recyclable	2 categories. Organic waste plus recyclables.	6 categories.
6 Recommendations	Less categories to separate waste.	Alternating days for waste pickup.	Community level programmes to practice waste separation at home.	Raise awareness on waste separation.	Need to implement legislation and target supply side of supply chain.

(Source: The author)

Question 1 is regarding overall experience with the waste separation practice. The most received comment is that it was ‘Difficult at first but became easier with practice’ with 5 responses. This was followed by ‘Increased awareness of waste produced’ with 4 responses and ‘Cross checking the waste bags’ with 3 responses. With 2 responses each were ‘Labelling waste bags’, ‘Collecting in one waste bag before separating’ and ‘More hygienic’. With only 1 response was ‘Helped with waste organization in general’.

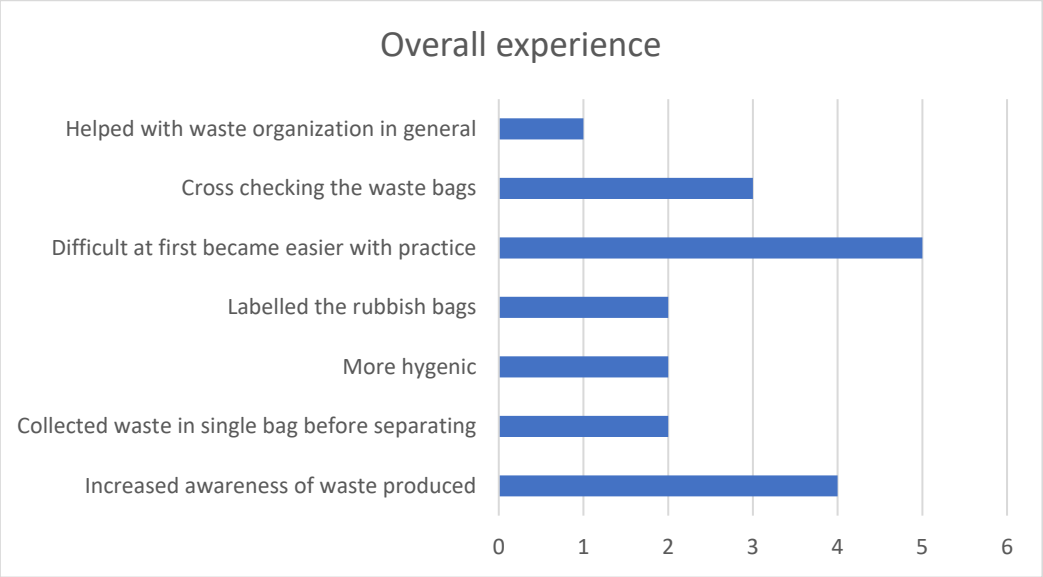

Figure 9: Overall experience
(Source: The author)

Question 2 looked into the challenges faced by households with waste separation. The challenge that garnered the most responses was ‘Identifying types of waste materials’ with 6 responses. After this was ‘Coordination with other household members’ with 4 responses and ‘Storage’ with 3 responses. Finally, with 1 response each was ‘Separating waste products with multiple materials’ and ‘Hygienically handling waste’.

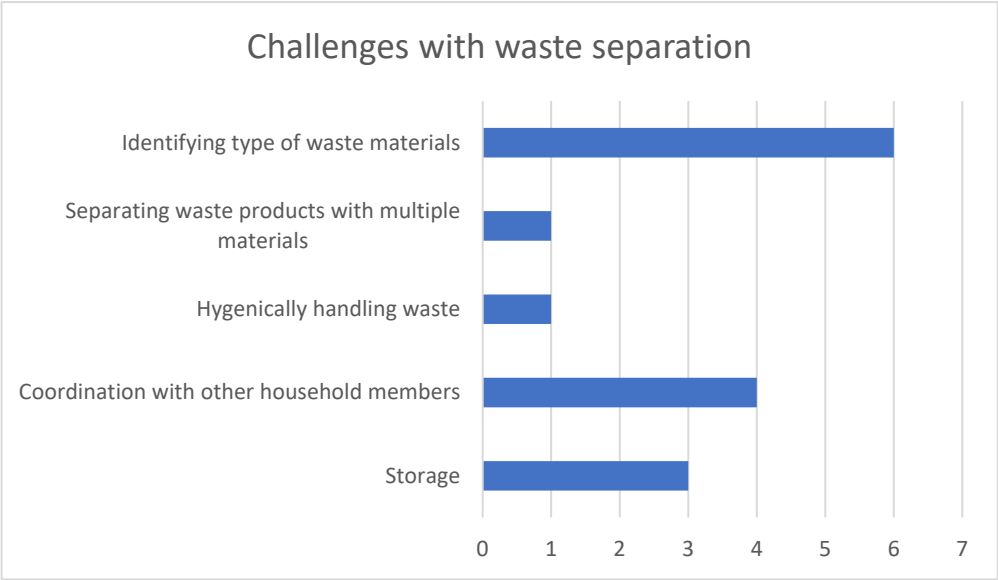

Figure 10: Challenges with waste separation
(Source: The author)

Question 3 asked whether representatives found the waste separation practice 'Difficult', 'Easy' or 'Neither difficult or easy'. There were 4 responses each for 'Difficult' and 'Easy' while there were 2 responses for 'Neither difficult or easy'.

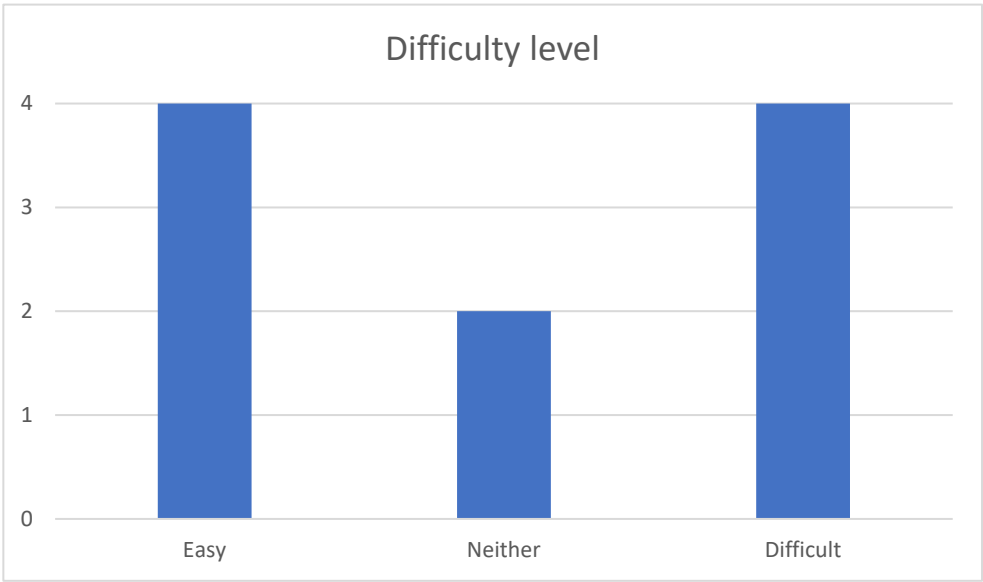

Figure 11 Difficulty level
(Source: The author)

Question 4 asked whether respondents think the practice of waste separation should be implemented. This question garnered a 'Yes' from all respondents. The follow up to this was to state the reasons for why they think waste separation should be implemented. The most cited reason for the implementation of waste separation was to support 'Recycling' with 5 responses. The second most cited reason was 'Environmental Protection' with 4 responses. This was followed by 'Increase awareness on the waste we produce' with 3 responses and 'More hygienic' with 2 responses. The final reason stated was 'It would be beneficial to areas that don't have consistent waste disposal services' with 1 response.

Figure 12: Reasons to implement waste separation
(Source: The author)

Question 5 asked what representatives suggested should be the number of waste categories to be separated and what these waste categories would be. The most recommended number of categories to be implemented was '6 categories' with 5 responses. Second was '4 categories' with 2 response followed by '2 categories', '3 categories' and '7 categories' with 1 response each. Looking at the types of waste categories to be implemented, 'Organics' was

the most mentioned category with 9 responses. Second to this was ‘Aluminum/Glass’ and ‘Paper/Cardboard’ with 8 responses. This was followed by ‘Miscellaneous’ with 7 responses, and ‘PET bottles’ and ‘Plastics’ with 6 responses each. ‘PET bottles/Plastics’ and ‘Recyclable’ received 2 responses each while ‘Non-Recyclable’ and ‘Sanitary Products’ received 1 response each.

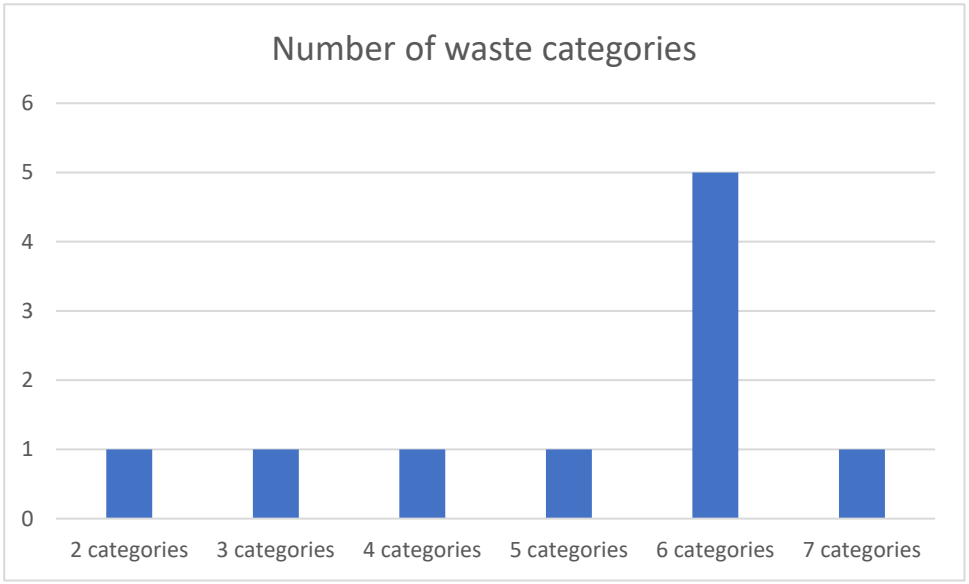

Figure 13: Number of waste categories
(Source: The author)

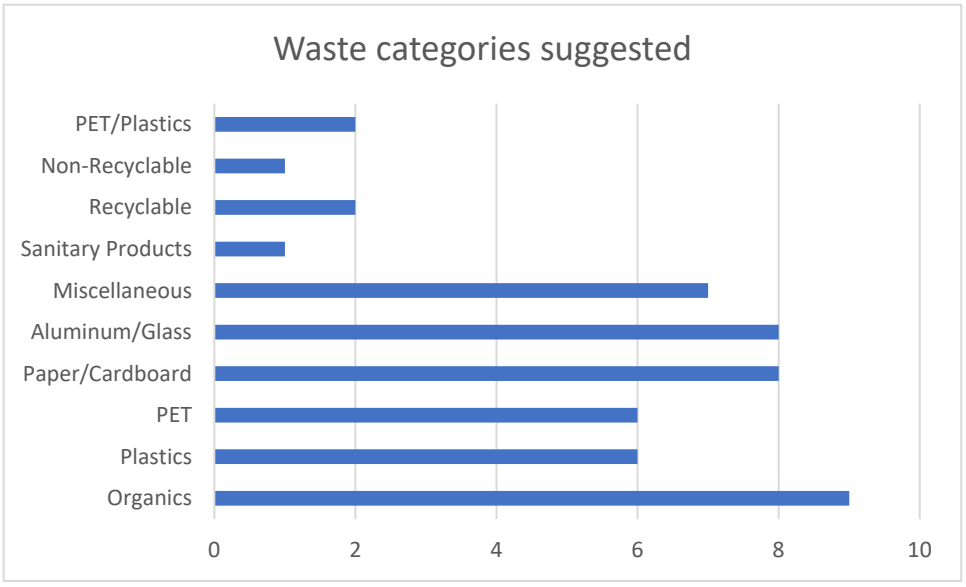

Figure 14:Waste categories suggested
(Source: The author)

Question 6 is regarding recommendations and comments about waste separation and it received various types of responses. The responses are tabulated below in Table 12. At a glance, the responses targeted tools and methods to make waste separation easier in households, education and awareness for waste separation outside the house and legislation to support waste separation.

Table 11: Recommendations to support waste separation implementation

Recommendations	Number of Responses
Waste categorization guide for households	1
Methodology for separating waste households	1
Need legislation to implement	2
Need to change in attitudes from people	2
Provide households the tools to separate waste	1
Color coded bags for different waste types	1
Specific waste separation technique for organic	1
Education in school on waste separation	1
Less categories of waste	1
Alternating days for different waste because they fill up at different rates	1
Community level programs to practice waste separation in households	1
Raise awareness on waste separation	1
Target supply side of supply chain	1

(Source: The author)

All answers in the 'Results' section of the research were synthesized by the researcher to produce an extensive but digestible table of figures and results. Additional comments from household representatives not mentioned in this section are brought up in the 'Discussion' section to cultivate critical analysis and support findings from the 'Results' section.

5.2.2 Material Flow Analysis

The results of the MFA are as shown in Figure 15 and 16. Figure 15 displays the results on average for each household and Figure 16 displays the average for an individual. The sources of materials into the household include supermarkets, fruit and vegetable markets and backyard gardens. The average input of material into the household per week was 35.61kg and for individuals was 5.38kg. 28kg of the materials entering the household either remained in the household as 'Household Stock' or was digested through the process of 'Consumption' while for each individual it was 3.86kg per week. 'Household Stock' is the act of keeping those materials within the system without using them or it undergoing any changes. 'Consumption' is the process of the materials being consumed by the household members as a food source. The remaining 8kg of materials exited the household as waste and for the materials exiting the household for individuals it was 1.52kg. The materials exiting the household were divided into 6 different streams. Swapna & Singh (2018) estimate a 129.6kg per person per annum generation rate for the greater Suva region. When divided by 52 weeks, this comes to 2.5kg per person per week.

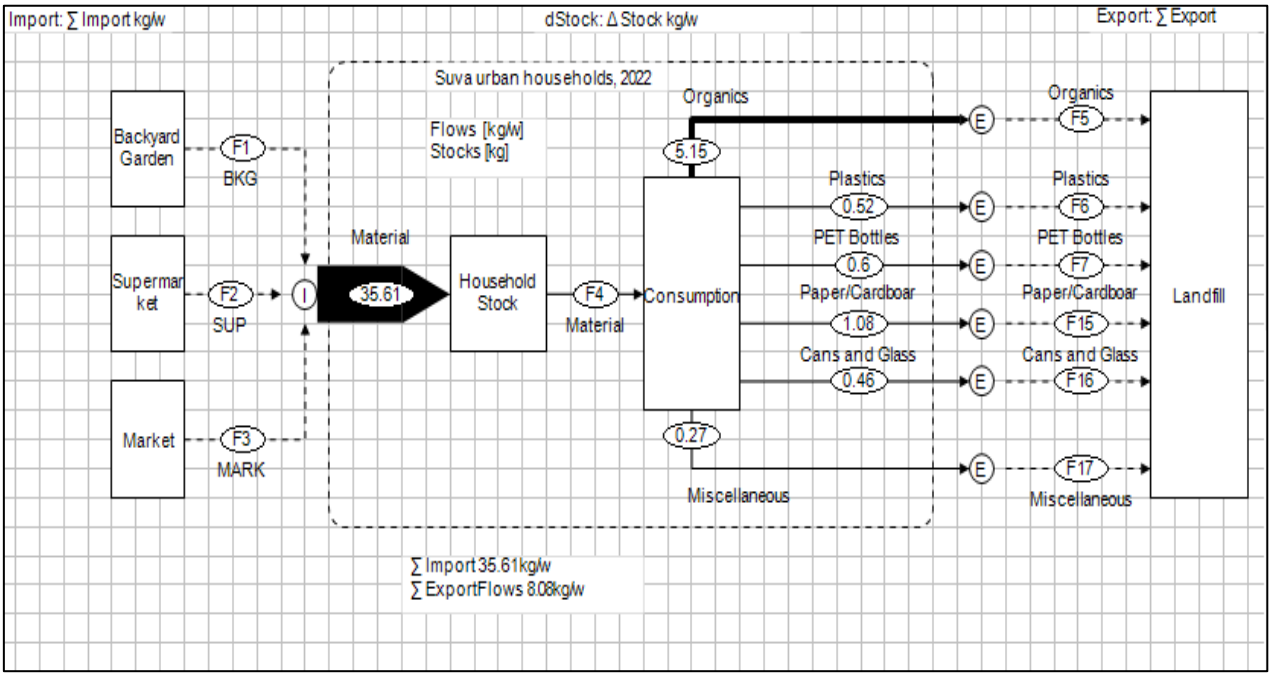

Figure 15: Material flow analysis of households
(Source: The author)

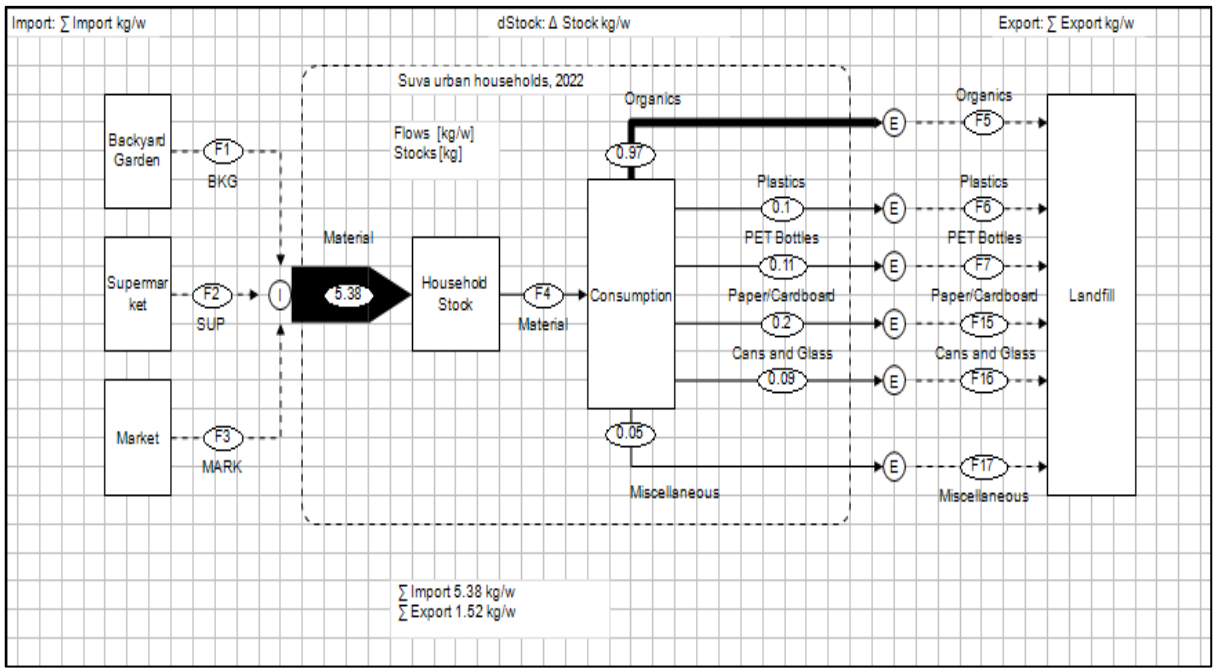

Figure 16: Material flow analysis for each individual
(Source: The author)

Table 12 is the breakdown of waste streams and the total percentage of each waste stream averaged across all households.

Table 12: MSW material output average across all households

Category	Quantity of Waste	Percentage of Waste
Organic	5.15kg	64%
Plastic	0.52kg	6%
PET bottles	0.6kg	7%
Paper/Cardboard	1.08kg	13%
Aluminum and Glass	0.46kg	6%
Miscellaneous	0.27kg	3%
Total	**8.08kg**	**100%**

(Source: The author)

The largest waste stream to exit the household was the organic waste. The total of 5.15kg per household was the greatest and was a total of 64% of the overall waste stream. The second largest waste stream was the Paper/Cardboard waste which totaled 1.08kg and accounted for 13% of the total waste stream. The waste streams for PET bottles, Plastics and Aluminum and Glass accounted for between 6-7% of the waste stream. The smallest waste stream was the Miscellaneous waste which composed of just over 3% of the overall total. There is only one destination for the waste produced in households. In the greater Suva region, rubbish disposal services collect waste from urban households and take them to the Naboro landfill.

In Table 13, it shows the minimum and maximum amount of waste collected for the duration of the week. The minimum and maximum table shows the smallest quantity of a particular waste collected from the household and largest quantity collected. The results show that the maximum amount of waste produced at any household was the Organic. Second to that is the Paper/Cardboard waste stream. The PET bottle, Plastic, Tin/Steel/Aluminum Cans and Glass, and Miscellaneous categories all had similar maximum amounts. This pattern in ranking of maximum quantity for waste streams correlates distinctly with the waste output quantities from the households. For the minimum output PET bottle, Plastic, Tin/Aluminum

Cans and Glass, and Miscellaneous had no waste output in some of the households. There was always waste output for Organic and Paper/Cardboard. The Organic minimum output was slightly larger than the Paper/Cardboard output. This again correlates with the large quantities of Organic and Paper/Cardboard waste exiting household with much lower quantities collected for other waste streams.

Table 13: MSW maximum and minimum outputs across all households

Waste Category	Minimum	Maximum
Organic	0.318 kg	11.505 kg
Plastic	0 kg	1.564 kg
PET bottles	0 kg	2.06 kg
Paper/Cardboard	0.123 kg	2.747 kg
Aluminum and Glass	0 kg	1.113 kg
Miscellaneous	0 kg	1.057 kg

(Source: The author)

5.3 Discussion

5.3.1 MSW Material Potentials

The results of the MFA were insightful in the part of the outputs of waste material from households. Due to the difficulty of differentiating between materials being brought into the household and the high level of cooperation required from households for this, disaggregated input data could not be gauged from the MFA. Although all households were located in urban or suburban areas in the greater Suva region, 4 of the households in the research sourced food from backyard gardens. The practice is more typical of residents residing in towns and rural areas of Fiji. This practice may have led to a larger organic output for the household waste. The aggregated data obtained from the MFA show that a majority of the materials brought into the households, remain in the household either as 'Household Stock' or undergo 'Consumption' from the household members. Only a small fraction of

these materials leaves the household as waste outputs. The reason for this could be determined by a number of factors including household member behaviors, family lifestyle and consumption patterns of household members. From the aggregated data obtained from the MFA, it is unclear what these reasons may be and further investigation into this is required. However, from the disaggregated output data obtained from the MFA, a number of clear findings can be determined.

The largest waste material output was 'Organics' with an overwhelming 64% of the overall waste stream. Kumar & Singh (2018) measured a 70% total for organic waste in MSW in the greater Suva region while Joseph & Prasad (2020) estimate between 65%-72% in Fiji as a whole. In all 10 households that participated in the research, the organic waste stream was the largest. This pattern of large amounts of organic waste emanating from households can be reaffirmed with findings from JICA (2013) and the Pacific Regional Infrastructure Facility (2021) which show similar results from households in the Pacific and Fiji. It is clear that for households in the Pacific, regardless of being in rural or urban areas, the majority of waste output is organic waste. The second largest output stream of waste was 'Paper/Cardboard'. Although significantly smaller than 'Organics' at only 13% of the total output stream, this is significant when applied at scale for the entire greater Suva region. Of the 10 households in the study, 8 households had 'Paper/Cardboard' as the second largest waste stream in their households. This shows a consistency of the 'Paper/Cardboard' waste stream throughout all households. The remaining four waste types composed the remaining 23% of the waste stream. If the two largest waste streams of 'Organics' and 'Paper/Cardboard' could be targeted by the city councils and the Department of Environment through recycling and material recovery programs, the greater Suva region could reduce its waste output by over 75%. A number of city councils have already implemented composting programs in urban households. However, of the 10 households that were a part of the study,

only 2 had been practicing composting, 1 as part of the city council program and 1 through self-initiative.

Organic MSW stream alternatives

One alternative for the use of organic waste is to implement a comprehensive composting program for all households and discontinue the waste disposal services for organic waste. Provisions to fully subsidize compost bins and training programs for households could be implemented with the option for households to use their compost soil as fertilizer for personal use or sell the organic compost back to the city council and other relevant stakeholders such as farmers and agriculture business owners through a fixed compulsory purchase agreement. This option eliminates organic waste completely from the landfill and provides residents with the free organic fertilizer or a cashback option while severely reducing the burden on waste disposal services for city councils.

A second alternative is the use of organic waste for biogas production. Biogas is produced as a result of the anaerobic respiration of organic matter. The biogas can be converted to electricity or other forms of energy in a combined heat and power (CHP) plant. A 1MW biogas plant can produce 60 gigawatt hours (GWh) of electricity per year with between 25,000 – 35,000 tons of organic biomass feed (Piekutin et al., 2021). Using organic MSW data collected from the study, 0.97kg per week, multiplied with the total population of the greater Suva region, 93,870 people, the total potential organic MSW produced per year in the greater Suva region is 4,735 tons. However, combined with other urban regions and through collaboration with the forestry and agriculture sector, the annual required organic biomass feed can be reached. A smaller sized biogas plant can also be constructed in the case of a lack of organic material. This alternative eliminates organic waste from the waste stream but more importantly converts a previously labelled expense, in organic waste, into a revenue

stream for the city councils and DOE through the production of electricity. A biogas plant is also more favorable environmentally due to composts releasing carbon dioxide into the environment and methane production in biogas plants being recovered and converted to heat and electricity (Lin, Xu, Ge & Lin, 2018).

Remaining MSW stream alternatives

There are currently no government recycling initiatives for paper and cardboard waste. The average output of paper and cardboard waste per capita in the study was 0.2kg for the data collection week. If this is quantified over a one-year period for the greater Suva region, a total potential of 976 tons of paper and cardboard material can be recovered per year. This is only for one urban region in Fiji. The total amount of material will be much larger if combined with Fiji's other urban regions. The remaining waste streams of 'PET bottles', 'Plastics' and 'Aluminum and Glass' have existing private sector recycling companies and regional programs available to capitalize on these waste streams. One alternative here is to coordinate between the government and existing private sector recycling companies and intergovernmental organizations to utilize these waste materials. While each of the streams is smaller in comparison to the organic waste stream, combined they are 32% of the waste stream in urban households and are primed for recycling. This option would benefit both private sector, regional organizations and city councils through the elimination of these waste materials from the landfill and new revenue streams for the recycling companies and recycling programs currently in place. However, it would entail significant effort from households in implementing waste separation for all materials.

A second option is for the Department of Environment and city councils to utilize all waste materials through construction of a waste material recovery facility (MRF). An MRF is a recycling facility where waste materials are separated, treated and then redistributed to

manufacturers and buyers who purchase the waste materials (Ardolino et al., 2017). This alternative eliminates the waste materials from the landfills, has the option to implement waste separation at the household level or outsource it to the MRF and similarly to the biogas plant, creates a new revenue stream for the DOE and city council. The last waste stream of 'Miscellaneous' due to its small quantity within the waste stream will need further consideration in the best course of action to implement.

MFA methodology adoption for national waste management

The methodology of MFA using STAN can provide useful technical information if adapted at the regional and national level provided that the underlying waste flows can be attained. Patterns between different towns and cities can be determined using MFA and the relevant strategies can be adopted to support the material recovery of waste as shown in this study. The underlying waste streams combined with import data and local industry production data can provide an image of Fiji's total waste material flow and thus act as the baseline for providing strategic support in the formulation of a long-term waste management plan for the country with alternatives that move away from the use of landfills.

5.3.2 Waste Separation

The semi-structured interviews offered insights into individual waste and environmental knowledge of urban household residents along with their opinions on the practice of waste separation.

Pre-Data Collection

The pre-data collection interview questions targeting knowledge of waste classification, destination of household waste and daily waste output quantity showed that 5

of the household representatives were aware of these issues and 4 at least had some idea about them. All household representatives had received some form of tertiary education and this may have contributed to this high level of awareness and baseline knowledge of waste in their households. Regarding the opinions on Fiji's environmental issues, 'Public Littering' was the most cited issue followed by 'Ocean Pollution' and 'Climate Change'. In all cases of 'Public Littering' and 'Ocean Pollution' being cited, respondents said it was an issue that could be physically seen and was an eyesore as opposed to 'Climate Change' which was more abstract.

Post-Data Collection

Overall experience with waste separation

In the post-data collection interview, the waste separation practice opinions were investigated. The first question looked at the household's general experiences and it showed 'Difficult at first but became easier' as the most common experience. This can be attributed to the fact that the practice of waste separation for households was entirely new but household members became use to it over time. Thus, if the practice of waste separation was incrementally implemented over a period of time, household members could have more time to adapt to the new practice. 'Increased awareness of waste produced' also received a number of responses. As the data collection period required household members to store waste for a one-week period, they were able to see the quantity of waste build up over time. The greater Suva region receives waste disposal services 3 times a week and so awareness and the quantities a household produces over that period of time was new for residents.

Challenges with waste separation

The second question looked at the challenges faced by household members highlighted 'Identifying type of waste material' as the most common challenge. This is expected as waste separation practice requires household members to segregate waste items according to their respective categories. Also, waste separation is a completely new practice being done at the household level. It is also difficult to identify types of waste such as snack wrappers or styrofoam which do not have specifically outlined waste categories. Further clarification on these materials was required with the researcher. A clear and concise guideline for all households in the form of a poster or easily digestible awareness material would be beneficial to tackle this issue. 'Coordination with household members' was also cited numerous times. As the waste from the household is produced by all members, it is challenging for all members to coordinate efforts and ensure waste is segregated accordingly. Household members differ in age as well with children and older members finding it difficult to adjust to the practice. There will need to be a levelled awareness program that targets households and household members to ensure equal understanding and clarity on the method of waste separation. 'Storage' was mentioned as a challenge a number of times. Households in Fiji typically have an all-in-one garbage bag and disposal system. Thus, having six different bags for disposal required more space in the households and was challenging for household members, especially if the waste was stored indoors. Waste stored outdoor had the risk of rainfall getting into the bags, so it needed a sheltered outdoor area to safely store the rubbish bags. In addition to that, a number of households had pets or stray dogs in the neighborhood which were likely to attack the bags, so storing the waste bags in an elevated sheltered area became the best option. There will need to be a secure method that is adaptable to all households if waste separation is to be adopted. The number of waste materials separated and limited storing area will need further consideration.

Difficulty of waste separation

Looking into the overall difficulty of the waste separation practice, the households had a relatively even split between 'Difficult', 'Easy' and 'Neither'. Households that responded with 'Difficult' often cited 'Coordination with household members', 'Storage' and 'Identifying type of waste material' as the reasons. The households' representatives that responded with this came from larger households with 6 or more members. The representatives that responded 'Easy' or 'Neither' cited the waste classification guide provided to representatives and pre-data collection briefing as reasons for this. These respondents came from the smaller households with 5 or less people. The size of household member numbers may have played a role in the difference of opinion by household members. Due to larger households requiring greater coordination between members, this may have affected the ability and experience of the households with waste separation.

Reasons to implement waste separation

The fourth question asking household representatives whether the practice of waste separation should be implemented had all respondents respond with 'Yes'. The reasons for their response were primarily 'Environmental Protection' and 'Recycling'. In the experiences of the household members, environmental issues in Fiji are often associated with littering and ocean pollution, which have links to waste management, thus a number of representatives believe it could prevent these environmental issues from occurring. 'Hygiene' and 'Raising Awareness' were also mentioned multiple times. Representatives stated that separating the organic waste from the other waste categories as more hygienic and easier to handle the non-organic wastes. A number of households highlighted the issue of 'Raising Awareness' in their

individual experiences and thus believed this practice could realize heightened awareness of waste production within other households who implement the practice. The third question asked here included a pretext from the researcher on the environmental and economic benefits of waste separation. However, respondents did not mention the economic benefits when asked the reasons for the affirmative response to why waste separation should be implemented. There is a connection for household representatives between waste management and waste separation with environmental benefits but not economic benefits. This is an important issue to highlight. While the practice of waste separation is environmentally beneficial, the economic potential is what will make it feasible in the long run so that it is financially self-sustainable and not reliant on donor or aid funding.

Number of MSW categories to implement

The fifth question ascertained the number of waste categories should be implemented and what categories they should be. Household representatives that responded that the waste separation practice was 'Difficult' suggested less categories to be implemented. The number of categories ranged between 2 to 4. These categories included new categories such as 'Recyclables', 'Non-Recyclables' and 'PET bottles/Plastics'. These types of waste categories were a combination of the six categories implemented in the households and reduced the number through a combination of 2 or 3 of the categories. Households that found the practice 'Neither' or 'Easy' agreed that the 6 categories of waste implemented during the research data collection period should be maintained. Waste separation practice difficulty appears to correlate with the number of waste categories households would like to establish. The more difficult it is, the less categories households are likely to want to implement. Thus, if waste separation can be made easier for all households, a larger number of waste categories can be introduced.

Recommendations to implement waste separation in the future

The final question looked to ascertain general comments and recommendations for waste separation from household members. Household representatives highlighted waste separation tools such as waste classification guidelines, waste separation methodology guidebooks, color coded rubbish bags and separate waste bins. The motivation to implement waste separation is present, as highlighted by all household representatives wanting to implement the practice. However, the need of material and financial support for households members to implement waste separation is necessary as cited by household members. An important response from many representatives also mention that even if the practice of waste separation is implemented, Fiji currently does not have any public recycling initiatives and facilities and thus the implementation of waste separation will be pointless. This highlights the need for a comprehensive approach to waste separation that is connected to recycling initiatives and infrastructure that needs to be in place to support the practice. This is further elaborated upon by household representatives citing the need for education awareness programs in school to practice waste separation and the need for legislation in government and enforcement for the initiative to work. Two household representatives mentioned that while recycling and the practice of the 3R were promoted, how to actually carry out these practices were never explained. Thus, waste separation can elaborate and connect the practices of waste separation and recycling for the current awareness programs carried out in schools and workplaces.

Waste separation feasibility

Overall, waste separation has significant potential to be implemented at the household level. As highlighted in the section for waste material potentials, there are economic benefits

that can be attained for household residents and the DOE. A phased implementation process for waste separation will be required at all levels as emphasized through the responses from household representatives. Support for waste separation at the government level can begin through the legislative implementation of laws and policies in support of it. Discussions at government level can connect key stakeholders from different ministries and sectors. At schools and educational institutions, educational awareness of its benefits and hands-on practice within the school vicinity need to be implemented. This allows the knowledge of waste separation to be taught directly to students and teachers while also immersing individuals in the practice of waste separation on a daily basis. At the household level, government support through the DOE and city councils need to be provided through provisions of waste separation tools such as waste classification guidelines and separate waste material bins. Community level projects to encourage participation of waste separation and raising awareness of the benefits will strengthen the implementation in households. Finally, as highlighted by the household respondents, supporting infrastructure to realize the environmental protection and economic benefits of waste separation need to be implemented. Multiple alternatives for the use of waste materials have been highlighted in the previous section regarding waste material potentials with their individual benefits and challenges. These alternatives will require further investigation and economic feasibility studies to determine their long-term viability and implementation. From this discussion section, it is clear that the investment into alternative uses for waste materials and the implementation of waste separation are interdependent. Therefore, a comprehensive and coordinated approach between the two is required for the successful implementation of both.

Chapter 6: Conclusion

6.1 Policy Recommendations

6.1.1 Greater Suva Region policy

The domain of the greater Suva region comes under the Suva city council and parts of it under the Nasinu town council. Together, the combined areas are under the jurisdiction of both councils and cover the largest urban agglomeration in Fiji. The results from the research clearly indicate that there are opportunities to recover MSW material from urban households in the region. The organic fraction of MSW is the largest waste material stream followed by cardboard and paper. Support for the implementation of waste separation practices was affirmative across all households in the research. However, the lack of infrastructure such as recycling facilities demotivate households' residents to separate their waste flows if will eventually end up all in a landfill. Thus, aside from developing policy guidelines for the phased implementation of waste separation in households, schools and workplaces, it is essential to conduct an economic feasibility study to decide if the composting program continues to be subsidized or the construction of a small-scale biogas plant and CHP plant for the production of electricity shall be installed to re-valorise the organic MSW of households in the greater Suva region. For the other materials streams, an economic feasibility study into the construction of an MRF and support for coordination between existing recycling companies and regional organization initiatives for the use of these waste materials is needed as well.

6.1.2 National Policy

The MFA methodology can be adopted at the national level in combination with a national waste audit to provide an overall picture of the waste material streams across the

country. This research has provided a blueprint for the adoption at the national level, and is a methodology that can be adopted at smaller scales. This will provide key data in the adoption of waste separation practices and what types of MSW materials to focus recycling initiatives on. While the research is adopted to urban households in Fiji, a similar approach can be adopted for rural households at a different scale. In addition, the MFA methodology is useless without waste separation policy adoption at the national level. This policy will create a blueprint for local city and town councils to follow and adopt, creating a waste material map throughout the country. The creation of this map will assist policymakers in what MSW materials to target and how these materials should be used. Policy to implement and streamline the MFA methodology alongside waste separation across all urban and rural areas in Fiji will be key to Fiji moving away from the use of landfills and into investments on practices and projects, such as composting, MRF's and biogas plants, that will benefit both environmentally and economically. Similarly, to the policy in the greater Suva region, studies into the construction of these facilities and the expansion of the current compost program will be needed. Coordination with the town and city councils will enable these effective and targeted policies to enacted.

6.2 Research Significance

Fiji is currently faced with the challenge of developing the appropriate infrastructure and technology to tackle it's MSW management issues. The Naboro landfill that services a majority of the municipal waste produced in Fiji's urban centres has a limited lifespan and is not a long term sustainable solution due to the environmental impacts caused by landfills (Rabl et al., 2008) and its significant economic impact of the operations to the municipal budget. The landfill gas (methane) emitted by the landfill is released into the atmosphere further contributing to climate change instead of being captured to produce energy. The

absence of methane capture technology to produce energy at the Naboro landfill emphasize its environmental impact and highlight its economic liability (Mani & Harvey, 2016). This leaves Fiji in a vulnerable position both economically and environmentally. In addition to this, Fiji's waste management infrastructure suffers from inefficient transportation of MSW to landfills (Asian Development Bank, 2014), no separation of waste materials (Secretariat of the Pacific Regional Environment Programme, 2010) and the absence of government recycling initiatives (Japan International Cooperation Agency, 2013). Discerning alternative uses for waste materials will reduce the amount of MSW transferred to landfills and identify market potential with key stakeholders. Not only will these alternatives tackle the current dilemma for Fiji's waste management system, they will help identify revenue streams to support Fiji's waste management infrastructure become fully self-sustainable financially. Ascertaining waste separation practice sentiment will support the implementation of the practice in the future and identifying the waste composition at the household level will help structure effective policies for recycling. Fiji needs to take a pragmatic approach to treat its waste and invest in sustainable technologies and approaches such as MRF's, biogas plants and household source waste separation. This is not only significant for Fiji but other island states who are facing similar issues with waste management and can adopt this approach to address these problems. Thus, the impact of this study is not only limited to Fiji but other countries and islands states that share the same waste management issues.

6.3 Research Limitations

The one-week data collection process could not be carried out directly by the researcher. The researcher could not be present in the study region due to the travel restrictions imposed by Fiji government to combat the COVID-19 pandemic. Thus, a research assistant was hired to purchase and drop off waste separation equipment for the households

and weigh the different quantities of waste after the one-week data collection period. Coordination of the logistics for the data collection was done by the researcher and carried out by the research assistant. The weighing of the waste quantities was supervised by the researcher directly through video call while carried out by the research assistant. The challenges that were faced during the data collection by the research assistant were recorded and are included in this research limitations section. The challenges faced by the research assistant included coordination with household representatives for the pick-up and drop off of waste separation equipment, attaining accuracy of weight measurements of waste materials on kitchen scales and the odor of waste materials.

The 10 households selected for the research were acquaintances of the researcher and not selected at random. This was also due to the absence of the researcher in the study region. The inability to approach a variety of households directly to partake in the research severely hindered the diversity and number of households partaking in the research, so the number was limited to 10 households and those with an ability to directly communicate with the researcher through online platforms in order to carry out the interviews and relevant preparatory video calls and daily check-ups to ensure procedure during the data collection week. Although these daily check-ups were conducted, some household representatives failed to record certain inputs into the household such as shopping or harvests from backyard gardens and this may have affected the data collected. Due to the small number of households participating in the study, the validity of the results must be taken into consideration and the need for a similar study with a larger pool of participants and households will be beneficial in strengthening the validity of the results.

6.4 Conclusion

Waste management in Fiji has continued to be a critical environmental and economic issue. It was temporarily addressed with the construction of the Naboro landfill in 2005. However, this was a temporary solution and only prolonged the urgent need for a long-term strategy to Fiji's waste management system. The idea of waste material recovery and recycling are not new to Fiji but have yet to be adopted at a large scale. This is in part due to the lack of data on Fiji's underlying waste material output. This underlying data cannot be synthesized because waste materials are not segregated at any level of the waste management system. Thus, this papers research questions 'What are the waste material flows of Fiji's urban households?' and 'What are the attitudes of urban residents towards waste separation' look to address this.

To identify the waste material flows, MFA was adopted at the household level with the use of STAN. This identified the sources of waste materials, different quantities of waste materials and their final destination at the household level. It identified organic wastes as the major source of waste materials followed by cardboard and paper. However, to carry out the MFA, waste separation needed to be implemented and so the attitudes towards waste separation by household representatives were investigated. The adoption of waste separation was received positively by household members and so adoption of the practice could feasibly be implemented at the household level. Given the large population of the greater Suva region, the economic impact of diverting organic, cardboard and paper waste to be recovered and recycled will be significant and needs to be further investigated. However, the potential benefits to the region economically could allow for a financially self-sustainable system to flourish and create a blueprint for other regions in Fiji to adopt. Through the MFA methodology, Fiji can slowly shift its approach to waste management away from a one-

dimensional linear system that addresses the issue as solely environmental towards one that is a circular system and addresses the economic and social dimensions too.

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Appendix

Appendix 1: Participants Roles and Responsibilties

Material Flow Analysis of Suva's Urban Households:

Participants Roles and Responsibilities

Thank you for volunteering your participation for this research project. Your cooperation is highly appreciated.

The aim of this research project is to showcase the material flow of waste in Suva's urban households and outline potentials to reuse this waste as a resource. The objective of this research is to collect data on the type, quantity and sources of waste in urban households in the greater Suva area.

As a part of this research project, the following six items will be required on your part for your participation throughout the one-week period:

1. Weigh all shopping items and products that are brought into the household with the provided scale. The weight data will be collected from you at the end of the day.

2. Take a picture of all shopping items and products brought into the household. One general picture of the item and one picture of any information that shows the physical weight of the item.

3. Please send the photos to the researcher through the Messenger application or via email

to sjkonusi@gmail.com

4. Please separate all waste into the appropriate waste bag category as detailed below:

I. Organic Waste

II. PET bottles

III. Plastics

IV. Paper and Cardboard

V. Steel/Tin/Aluminium Cans and Glass

VI. Miscellaneous items (those which do not fit into the above categories)

For further clarification, please refer to the 'Waste Audit Handbook' that is has been sent to you and refer to pages 45-48.

5.. The researcher will contact you via video call, message or email everyday to clarify any issues or problems you may encounter and follow-up on all activities throughout the day.. Please avail 5-10 minutes everyday for this check-up call as it is necessary to ensure all procedures are followed.

6. Prior to the beginning of the data collection week an interview will be conducted before and afterwards. The interview will be conducted via video call and will be recorded for data collection purposes. Your consent will be required to record this interview and your cooperation will be much appreciated. All information disseminated from the interview will be strictly confidential and only be used within the purposes of the research project.

Any further information with regards to the research project will be directly communicated by the researcher.

Appendix 2: Waste Sorting Categories

Appendix L - Sorting categories

Material Categories, definition and source of data

C	Category	Description	EOL Source	Incoming
Metal	Aluminium cans	Alcoholic sodas and spirit-based mixers, beer and soft drink, Food cans, pet food cans, aerosols, industrial cans	H, C, L	Cu, D
	Aluminium 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% aluminium items that are not cans/tins/or packaging materials, any other aluminium	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	
Plastic	PET containers	(Polyethylene) – soft drink, flavoured 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 flavoured 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	the 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

C	Category	Description	EOL Source	Incoming
	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	
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	Batteiries 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 & Peripherals	Radio, iPod, Gameboys, stereos, speakers, VCR, DVD players, powertools, 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 colours) – beer bottles, wine bottles, spirit cider/fruit-based, flavoured water, fruit juice, sports drinks, plain water	H, C, L	Cu, D
	Glass Jars	Non-beverage containers (all colours) – 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	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	
Organics	Food	Vegetable/fruit/ meat scraps	H, C, L	
	Wood/timber		H, C, L	

C	Category	Description	EOL Source	Incoming
	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 fibre materials	H, C, L	
	White goods		H, C, L	Cu, D
	Ceramics		H, C, L	
	Containerised used oil		H, C, L	Cu, Retail
	EOL renewable energy equip	Includes EOL solar panels	H, C, L	Cu, Power company, installers
	End of life Vehicles		H, C, L	Cu
	Tyres		H, C, L	Cu
	Please describe			

Codes used:

H = Household audit

C = Commercial audit

L = Landfill audit

Cu= Customs

D = Distributors

(Source: Pacific Regional Infrastructure Facility, 2019)