THE ROLE OF INDIGENOUS SOLID WASTE MANAGEMENT PRACTICES (ISWMP) IN MANAGEMENT OF SOLID WASTE IN URBAN CENTRES IN PNG

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Submitted in fulfilment of the requirement for the degree of Doctor of Philosophy

School of the Environment
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Flinders University
September 2014

ABSTRACT

Improper management of solid waste causes environmental and public health problems. New waste management approaches are required to minimise pollution and recover vital resources. One such method is indigenous solid waste management practice (ISWMP), which focuses on resource recovery leading to conservation of limited resources minimizing of environmental pollutions. However, there is minimal research on ISWMP in Papua New Guinea, therefore, an understanding of the use of ISWMP and its transferability to urban areas would assist in improving urban solid waste management. This thesis investigated the role of ISWMP in Wamonagu village and Goroka town of Papua New Guinea with a result that shows that ISWMP focuses on resource recovery using the "reduce-reuse-recycle" or 3R approach. The 3R approach is used for managing solid waste in homes and public areas in Wamonagu, but not for recycling non-biodegradable solid waste. In contrast, not all the households in Goroka use ISWMP even though all households have some knowledge and skills of ISWMP. The bulk of solid waste in Goroka town is collected as mixed garbage and disposed of by the town council Even though most households segregate the biodegradables and non-biodegradables SW and manage them using ISWMP.

Hence the study recommends ISWMP as an option for managing municipal solid waste in urban areas.

DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university: and to the best of my knowledge and belief, it does not contain any material previously published or written by other persons except where due reference is made in the text.

Signature……
(D.A PANTA)

Date…29/09/2014

ACKNOWLEDGEMENTS

It has been an honour and a privilege to have been welcomed and embraced by the Wamonagu villagers. I particularly want to thank the Lowari family for embracing me as one of their own especially Amos and Delka Lowari for introducing me to David and rest of the Lowari family at Wamonagu. The Wamonagu village leaders and the village council for kindly welcoming me to stay in Wamonagu during which time I have meet many kind and loving people who made my stay there worthwhile. I am also grateful to Ufi Ifana my sister and friend for standing by me and supporting me through my journey.

My journey has been possible with the emotionally, financial and technically support of number of people. First of all, I wish to express my deepest gratitude to my principal supervisor Dr Udoy Saikia for the guidance and mentoring me through my journey as a researcher and at all the stage of my thesis development. As a supervisor you have also been a support for me during the challenges that I encountered both personally and academically and I am grateful for that. I would also like to thank my co-supervisor Associate Professor Gour Dasvarma for his valuable feedbacks, guidance and advice during the production of my thesis. I am privileged to have been guided by you with your experiences and your expertise. I would also like to thank Dr Meryl Pearce for being my initial co-supervisor and guiding me in the initial stage of my thesis development especially during my proposal writing.

The field work involved in this study especially for Goroka town would not have been completed without the assistance of the Goroka Town Council staff. The staff gave their valuable time allowing me to travel to collect data without time restrictions. I am also thankful for the provincial planning manager and his staff especially Josephine Aho for her kind assistance with the documents that was needed for the research. My heart -felt gratitude to Mr Masa and Goroka International School students and staff for your support for me during my field work in Goroka especially for giving me room space to work in.

There are some people I am privileged to have in my life who have supported me in my academic journey. I am thankful for my husband Patrick Panta for his love and support during

my study. To my beautiful children Angelica, Narelle, Beatrice, Ezra and Michael Panta for the sacrifices that you have made during my journey I am indebted to you all for that. To my mother Nomora Masie who supported me through words of encouragement and her love, I thank you for standing by me. To all my other family members in Papua New Guinea, thank you for your support and love during the duration of my study.

I wish to express my humble appreciation to my Antioch church members in PNG for your prayers. My Activate family here in Adelaide especially my beloved and supporting families Andrew and Linda Davey and Robert and Denis Pride and Mark and Beth Kaesler for all that you have done for me and my family. Amongst the people who assisted with my research I would like to thank, Robin Sabumei Kofikai, Sylvester Lowari, Rosey Wapia, Matilda Kimas, James Nokose, Janet Russell, and Jacob Izod for your support during the interviews. I would not have done that without your assistance.

For your support emotional and for accommodating me, I would like to thank Glenda Wynn and Estera Tsika. Jane Saking for your friendship and endless support I thank you my dearest friend. My heart- felt gratitude to Paula and Ray Krai for being the support for me and my children during my study.

List of Abbreviations

ADF	Advance Deposit Fee
CBD	Central Business District
CBOs	Community Based Organization
CCD	Convention to Combat Desertification
CDL	Container Deposit Legislation
DEC	Department of Environment and Conservation
DPI	Department of Primary Industry
DSW	Domestic Solid Waste
EHP	Eastern Highlands Province
GRCA	Goroka Rural Council Area
HDI	Human Development Index
IEK	Indigenous Ecological Knowledge
IEK	Indigenous Environmental Knowledge
IK	Indigenous Knowledge
IMR	Institute of Medical Research
IRRP	Indigenous Resource Recovery Practices
ISSWM	Integrated Sustainable Solid Waste Management
ISWDP	Indigenous Solid Waste Disposal Practices
ISWMP	Indigenous Solid Waste Management Practices
ISWM	Indigenous Solid Waste Management
ISW	Indigenous Solid Waste
ISWM	Integrated Solid Waste Management
ISWMS	Integrated Solid Waste Management System
IT	Information Technology
IWM	Integrated Waste Management

IWMS	Integrated Waste Management Strategy
JICA	Japanese International Cooperation and Aids
LCI	Life Circle Inventory
LLG	Local Level Government
MPLC	Medicinal Plants and Local Community
MTDS	Medium Term Development Strategy
MI	Melanesian Institute
MDGs	Millennium Development Goals
MSWM	Municipal Solid Waste Management
MSWMS	Municipal Solid Waste Management System
MSW	Municipal Solid Waste
NSWMS	National Solid Waste Management Strategy
NSWS	National Solid Waste Strategy
NGOs	Non-Government Organizations
OECD	Organization for Economic Co-operation and Development
PICs	Pacific Island Countries
PNG	Papua New Guinea
RCA	Rural Council Area
RCF	Research and Conservation Foundation
RMI	Republic of Marshall Islands
RLLGs	Rural Local Level Governments
RRP	Resource Recovery Practice
RSWMS	Regional Solid Waste Management Strategy
SDA	Seventh Day Adventist
SIDS	Small Island Developing States
SMSWM	Sustainable Municipal Solid Waste Management

SP	South Pacific
SPREP	South Pacific Regional Environment Program
SSWM	Sustainable Solid Waste Management
SWM	Solid Waste Management
SWMS	Solid Waste Management System
SW	Solid Waste
ULLGs	Urban Local Level Governments
UNFCCC	United Nations Framework of Convention on Climate Change
UOG	University of Goroka
US	United States
USW	Urban Solid Waste
WCED	World Commission on Environment and Development
WMS	Waste Minimisation Strategies
WRA	Water Resources Act

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CHAPTER ONE:

INTRODUCTION AND BACKGROUND

1.1 Introduction

Municipal solid waste is a global concern that cuts across all disciplines related to health, the environment and the development of an area. Municipal solid waste is perceived to have contributed to severe environmental change in fast urbanizing developing countries (Achankeng, 2004). The increase in solid waste (SW) production has had serious impacts on biological diversity and public health in island nations such as Papua New Guinea (PNG), the Marshall Islands (Rogers 2004), and other developing countries. The amount and types of solid waste generated in the world are increasing as a result of population growth, rising standards of living, and the change in technology.

The actors involved in the generation of the SW from country to country are multiple and complex. The existence of this range of actors means that finding a suitable system of municipal solid waste management (MSWM) that accounts for all elements related to this issue is a challenge. An appropriate system has to consider many factors, stakeholders, and actors in the MSWM. This includes taking into account the capacity of the actors, in terms of financial, technological, and human resources and a MSWM system that is acceptable for the actors (Achankeng, 2004).

1.1.1 Global Municipal Solid Waste

The problem of solid waste management (SWM) is a universal issue as the amount of waste generated grows with an increase in population. According to Achankeng (2004) research carried

out in Ireland shows that the global SW generation was 1.84 billion tonnes in 2004, which is a 7% increase from 2003genration of SW. This was predicted to increase by 31.1% between the years 2004 and 2008 (Achankeng, 2004). The approaches taken by the nations to manage the SW issue have varied from nation to nation.

Developed nations generate larger amounts of SW as their consumption rates are greater than those of developing nations where consumption is smaller in comparison. The top 15 nations that produce the most MSW per capita are developed nations (MC Collough, 2001). According to De Tillly (2004), SW generation in developed nations increased by 14% (530 to 604 million tons) from 1990 to 2000 with an increase of 509kg-540kg per capita per year or 1.4kg to 1.5kg per capita per day (OECD, cited in Achankeng (2004). These figures vary from country to country. For instance, in 2008 the United States (US) produced approximately 250 million tons of SW with 2 kg per person per day (USEPA, 2010). It was also noted that the US was generating SW with a mean of 2.1kg per capita per day before 2008 (Mihekcic & Hutzler 1999; USEPA, cited in Achankeng, 2004).

On the other hand, Achankeng (2004) stated that 'SW generation by the developing nations is less than 1kg per capita per day but varies from one nation to another' and is also increasing as consumption patterns change with the rise in income (Farrara 2008). The overall SW generation in developing nations depends on the rate of their industrialization. For instance, according to Buekering et al (1999), the amount of SW generated daily in India was between 0.1 and 0.6kg per person and Hong Kong generated 5.5kg per person. Buekering et al. (1999) also stated that the amounts of solid waste generated in the developing nations are increasing due to rapid urbanization. Much of the SW produced in developing nations is municipal or household SW

(Getahun, 2011). According to Damanhuri et al, (2009) the household SW produced in Bandung city in Indonesia is 82% of the total municipal solid waste and consists of organic and inorganic SW, but in Aligarh city in India the household SW constituents 69% of the total MSW (Khalil et al, 2008) . This means that there is a need to manage and minimize this household waste from reaching the dumpsites. The municipal waste in developing countries consists of both biodegradable and non-biodegradable materials, with the bulk of the waste being biodegradable. Tchobanoglous et al. (cited in Das et al., 2002) stated that over 69 % of the total weight of the global municipal waste consists of organic biodegradable solid waste that can be managed using biological recycling (composting).

Even though developed nations generate more waste, they are able to better manage their SW than the developing nations (Achankeng, 2004). Developed nations seem to manage their waste more successfully due to their economic and technological capacity which the developing nations lack. Furthermore, the citizens and governments of developed nations make municipal waste management a priority and thus measures are taken to minimize solid waste. According to the USEPA (2010), Americans consider municipal SW an important issue this century; therefore SW minimization is vital in communities. However regardless of the minimization efforts most of the MSW ends up in the landfills for both the developed and the developing world as not all the SW are recycled.

There are concerns about the environmental pollution caused by the sanitary landfills method of disposal where SW is disposed of in a designed dumpsite and later covered with soil with collection of leachate (Silva et.al, 2003). This is especially true about the contamination of groundwater, surface water and soil due to leachate leakage (Ehrig 1983; Tatsi & Zouboulis

2002). Studies carried out on landfills show that many countries prefer the landfill method as it is economically cheaper than other methods of disposal (Tatsi and Zouboulis, 2002). However, there is the threat of environmental contamination from the leachate produced from the landfill. The developed nations with financial and technological capacity have created preventative strategies and have implemented them in order to minimize the leakage and leachate contamination. Sanitary landfills that is carefully prepared for leachate collection prevents toxic substance from contaminating the surrounding environment especially the surface and ground water. The leachate collected, if left over time, will stabilize and become less toxic, but is still difficult to assess its composition (Tatsi and Zouboulis, 2002).

1.1.2. Municipal SWM in Developing Countries

The quantity of solid waste is one of the major environmental problems that the Pacific Island countries (PICs) are faced with. According to South Pacific Regional Environmental Program (SPREP, 2005): 'Disposal of wastes continues to be a worldwide problem and the Small Island Developing States (SIDS) of the Pacific increasingly share this problem'. In the past, PICs had only biodegradable SW that was easy to manage with the use of indigenous or traditional environmental knowledge. However, the composition and amount of SW in the PICs has changed due to urbanisation.

The rate of waste generated from consumption of manufactured goods has increased and is causing environmental problems for the Pacific Islanders (SOPAC, 2007). The PICs with small land area, lack of expertise, financial, and technological capacity are not able to appropriately manage solid waste compared to developed countries (SOPAC, 2007; Eric, 2004). Furthermore, SPREP (2005) stated that '[improper] waste disposal is now impacting negatively on public

health, water, the environment, food security and fish nurseries in the mangroves [in the Pacific]'. PICs are members of Small Island Developing States (SIDS). In the United Nations Assembly Special Session in 1999, SW management problem was identified as a strategic issue for SIDS (SPREP, 2005). PNG being part of the PICs also shares the problems associated with SW. In order to adequately manage the solid waste, PNG needs to strategically create and implement plans through development of appropriate model for solid waste management.With the change of lifestyle from traditional to modern, PNG is faced with both the increasing generation of SW and the serious problem of its improper management in urban centres. This problem is evident as piles of SW are disposed and discarded along streets, roads and in front of buildings with overflowing garbage bins that is uncontrolled dumping (ADB, 2013). The increase in the production of SW in PNG and the inadequate management of the SW in the urban centres by the urban councils is a major challenge. Therefore, appropriate Solid Waste Management system (SWMS) is needed for PNG in accordance with the country's needs.

1.1.3. MSWM in Papua New Guinea

The delivery of essential services such as water supply, sanitation, collection, transportation and disposal of municipal solid wastes (MSW) in PNG is the responsibility of the town and city councils. The main focus of the municipal councils in PNG regarding municipal solid waste management is the improvement of public health, a system that was adopted from the developed world by developing nations during the colonial era (Baud. 2004). Even though public health may have been the focus of SW management in PNG, environmental health concerns are now major issues due to increased production of SW. The Waste Management Strategic Plan by SPREP (2005) was developed to assist PNG and other PICs to address environmental pollution concerns of their nation. The complexity in the amount of solid waste produced and the cost

involved in adequately managing the SW is a problem for town and city councils in developing nations such as PNG (Baud, 2004 p4, in Baud et al, 2004).

The town and city councils in PNG, also known as urban councils are faced with the issue of providing appropriate technology, capital and expertise to adequately manage the SW. Achankeng (2004) stated that all the nations of the world encounter difficulties in managing SW in an ecologically sustainable way, with easily accessible technology that is financially affordable. PNG shares these difficulties with the rest of the world. These constraints are more critical in PICs like PNG than they are in developed nations. According to SPREP (2008):

> "*Waste collection and disposal requires a lot of resources for proper and effective management system. Therefore due to inadequate funding, limited trained and skill personnel, inadequate regulations and management with limited infrastructure support many collection and disposal services in the Pacific region have fail to perform at a desired level".*

PNG and many other developing countries have local, traditional ways of managing solid waste. Although there are many modern SWM models and techniques used in the world, in order to develop an appropriate model for PNG there is a need to start with local knowledge on solid waste management and its relevance to Papua New Guinea's situation. This can be then integrated with the modern models and techniques to mitigate improper SWMS. The reason for having an appropriate SWM model is for it to be operational with long-term sustainability.

The model should firstly take into account the socio-economic, political and physical capacity of the society. For example, there must be financial capacity and support from all levels of government. The people's understanding and educational levels are vital for better information dissemination and implementation of the SWM model. According to SOPAC (2007) and

Achankeng (2004), a country's financial, technological and human resource capacities need to be taken into account for viable Municipal Solid Waste Management (MSWM).

Secondly, the amount of solid waste generated by the total population and the distribution of that population also needs consideration. These factors will determine the resources, time and space needed for a SWM model to work. For instance, by knowing the quantity of waste generated within a given population and its distribution will allow for an appropriate land size to be obtained for SW disposal.

Thirdly, cultural views and practices, customs and values have to be considered when developing an appropriate SWMS. For instance, some SWM techniques that are culturally acceptable in other societies might not be acceptable in others. Thaman et al. (undated) stated that'the cultural differences and values have to be considered for each PIC to better manage waste'. For example, PNG's culture is still based on oral communication and practical application through activities. Most activities in the rural communities involving the public are conducted verbally with the public participating after listening to and observing practical demonstrations. These practices have been in existence since traditional times. One of the contributing factors for these types of cultural practices is the high illiteracy rate in the country. For instance, the national rate of literacy in PNG is 63% yet in Goroka in the Eastern Highlands Province of PNG, the literacy rate is 55% with 20% of the adult population having secondary education (World Bank, 2014; UN-Habitat, 2010).An appropriate SWM model would consider these factors.

1.1.4. The Indigenous Solid Waste Management

Before the organisation of knowledge into the modern knowledge system, humans had certain ways of doing things related to their culture, experiences, geographical location and the environment. This knowledge system is known as Indigenous Knowledge system (IKS) (Ajibade, 2007). The type of IKS is local knowledge and varies from one indigenous community to another and is handed down from one generation to another (Ajibade, 2007). The indigenous solid waste management practices (ISWMP) is part of the IKS, which is part of the Indigenous Waste Management (IWM). The studies by Ajibade (2007) and Izugbara and Umoh (2005) indicated that the ISWMP are still in existence in the rural indigenous communities in Nigeria.

PNG like Nigeria is a developing nation where a large number of people are indigenous and live rural communities. These rural communities are isolated have poor access to government services (Rogers et al, 2011). The services include the management of waste by the rural councils which the rural community in PNG has not access to. The lack of accessibility to the services especially for solid waste management means that the people use the local knowledge that they have to manage the SW. In PNG, as 80% of the population live in the rural community (World Bank 2015) they are prone to use ISWMP for the management of the solid waste a practice that is embedded in their culture. As the people migrate from rural to urban centres they bring the ISWMP knowledge with them and use it in the urban location as the needs arises.

The IK had been used as a tool to address concerns in other field of studies in PNG. For instance IK is being used to mitigate impacts of disasters caused by hydro-metrological hazards (Hiwasaki et al, 2014) and for conservation biodiversity and rehabilitation purposes in PNG (Butler et al, 2012; Tiu, 2007). Though there were researches on Indigenous Waste management

in Africa and the Pacific especially in Nigeria and Republic of Marshall Island by Roger, (2004) and Ajibade (2007) and Izugbara and Umoh (2005), there has been no research on IWM in PNG. Hence, there is limited research into use of ISWMP in the world and Papua New Guinea is no exception.

1.1.5. Research Aims and Objectives

The main aim of the study is to investigate the relevance of Indigenous Knowledge (IK) through Indigenous Solid Waste Management Practices (ISWMP) as a tool for in contributing to the improvement and sustainability of Municipal Solid Waste Management System (MSWMS) in urban PNG. It will investigate traditional practices, values and behaviours that is in use. The objectives outlined below are derived to achieve this aim:

1. To examine the current municipal waste management system used in Goroka
2. To investigate the Indigenous Solid Waste Management Practice (ISWMP) used in Wamonagu and Goroka
3. To identify the appropriate Indigenous solid waste management practices and techniques used in Wamonagu and Goroka that can be used as a tool to develop policies for the current SWMS in Goroka to promote effective, sustainable solid waste management systems.
4. To evaluate ways of educating the public about the management of solid waste in Goroka
5. To identify and strengthen the partnership between the actors involved in SWM in Goroka to promote effective SWM for the common good of all partners and stakeholders in SWM

To achieve these objectives the study seeks to answer the following research questions:

1. What are the current Solid Waste Management Systems used in Goroka town and Wamonagu village in EHP in PNG?
2. What are the problems associated with the current method of Solid waste management in Goroka and Wamonagu?
3. How could these problems be minimized?
4. Could Indigenous Solid Waste Management Practice contribute to the minimization of the SWM problem?
5. What is the Indigenous Solid Waste Management Method used in societies in PNG?

1.1.5. The rationale and significance of the study

1.1.5.1 The Importance of the Study

The research on the Role of IEK and ISWMP to current SWMS in Goroka is important for the following reasons. Firstly, there is a need to identify appropriate methods of managing SW in Goroka, as the current method is inadequate, problematic and poses a threat to public and environmental health. Secondly, an appropriate SWM method must be easily understood by all residents of Goroka as the illiteracy rate is high in the Eastern Highlands Province where Goroka is situated. Thirdly, the SWM method must be sustainable in the long-term with benefits for all the actors involved in its management. Therefore investigation and use of IEK and ISWMP as a solid waste management tool may be able to address the issue of inadequate SWM in Goroka town.

1.5.1.2 *Benefits of the Study*

The research will contribute towards the knowledge in the following study areas: indigenous environmental knowledge (IEK), sustainable solid waste management, urban planning in solid waste management and sustainable development

The use of IEK through ISWMP as tools could mitigate impact of environmental degradation and public health threat caused by the SW problem in towns in PNG. The use of ISWMP would promote the field of IK in dealing with other developmental and environmental issues. In addition, this research will be the first study to investigate whether ISWMP can be applied with urban municipal solid waste management in urban centres (towns and cities) in PNG to improve the municipal solid waste management system (MSWMS). This could be through the application of ISWMP with the modern municipal solid waste management system using the waste management hierarchy employed in Integrated Waste Management (IWM). Exploring IEK through ISWMP would add to the understanding of how IK could contribute to maintaining environmental health and public health through sustainable solid waste management.

This study will also provide an insight and information into the processes of IEK through ISWMP used by Indigenous people and empowering them to seek solutions to their problems from their local knowledge. In-depth research will provide the vital data that are needed to make decisions on the most appropriate waste management system and model to meet PNG's needs according to its geographical location. Finally, the study would provide practical techniques for communities, managers and policy makers who aim to apply IEK through ISWMP as tools to develop an adequate SWM model for sustainable SWM in urban areas.

1.2 Terminologies

1.2.1. Terminology of waste

Waste: Waste is a term that has varying definitions and is also classified differently by different people. It is commonly referred to useless material discarded from all human activities. Waste is increasingly being considered as a resource and there is no absolute waste (Achankeng, 2004). It is considered as material which is not required by individuals, institutions or industries that is removed and disposed of (UNESCAP, 2000 cited in Achankeng, 2004). It is also defined as a collection of moveable items that have no use and are disposed of permanently (Rogers, 2004). Therefore an item considered as waste by an individual, institution or industry is a resource to another individual or organization. Waste is also defined as a by-product of human activities (McDougall et al., 2003).

Solid Waste: The term solid waste (SW) is defined in various ways. According to USEPA (2010), materials that are of no use or unwanted that are disposed of and have no liquid content or an insufficient amount of liquid to allow for them to flow easily, are termed as solid waste . SW is also referred to as a non-liquid or non-gaseous material produced by individuals, communities, institutions and industries through their activities and not viewed as valuable by first waste generators (Elainor et al., cited in Achankeng, 2004).

Other definitions of waste remove the term waste and replace it with other terms. Brown (cited in Achankeng, 2004) uses the word superfluous for waste as materials can be discarded when owners have a surplus of that material. SW is referred to as solid material including fluids in containers that are disposed of as useless, worthless and in excess (Tchobanoglous in Nemerow et al., 2009). The perception of SW is changing from materials being seen as a waste to being perceived as a resource (USEPA, 2010; Achankeng, 2004; SPREP, 2008). The change and

perception of the concepts of solid waste is focused on the reuse, recycling and recovery of resources from the trash.

Municipal and other urban solid waste or their management: The terms used with solid waste or their management are abbreviated and are common with the literature on the subject. This begins with solid waste (SW) and other terms as listed below (compiled from many sources) in Table 1.1 below.

Table 1.1: List of terms associated with solid waste literature

Number	Terms used with the subject of solid waste
1	Municipal solid waste (MSW)
2	Urban solid waste(USW)
3	Municipal solid waste management(MSWM)
4	Domestic or residential waste
5	Non-domestic waste
6	Industrial or commercial waste
7	Recycle
8	Reuse
9	Composting
10	Incineration
11	Biodegradable solid waste
12	Non-biodegradable solid waste

Source: compiled from varies sources

The MSW refers to the non-toxic SW produced by the residents, commercial and institutional establishments including the waste from non-manufacturing industries such as papers and cardboards (Tchobanoglous in Nemerow et al., 2009). As EPA South Australia (2010) and Schübeler (1996) stated, MSW covers waste produced in homes and businesses, institutional establishments, markets, yards and streets that is not a liquid or gas. Urban solid waste includes

all the waste in the urban centres. The next two terms refer to the source of the SW generation. Domestic, residential wastes are various terms used interchangeably referring to SW from households. The other three terms refer to the activities of SW minimization and resource recovery. Recycling refers to the activity where waste is transformed into same type of primary materials or different materials to be used. Reusing is when materials are used again differently from their formerly primary purpose. Compost is the product of organic and biodegradable materials that are disposed together and through activities of microorganisms form rich materials that is good for agriculture. The composting process is also known as biological recycling. The MSWS involves the different activities of managing SW that includes collection, transfer, treatment, recovery of resources and disposal. Municipal solid waste management (MSWM) involves the process and activities of waste production, storage, handling, transportation, treatment and disposal of residents, commercial and institutional establishments (UNESCAP 2000 cited in Achankeng, 2004). Biodegradable solid waste refers to any waste that can degrade through the activities of the microorganisms in a short period of time. The biodegradable SW waste is organic in nature. Non-biodegradable SW refers to waste that cannot degrade easily and can be present in the soil where it is disposed for a long time.

1.2.2. Indigenous knowledge and Indigenous solid waste management terminology

The word indigenous is defined in several different ways including local, original and traditional (World Bank, 2010). The term indigenous also refers to all activities, values, and knowledge that is local, original or unique. The term Indigenous Knowledge is defined in various ways too. The World Bank (2010) defines Indigenous Knowledge (IK) as the local knowledge that is unique to a given culture or society. Warren et al. (1993, p.2) describe IK as ‘the systematic body of knowledge acquired by local people through the accumulation of experiences, informal

experiments and intimate understanding of the environment in a given culture**.** Therefore indigenous solid waste management may be considered to refer to the local or traditional values, practices, methods of collection, storage, handling, transporting and disposal of solid waste.

1.3. Introduction to the country of research

1.3.1. A brief history of Papua New Guinea

Papua New Guinea (PNG) has a long history of human habitation dating back to approximately 50,000 years. PNG is located on the island of New Guinea, and was discovered by the Portuguese explorer Don Jorge de Meneses in 1526-27 who named it 'Papua' a Malay word that describes the inhabitants' frizzy hair (USA Department of State, 2010). In 1545, Spanish explorer Inigo Ortiz de Retes named the island New Guinea as the inhabitants resembled the inhabitants of Guinea in Africa. The Dutch took control of the western part of New Guinea in 1828 and called it Dutch New Guinea which is currently West Papua, a province of Indonesia since 1963 after the Dutch left. The eastern half of New Guinea was divided into two: German New Guinea in the north and British New Guinea in the south.

In 1884, German New Guinea was made a colony of Germany mainly to establish coconut plantations for Germany industry. The Germans established plantations in the coastal areas of mainland New Guinea and the islands that were part of German New Guinea. The capital of German New Guinea was Lae in Morobe Province. British New Guinea was taken by the British as a Protectorate on November 6, 1884 principally as a political colony to protect the Australia the British colony. The administrative capital of British Papua was Port Moresby, named after the British explorer Captain John Moresby. British New Guinea was placed under Australian authority in 1902. When the Papua Act of 1905 was established British New Guinea became the

Territory of Papua and was formally administered by Australia in 1906. The two territories spoke different languages under the colonial powers. The German New Guineans communicated in pidgin while the British New Guinean (Territory of Papua) communicated in English - the official lingua franca.

German New Guinea was mandated to the British as a territory by the League of Nations in 1921 after Germany lost the First World War to the Allies. The British mandated the territory of New Guinea to Australia in 1921. Australia administered the two territories separately until they were unified under the Provisional Administration Act of 1945-1946. In 1949, the country was named the Territory of Papua and New Guinea. The independence process began from this point with the name change to Papua New Guinea in 1972. The country was granted independence by Australia on the 16th of September 1975. Port Moresby was made the administrative and political capital of Papua New Guinea.

These major divisions produced two different systems and separate developments that were difficult to combine before and after independence. The different administrative systems, compounded with the diverse cultural differences influenced people's perception of solid waste management.

1.3.2. Geography, people and the economy

Papua New Guinea is located between three degrees south of the equator and 147 degrees east of the Greenwich. It shares it sea border with Australia to the south, the Solomon Islands to the east, the Republic of Marshall Islands to the north, and its land border with the West Papua province of Indonesia. The country has a very diverse landform. The rugged terrains, many river systems,

deep valleys, open plains with tropical rainforests, rich coastlines with swampy inlets and vast islands form unique and diverse ecosystems in the country (PNG Embassy in USA, 2010). Located in the Pacific Ring of Fire it has active volcanos and hot springs and high mountains. The highest mountain in the country, Mount Wilhelm (*Enduwa Kombuglu* in the local Kuman language), is 4,509 metres high. The country has a total area of 462,840 square kilometres (452,860 sq. km of land and 9,980 sq. km of sea area) (CIA, 2010). These variations in landforms have caused the development of a diversified range of natural environment (United Kingdom Foreign and Commonwealth Office, 2010), and the variety of plants and animal life ranks PNG as the fourteenth most bio-diverse country in the world (CIA, 2010).

PNG is a tropical country with an average temperature range of about 27 degrees Celsius (°C) which varies between the coastal regions and the highlands. The coastal regions have temperatures ranging from 24 to 35 degrees °C and highlands regions ranging from 12 to 28 degrees °C (Anderson, 2015). There are two seasons in the country: dry and wet. The two seasons are not distinctive, as during the wet season it can be dry for few weeks and in dry season it also rains. The wetter months are from December to March when the North east trade winds are blowing. The drier months are from May to October when the South east trade winds are blowing. However, there are seasonal variations from the coast and the highlands.

The country's cultural diversity matches it geographical diversity. Papua New Guineans speak 833 languages out of the 6,800 languages spoken in the world (Loh & Harmon, 2005) making it the world's most culturally diverse country. The diverse landform and culture in the country meant that the people developed separate practices, values, understanding and behaviours related to their environment. This factor determined their waste management practices in indigenous

communities. The rural population constitutes 87% and they own 97% of the land in tribal groups (World Bank 2015). The other 13% of the people live in urban settlements. The national rate of rural-urban migration is 13% while the counter migration from urban to rural areas is 0.7% (Un-Habitat, 2010). According to Mathews (in Assan, 2008, p.378) the Food and Agriculture Organization (FAO) indicated that the rural population in the developing countries would change from being in the majority of 60% to a minority of 44% by 2030. The trend of people migrating from rural to urban areas in PNG supports the above statement. The urban population in PNG is growing at the rate of 4.3% annually (UN-Habitat, 2010); that is over the national growth of 2.8% as indicated in the 2011 national census (NSO, 2012). The total population of PNG is 7.05 million as of 2011 (NSO, 2012). The urban and rural areas have different numbers of members in each household. The household heads are predominantly males with a slightly lower proportion for rural (83%) than urban (85%). A rural household has an average of 4 to 5 members while an urban household has over 6.8 members. The average size of household nationally is 5.2 members.

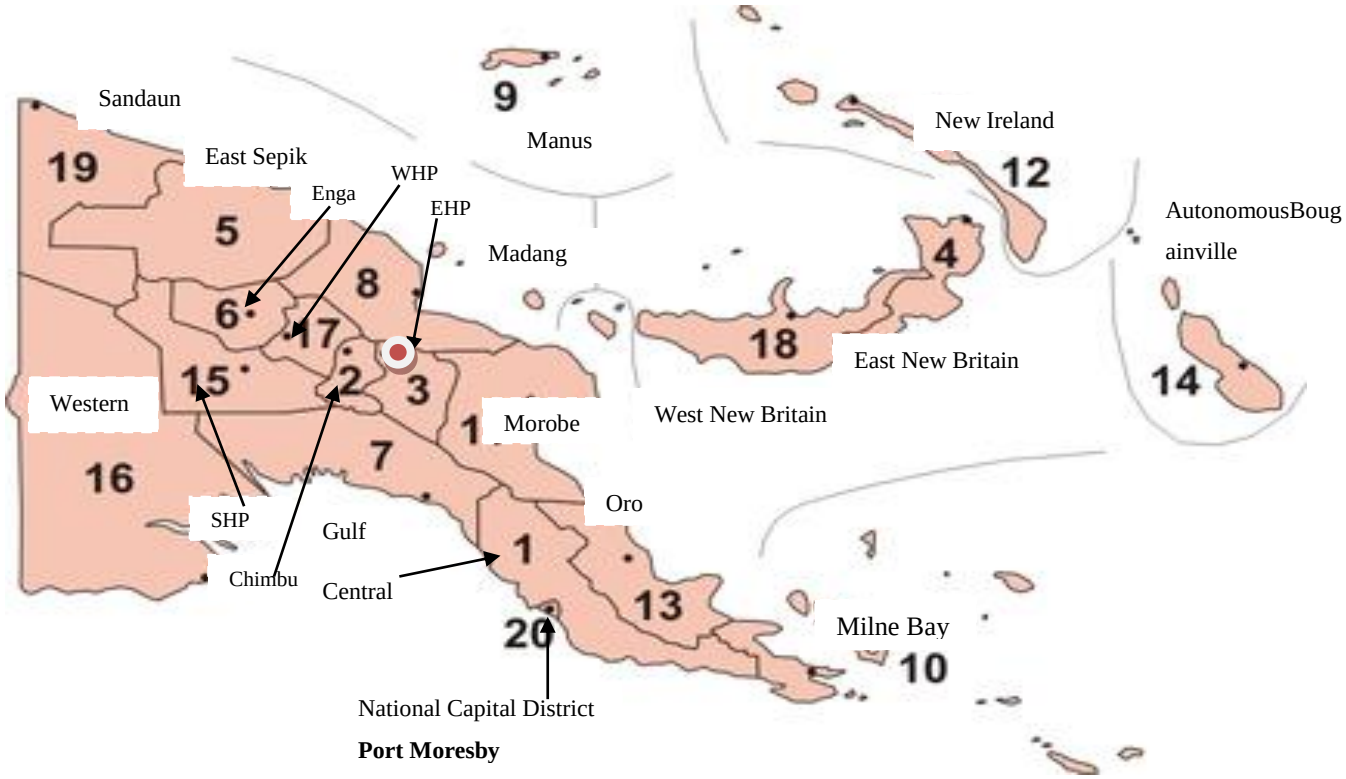
The urban centre in PNG refers to the settlement where basic services in education, health, electricity and water are available in a formally built housing on a land that is identified in sections and allotments, with the settlements having over 1,000 residents in it. The daily activity of an urban centre population is based around cash economy and services such as SW collection and disposal provided by the government agencies such as town and city councils. A rural area or village refers to a settlement of about 30 to 200 inhabitants who depend on subsistence farming and with households located on land that is customarily owned where there is a lack of basic services such as water supply, electricity and SW collection and disposal service by a government agency.

The urban centres include all the administrative capitals. The administrative capitals are towns and cities where administrative offices of the district (local government) and provincial and national governments are. These three different administrative divisions were established during the colonial era. These urban centres are called cities, towns and stations depending on the population and infrastructure development. The population of a city ranges from 60,000 to 400,000 inhabitants. There are three cities in PNG namely, Port Moresby, Lae and Mount Hagen with the national capital city, Port Moresby, having a population of approximately 400,000 people. Towns have populations ranging from 1000 to 23, 000 people with stations having just over 200 residents. The annual rate of urbanization in PNG is 1.9% but it is changing (CIA, 2010). The national literacy rate is slightly higher rate for males than females. PNG is predominantly a Christian country with only minorities from other religions (EHP Government, 2010; UNESCO, 2002).

The country is divided into several administrative regions comprising 20 provinces, one capital district, and an autonomous region. Two of the 20 provinces, Jiwaka and Hella have been recently established and formally endorsed by the national government in 2010. However, there is no updated current map to show its administrative boundaries as they are not shown in figure 1.1. The system of government in Papua New Guinea is a parliamentary democracy. The administrative unit begins with Ward councils as the smallest administrative unit that make up the local level government (LLG). Next higher up are provincial governments and the highest administrative unit is the national government. Administrative unit was established when the LLG and Provincial Government Act was passed in 1995 and amended in 2003 (PNG AGO, 2010). The provinces are classified into four regions depending on their culture and location. These four regions are (i) southern region, consisting of five provinces and the national capital

district ; (ii) Momase region, consisting of four provinces;(iii) Islands region, consisting of four provinces and one autonomous region; and (iii) Highlands region, consisting of seven provinces including the two new ones. The map in Figure 1.1 shows the different administrative capitals of the provinces in black dots excluding the administrative boundaries of Hella and Jiwaka provinces. The administrative capital of Eastern Highlands Province is Goroka that is shown in red and white. Goroka is where the current study was carried out as it is discussed later on in this chapter in section 1.2.4

*Figure1.1: **A**dministrative divisions in PNG and the administrative capitals in black dots*



Source: Map adopted from PNG business directory (2010)

PNG has a dual economy of formal and informal sectors (CIA 2010). Eighty seven percent of the rural community participates in the informal sector where they sell the surplus from subsistence

farming to earn their income (Wang and Kusabake, 2012). The urban communities are involved both in the formal and informal economy. The people in the informal sectors are mainly from the peri-urban areas, squatter settlements and surrounding villages. The informal economy have created a hybrid economy for the 87% of the rural communities where people are involved in subsistence agriculture for food production for their families but at the same time grow crops to be sold to the urban dwellers (Anderson 2015). The formal economy on the other hand involves the people from government institutions, Non-Government Organizations (NGOs), donor organizations and private companies.

Papua New Guinea is rich in natural resources such as minerals, petroleum, gas, timber, fisheries and cash crops such as coffee, cocoa and copra that contribute to the formal economy. The country's economy depends heavily on the mining of various mineral deposits, gas and oil in the country. PNG is ranked as the 11th largest gold producing country and 13th largest copper producer in the world (MHW SA, 2006). The mineral and petroleum industry is important for the country which contributed to 21% of the gross domestic product in 2003 (MHW SA, 2006). A country which is dependent on its primary industry, exports all the natural resources to generate revenue for itself. Of these exports, 74% are from the mining and petroleum industry. PNG is ranked 129th among the economies of the world with a gross domestic product of 7, 893 million US dollars in 2009 (World Bank, 2010) and is ranked 137thin the Human Development Index (HDI). The HDI is calculated using a combination of three indicators, namely life expectancy, educational achievement and per capita income. Although it is a country rich in natural resources, the social and economic indicators are low leading to it being classified in the low human development category in the HDI (UNDP, 2010).

1.4. Introduction to the Eastern Highlands Province (EHP) – the Province of research

The Eastern Highland Province (EHP) is a land-locked province that shares its boundaries with Morobe, Gulf, Chimbu and Madang provinces (see map in Figure 1.2). It has a land area of 11, 347 square kilometres (EHP Government, 2010; NRI, 2010). The province has high rugged terrain and broad fertile rivers and valleys where most people live. It also has a vast area of grassland. The many rivers in the province empty into the coastal provinces of Morobe, Madang and Gulf which border with the EHP. The province is located at an elevation of about1, 500 meters to 3,750 meters above sea level, with Mt Michaels being the highest mountain at 3,750 meters on the Bismarck Range (EHP government, 2003; EHP Government, 2010). The vegetation varies at different altitudes from mountain rainforests, alpine grassland and moss forests**.** The climate of EHP is cooler than the coastal provinces with an average temperature of 26 degrees Celsius (EHP 2010), and a level of rainfall at 2,500 millimetres annually. The wet season goes from December to April with a monthly mean rainfall of 200 to 300 millimetres. The dry season lasts from May to October with an average monthly rain fall of 50to 100mm. The seasonal variation is caused by the effect of two prevailing winds systems, the northwest and southeast trade winds. The seasonal variations in rainfall and temperature are small as it is warm and wet all the year round with less rain in the drier months.

The total population of the EHP was 579 825 in the 2011 national census, making it the second largest province in PNG (NSO, 2013) with 94% of the population living in the rural area (UN-Habitat, 2010).The annual population growth rate of EHP between 1990 and 2000 was 3.6% and was higher than the national rate of 3.2% during the same period (EHP Government, 2010). The population density of the EHP is 38 persons per square kilometres (MP Government, 2010) but

the actual population density of persons per occupied square kilometre of land is 76 persons per square kilometre (NRI, 2010). The increase in population is due to two factors. Firstly, the natural increase of population that is the difference between the birth rate and the death rate), and secondly the net migration that is the difference between in-migration and out-migration of population from EHP. In-migration is the movement of people coming into the EHP and out migration is the movement of people going out of EHP. EHP being the first highland province connected to the coast by a national highway (highlands highway), provides passage for the movement of the people from the highlands of PNG to the coast and vice versa. Therefore, the movement of people who are commuting between the coast, other highlands provinces and the EHP is high compared to the rest of the urban centres in PNG. The movement and passage of the people via the highlands highway through EHP to the six other highlands and the two coastal provinces means that these mobile populations have both direct and indirect impact on the socio-economic activities of the town. The literacy rate of the population of both sexes in EHP is 45%. The literacy rate of males is 51% and that of females is 37% (EHP Government, 2010; NRI, 2010). The literacy rate of EHP is lower than that of the country as a whole. The Eastern Highlanders speak about twenty different languages in their tribal communities. English and Pidgin are the languages used for formal communications.

The province is divided into eight administrative divisions or districts (Figure 1.2), namely Goroka, Unggai-Bena, Kainantu, Daulo (Asaro & Watabung), Henganofi, Lufa, Okapa and Obura-Wanenara. Of the eight districts, six have rural local level governments (RLLGs) and two (Kainantu and Goroka) have both urban and rural local level governments (ULLGs and RLLGs).

Figure 1.2: The eight administrative divisions of EHP with district administrative centres

Source: adopted from National Research Institute 2010

The political head of the province is the Governor with elected open members for each of the eight districts called electorates. The nine elected members including the Governor are members of the national parliament. The provincial government comprises the council president of each council area,, the town lord mayor, local member and the Governor as the political authority. The provincial administrator is the administrative head for the province and the district administrators are the administrative heads for the districts with council managers managing council activities. The highlands provinces (including EHP) were not properly explored until the 1930s by the gold prospectors Jim Taylor and brothers' Michael and Joe Leahy explored it (Jacka, 2007 and Hawksley, 2007).

The Eastern Highlands province is one of the major coffee producing regions of the country. Agriculture forms the largest part of the province's economy with other private and public institutions as contributors. There are also numerous non-governmental organizations in the province which provide employment to the people. The strategic location of the province makes

it the centre for the distribution of goods and services. The tourism industry also generates income in the province, especially during the cultural shows and the coffee festivals.

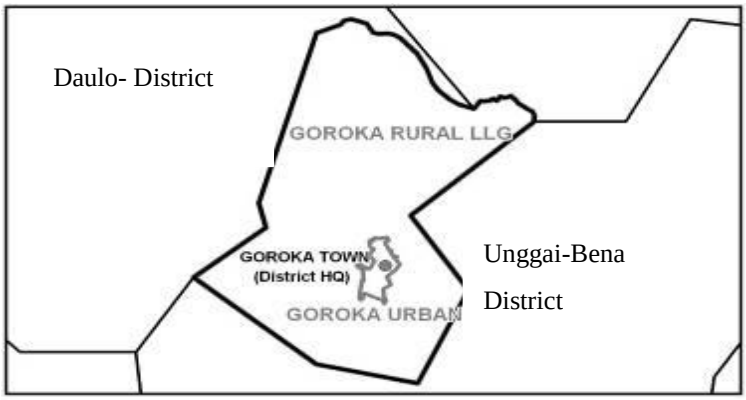
1.4.1. Districts and Goroka Town

Goroka town was established in 1939 as an outpost with an airstrip for the Australian and American soldiers during World War II. The town grew quickly around the airfield to become the administrative capital of the EHP in 1946. Goroka's development into a main urban centre in the highlands region for trade and administrative activities began in the 1950's (EHP Government 2010; Pacificwreck, 2010).

Goroka town is in Goroka district which is divided into urban local level government (ULLG) and rural local level government (RLLG). The RLLG consists of villages that are situated on the plateau as well as the valley within the vicinity of the town. The town is located in the Asaro valley with the Zokozoi River flowing through it from the north east to the west. The other rivers including the Kefamo are located outside of the town emptying into the Asaro River to the west of the town. The northern side of the town has hills extending to a plateau with steep river banks. The highest hill, Mt Kiss, overlooks the central business district while the rest of the town is built on the flat area. The town is surrounded by the Bismarck mountain range from the north to west and the Krate range from north to East. Located at a high altitude gives the town its spring-like climate with an average annual temperature of 23 to 25 degrees Celsius. It is sometimes referred to as the land of eternal spring. The average annual rainfall is about 1600 to 2000mm. It gets foggy in the mornings with the fog lifting later in the day and cloud formation and rain appearing in the evenings. The town is located at 6° 4' 60S latitude, 145° 22' 60E longitude (Pacific wreck 2010). The Goroka District has three Local Level Governments (LLGs), two of which are rural

local level governments (RLLGs) and one is Urban Local level Government (ULLG). The two RLLG are Gahuku Rural and Minimalo Rural with Goroka ULLG being the only ULLG in Goroka District.

Figure1.3: Map of Goroka district showing Goroka urban and rural LLGs



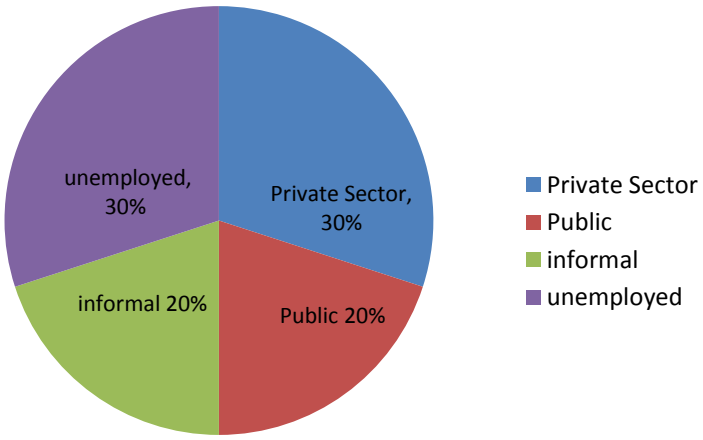
Source: Adopted from National Research Institute 2010

The population of the Goroka district is 71,870 with 19,523 (27%) people living in town in the ULLG area. The district has a land area of 296 square kilometres with a population density of 242.8 people/per square kilometre (NRI 2010).The other 73% of the population are located in rural areas making up the RLLG of Goroka district. Goroka town has a land area of seven square kilometres of which 80% is state-owned and 20% freehold. The land surrounding the town is traditionally owned by the Gahuku speaking people in tribal groups. The two main languages spoken in town are Pidgin and English with households speaking their own tribal languages at home.

There are two different types of housing in town. The planned formal housing occupied by the formally employed population is located in the five sections of the town. The five sections are

East Goroka (Seigu), West Goroka, Faniufa (southern) north Goroka and town (include market and Mt Kiss). Most formal housing is in West and North Goroka with the rest in the other three sections. The informal housing is unplanned houses built on state land unsuitable for development (UN Habitat 2010) mainly on the slopes and the gullies and are known as squatters' settlement. The formal housing density is one house on half an acre of land while the informal housing has about five houses on the same area of land. Most informal houses accommodate up to four families (UN-Habitat 2010) and the formal housing in urban areas in PNG has an average household size of seven persons (SPREP 2000). About 60% (12,000) of the population in Goroka ULLG live in the squatters' settlement. The unemployment in Goroka is 30%. Among the employed (which is 70%) 50% are employed in the formal sector and 20% in the informal sector (UN-Habitat 2010).

Figure1.4: Percentage of employed and unemployed population in Goroka



Source: Adopted from UN- Habitat, 2010

The main roads in Goroka are sealed with bitumen; however the streets in the residential areas are poorly maintained. The town has a network of two-lane roads and streets with residences with drive ways on each side. This allows residents to have access to services provided by the town council. The delivery of essential services such as water supply, sanitation and disposal of municipal solid wastes (MSW) in PNG is provided by the town and city councils. Goroka ULLG is administered by the council manager. The council is responsible for the provision and delivery of essential services mentioned above and the maintenance of street lights, parks and gardens in town. The services are provided to the residents of formal housing with very few services offered to residents of the informal housing. The infrastructure for the service delivery in Goroka was built about forty years ago to cater for a population of about 8,000 and cannot adequately service the current population (UN-Habitat, 2010).

The councils collect and dispose of rubbish from the residential areas once a week using open-back trucks. There is no landfill facility for municipal waste which is disposed of on land leased from traditional land owners at Fimito outside of town. The site is available to the public to dispose of waste at a cost of eighty kina (K80) per load ($35 AUD). Kina is PNG's currency. The burning of solid waste is common in Goroka to control the amount of SW. The streets of Goroka are filled with rubbish disposed of on a daily basis. There are many illegal sites that are close to the surrounding villages, urban residences, the Zokozoi and Asaro Rivers. The residents, businesses, NGOs, public and private institutions are charged for the collection, handing and disposal service of solid waste. The main focus of the councils in developing nations regarding municipal solid waste management system is for the improvement of public health, a system that was adopted from the developed world that colonized them (Baud in Baud et al., 2004). The urban councils' SWM in PNG are founded on the end of the pipe SWM where SW is collected

mainly for disposal at the dumpsite. Goroka town's SWM is no exception as shown in the current study.

1.4.2. Wamonagu Village

Wamonagu village is located in Unggai-Bena district and is about 30km away from Goroka town. Unggai-Bena comprises two areas, Unggai and Bena with each area having a local language of its own. The total population of the districts are between 30000 - 60000 people (EHP Government 2010). The district is governed by the Unggai-Bena RLLG with the elected parliamentary member of Unggai- Bena as political head, and the council manager as the administrative head for council activity and the District Administrator as the administrative head of the district. The district extends from the forested Bismarck Mountain Ranges (Unggai) through the Bena river valley (Lower Bena) dominant with grassland to the forested Krates mountain ranges (Upper Bena). The population in the Unggai –Bena constitutes predominantly subsistence farmers who are engaged in the informal sector of the economy in the province. Wamonagu is located in the Bismarck Mountain Range to the west of Goroka town in the Unggai area of the Unggai – Bena district. Most villages in Unggai are located on the hillside of the Bismarck mountain range through rugged terrain. The vegetation around the Unggai villages including Wamonagu is mountain forest with mosses. There are about fifteen villages in the Unggai area. The location of the villages in the hills gives it a cooler climate compared to the villages in the Bena and Asaro valleys.

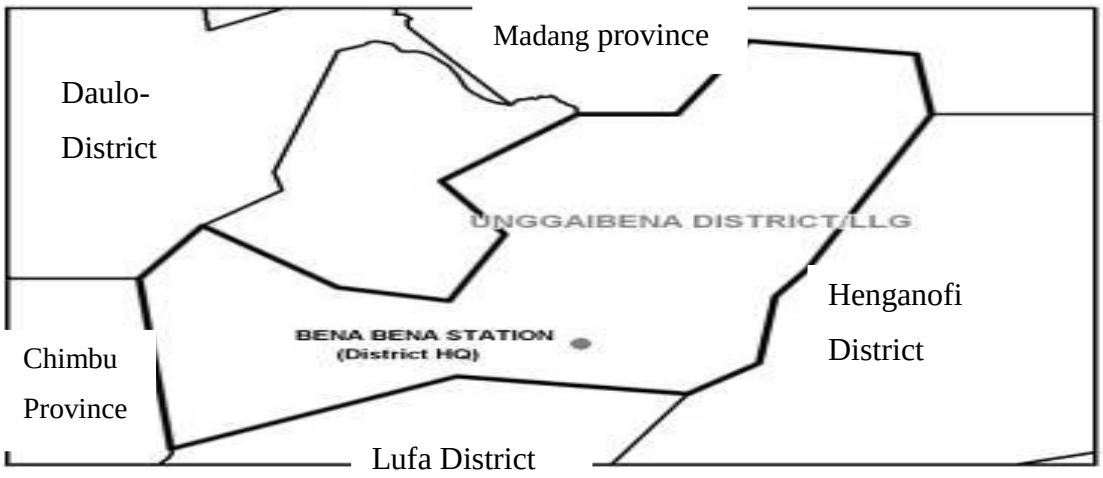
Wamonagu is located on the side of the ridge of a small stream known Atenamodo overlooking the Siane Valley and Ellimbary ridges. The village is surrounded by grassland with the forested ridges to the East with remnants of forest on hills to the west and north and steep sided gully to

the north east. The main road that serves the Wamonagu area and the other neighbouring villages to Goroka town runs through the village. To the Eastern side on a plateau there is another village called Orumba where the primary school is located. The Eastern forested areas have steep sloped ridges covered with grass and pine trees planted by the forestry department of EHP that was formerly vegetated with mountain grassland. The slopes on the eastern part fall off into the Asaro valley where Goroka is located. The western side of the village have slopes that are not as steep as the eastern side. Some tributaries of the Siane River start from these eastern ridges and empty into the Siane river valley.

The village has a population of over 500 people. The houses in the village are built in a linear pattern along a road on either side on the northern side of the stream whilst the houses on the southern side of the river are built in a circular pattern with a meeting area in the middle. The road runs from north east to south therefore the houses are divided either East or West of the road. The road is only accessible and used by vehicle with four wheels due to lack of maintenance. Few of the houses are built away from the road and the main village on the slopes but still on their tribal land. The houses have pathways between them and have large yards used for gathering such as family mumu (cooking in the earth oven) for special occasions. The villagers are subsistence farmers and depend on subsistence crops as their food source. They substitute their meals with manufactured food that they buy from Goroka. Wamonagu villagers have houses built from materials extracted directed from their natural environment with only a few buildings such as church building that is built from manufactured materials. The villages in PNG generally have population of about 200 to 500 people in their clan groups with houses built on the land that is communally owned by their tribal or clan.

The villages in Unggai are in the rural local level government (RLLG) of the Unggai –Bena district (see figure 1.4) and are divided into council areas called wards. Each council ward has couple of hundreds of people represented by an elected local councillor who is the elected political head. Wamonagu village has a ward councillor who is their political head and represents the people in the RLLG. However being a tribal community the villages also have their tribal and clans leaders who deals with issues in the village that the councillor is not able to deal with mainly issues to do with land and other resources. The village's actual organization and running of the daily activities operates at the family unit. The tribal elders play an important role in general organization including the traditional laws of the tribe apart from formal laws of the country. The basic services like water supply, electricity and gas is not available to the village as the people depend on the ecological services provided by the environment in terms of fresh water from the streams and wood from the forest for energy and light. There is no council waste collection or disposal service in the village; however this activity is organized at the individual household level.

Figure 1.5: Map of Unggai- Bena district with Benabena its administrative centre



Source: adopted from National Research Institute 2010

1.5. Organisation of the Thesis

The thesis is divided into eight chapters consisting of various subtopics. The first section consists of three chapters. These three chapters are: Chapter One which contains the introduction to the thesis, a discussion of the significance of municipal solid waste management (MSWM) in the world at different regional, national and local levels, especially the city's SWM in PNG. It also covers the major aims, objectives, significance and limitations of the study. The terminologies related to Municipal Solid Waste and Indigenous Solid Waste Management Practices are also included here.

Chapter Two reviews the literature related to the study including the conceptual framework, theories, principles and models used in Municipal MSW. This chapter reviews how the theories and principles have be translated into policies, strategies and practices in the world and their results. The evaluation was made of the outcomes and the gaps identified for the study through lessons drawn from the literature. Chapter Three details the methodology, including the methods of data collection and the data analyses used in the study. The rationale for choosing the methods, case studies samples and analytical tools are also included in this chapter.

The next two sections examine the main research results and discussions on the role of indigenous solid waste management practices (ISWMP), partnership and awareness of MSWM in Goroka using the ISWMP as a policy matter. The sections comprises of five chapters including a conclusion and policy recommendation. The second section has one chapter that covers the results and discussion on the ISWMP in Wamonagu village and the third section has four chapters including the conclusion chapter. The three of the chapters in the third section discuss the results and analysis of SWM in Goroka.

CHAPTER TWO:

LITERATURE REVIEW

2.1 Introduction

Management of Solid Waste is a global issue that crosses boundaries in many disciplines. The actors involved in it focus on the improvement of the system applied to manage it. In general the global community aims to protect and sustain the quality of the environment and public health and to promote economic growth (Schubeler in Achankeng, 2004). An efficient and productive MSWM provides employment opportunity for residents in urban areas. In many countries MSW is a booming industry as resources are recovered from materials discarded from the primary waste generators. However with these efforts the problem of SWM is a global issue as the amount of waste generated increases with population growth.According a latest report published by the World Bank, ten years ago there were 2.9 billion urban residents who generated about 0.64 kg of MSW per person per day (0.68 billion tonnes per year). However, today these amounts have increased to about 3 billion residents generating 1.2 kg per person per day (1.3 billion tons per year). By 2025 this will likely increase to 4.3 billion urban residents generating about 1.42 kg/capita/day of municipal solid waste (2.2 billion tonnes per year) Hoomweg et al., 2012). Tchobanoglous et al. (cited in Das et al., 2002) stated that over 69 % of the total weight of the global municipal waste consists of organic biodegradable solid waste that can be managed using biological recycling.

2.2. Concepts, principles, and philosophies in MSWM

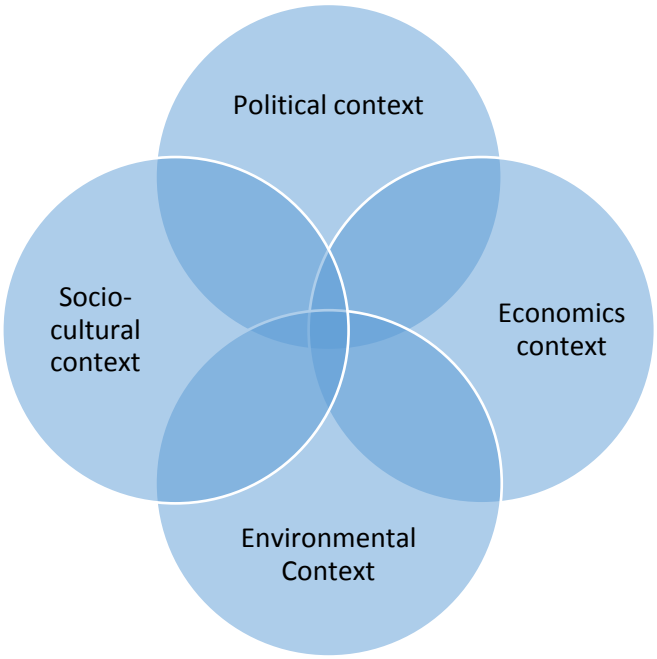
The SWM is perceived as a developmental and environmental issue that requires sustainable management. Sustainability of SWM is a global concern that crosses national and international boundaries (Fagan et al. cited in Achankeng, 2004). In current global urban societies sustainability is perceived in terms of development deriving from the concept of sustainable development which includes economic, social and environmental development. Sustainable development realizes that changes brought about by human ensure that the needs of the current generation are met without comprising those of the future generation (White, Franke & Hindle, 1999). However, there are concerns about the conflicting relationship between sustainable development and the concept of ecological sustainability. The concerns relate to maintaining environmental health at the same time as meeting the needs of people. According to Freire & Strens (cited in Achankeng, 2004), many urban centres achieve economic development but fail to protect the environment. The developing and developed nations differ in their perception of sustainable development where the developed world is concerned with environmental health and resource depletion known as the green agenda (Achankeng, 2004). The developing world concentrates on improvement of human livelihood through provision of better basic services which is known as the brown agenda. Baud and Post (2002) suggested that the issue of environmental health is overlooked in the brown agenda.

The SWM in urban centres in the world are confronted with sustainable issues that lead to stakeholders in SWM such as managers, policy makers and private companies focusing on Sustainable Municipal Solid Waste Management (SMSWM). SMSWM in urban centres aims at utilizing a strategy that incorporates the approaches where the following factors are captured:

1. Four different management dimensions (political, social, economic and environmental)
2. Different stakeholders (actors) involved in the management of SW
3. Driving forces in MSWM
4. Diverse systems that are related to the MSWM

This process aims at integrating all actors, systems, drivers and management dimensions to achieve a sustainable MSWM. This forms a structure of the MSWM framework that can be used by the actors and managers in MSWM as shown by figure 2.1 and table 2.1 below:

Figure 2.1: Structure of the conceptual framework for MSWM showing the context of management



Source: The diagram adopted from Shubeler 1999

The management of MSW to be sustainable involves the decision making that includes all the four different context of the society as show in figure 2.1 above. The integration of the various

contexts for decision making and management allows for the involvement of the different actors with common objectives, strategies and activities. This leads to sustainable and effective MSWM.

Table 2.1: The actors, objectives and scope of their involvement and the type of SWM strategies use

Actors	**Objectives**	**Scope**	**Strategic Aspects**
1. National government 2. State government 3. local government 4. Private sectors 5. informal sectors 6. NGOs 7. Service users	Planning and management	Strategic planning Legal , Regulatory framework public participation Financial management Institutional Agreements disposal facility sites	political institutional social Financial economic technical
	Solid Waste generation	Solid waste characterization Solid waste minimization	
	Solid waste handling	Solid waste collection transfer, treatment and disposal	

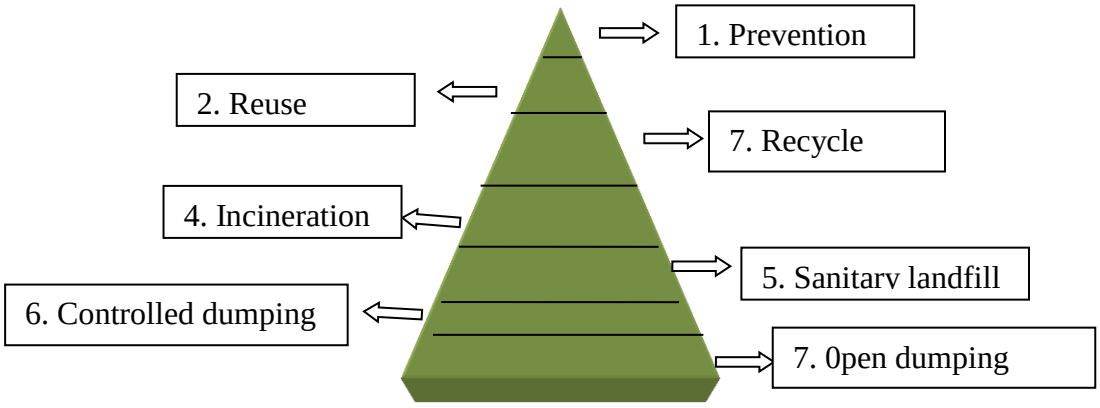
Source: The table adopted from Shubeler 1999

2.2.1 Integrated Sustainable Solid waste Management (ISSWM)

The principle of Integrated Solid Waste Management (ISWM) is defined as selection and application of appropriate techniques of SWM aimed at waste reduction and minimization programs such a recycling and reusing (USEPA; Achankeng 2004; SPREP 2009). The ISWM aims to apply techniques in SWM that are sustainable and minimizes the impact of SW on environmental and public health through integration of economically, politically, socially and environmentally effective, efficient and acceptable approaches that bring together all actors in MSW (Achankeng 2004). The principle of ISWM promotes a MSWM in which priorities are focused on reduction through prevention, reuse and recycling before the SW reaches landfill. This concept of prioritizing the SW techniques from the most preferred to the least establishes a

model known as waste hierarchy (UN-Habitat, 2010; Beukering et al., 1999; Adam et al. 2000 and Hansen et al., 2002).

Figure 2.2 The model solid waste management hierarchy



Source: adopted from Achankeng (2004); Hansen et al. (2002); SPREP (2009)

However some authors argue that the waste management hierarchy has short falls in that it only addresses the environmental outcomes and no other aspects (Achankeng, 2004). This concept is accepted by managers and policies makers in both developed and developing nations to create their MSWMS even though there is an ongoing debate on the sequence of priority in the hierarchy.

Managers, legislators and other actors in MSW use the concept of waste reduction through the application of techniques in the waste hierarchy model established around the ISWM framework to develop legislations, strategies and policies to achieve that goal. However the application and integration of the waste hierarchy in MSWM varies from country to country. Furthermore, the

waste hierarchy is transferred into actual practice in the developed world compare to that in the developing world.

2.3. Literature Review

The solid waste management principles, strategies and policies used by nations around the globe cannot be generalized for use by all. The nations are becoming more and more aware of the environmental and health problems in their countries (Ferrara 2003). This has led to formulations of policies and strategies to mitigate the impact of pollution attributed to MSW. Research carried out in Ireland (Achankeng, 2004) showed that the global SW generation was 1.84 billion tonnes in 2004, a 7% increase from 2003. This was predicted to increase by 31.1% between the years 2004 and 2008 (UNEP, 2004; Achankeng, 2004).

2.3.1 Municipal solid waste management in developed nations

Developed nations are industrial nations located mostly in the northern hemisphere in Europe, North America, and including the Asia-Pacific namely Japan, Australia and New Zealand in the southern hemisphere (UN population Division, 1998). The developed nations produced a large amount of municipal waste and are called ‘throw way societies’ (Achankeng, 2004). These countries are market driven and aim to produce goods that are of the latest model and improved quality that consumers buy to replace their old goods which are disposed even when they are functional. Developed nations generate large amounts of SW compared to developing nations as their consumption rates are greater where populations are smaller in comparison to the developing nations. The membership for the Organisation for Economic Co-operation and Development (OECD) are made up of majority of the developed nations.

Developed nations with their technological and capital capacity are able to develop policies, strategies and laws aimed at reducing municipal solid waste by means of formulating models such as the waste management hierarchy (Achankeng 2004). The use of an integrated solid waste management strategy encourages different waste streams to be stored, collected, and transported separately allowing for the application of the waste management hierarchy. For instance in Adelaide, South Australia, the local councils provide three different garbage bins for households to store recyclable, compostable and disposable SW. The policies that the developed nations formulate for the management of municipal solid waste are aimed at diverting SW away from landfill and reducing the amount of solid waste produced. In North America a user fee and bag limit policies have been introduced (Ferrara &Missios, 2005). However according to Ferrara & Missios (2005) others researchers have argued that these policies can lead to illegal dumping and increased production of recycled materials (Houven &Morris in Ferrara & Missios, 2005). It is also argued that the recycling program does not encourage source reduction of household waste but subsidizes the disposal practices (Nestor & Podolsky in Ferrara & Missios, 2005). The policies and techniques used in developed nations are aimed at reducing and managing municipal waste going to landfill. In Ontario, Canada, the user fees encourage recycling in the municipalities although the bag limit policy indicates a reduction in recycling (Ferrara & Missios, 2005).

2.3.2 Characterization of municipal solid waste

The information of individual nation is difficult to access; however, the data available indicate that municipal waste generations are increasing. According to the OECD (2010), solid waste generation in developed nations increased by 14% (530 to 604 million tons) from 1990 to 2000

with an increase of 509-540kg per capita per year with 1.4-1.5kg per capita per day (OEDC in Achankeng2004).These figures vary from country to country. For instance, USA produced about 250 million tons of solid waste with 4.5 pounds / per person per day (1kg/ per person per day) in 2008 (USEPA 2010). It was also noted that the USA was generating SW with a mean of 2.1kg per capita/ per day per person before 2008 (Mihekcic et al., 1999; USEPA in Achankeng, 2004). Population increase and high income levels maybe contributing factors to the increase in municipal solid waste production in the world. In the developed world the latter is the main factor while the developing world both factors contribute to increased SW generation (Braathen in Roger, 2004). However, other factors include long-life goods and single member households who produce more non-organic SW from readymade food with lots of small package compare to a household with more family members who are likely to prepare homemade meals (Rogers, 2004). The composition of municipal solid waste produced differs from country to country. In developed nations generally, the composition of solid waste are mostly non-organic with recycling potential. For instance, councils in Adelaide in South Australia use a three bin system for garbage storage, with two bins designated for non-organic waste and one for organic. The production of non-biodegradable municipal solid waste at the source is high for developed nations, however due to intensive recycling; the amount reaching the landfill is lower than that of biodegradable waste. Study carried out by the Environmental Protection Authority in South Australia in 1998 indicated that majority of solid waste reaching landfill was organic municipal waste, especially paper and cardboard (EPASA, 2000).

The amount of municipal solid waste disposed in landfill in developed nations is still high with over half of the waste generated being disposed. In recent years, there has been a decreasing trend of the amount of SW ending up in landfill. Study carried out by De Tilly (2004) indicated

that the percentage of MSW going to landfill decreased by 6% from 64% to 58% between 1995 and 2000.This decrease resulted from an increase in recycling activities of both biodegradable and non-biodegradable SW. The study by De Tilly (2004), also indicated that biodegradable recycling (composting) increased by 2%, from 4% to 6%, and non-biodegradable recycling increased from 14% to 16% in the same period in OECD countries.

Between 1993 and 1999, most OECD countries in Europe land filled over 60% of MSW with the exception of three nations: Denmark, Netherlands and Switzerland (Malcom in Achankeng, 2004). It is shown that between 13-15 % of the solid waste in Europe is municipal Waste (McDougall et al., 2003)

The non-European OECD nations also show a similar trend of disposal SW in landfill and recycling activities. For instance in USA, the total amount of MSW disposed in 1999 was 57% with only 28% being recycled (US EPA, 2003). In Australia, the amount of MSW going to the landfill was 95% and recycling was 5% between 1996 and 1997 (CSIRO in Achankeng, 2004) making Australia the second largest MSW generator amongst the OECD nations (Achankeng, 2004). Municipal solid waste in developed nations is categorized into three streams: domestic, industrial and commercial, and building and demolitions. The largest quantity of municipal waste in Australia, especially South Australia, originates from buildings and demolitions (EPASA, 2000). Refer to the pie chart below for the percentage of SW from each category in Adelaide, South Australia.

Figure 2.3: Different categories of municipal solid waste and amount disposed in landfill in Adelaide in 1998 by EPASA 2000, has been removed from this Thesis to fulfil the requirement of the third party copy right.

In Canada, 90-95% of the MSW was sent to landfill with 10-5% being recycled in 1998 (Achankeng, 2004). In Asia, mainly in Japan, the composition of MSW that ended up in landfill was 10% with 70% of it incinerated and the rest composted and recycled (Achankeng, 2004). The Japanese strategies and policies regarding incineration of MSW differ from the other OECD nations. However, the waste management strategies of reduce; reuse and recycle are no different to the other OECD nations of Europe and Northern America.

2.3.3. The methods, techniques and technologies of solid waste management

Waste minimization with the use of waste hierarchy is used by developed nations as accessibility to resources and facilities are easy for the solid waste actors. According to Ferrara and Missios (2005) 94 % of the municipalities in Ontario, Canada had access to curb side recycling. The growths of non-biodegradable and biodegradable recycling activities have increased as the methods of managing MSW in the last few decades. The common method of MSW management in all the OECD countries currently is carefully engineered sanitary landfill that collects leachates and methane gases produced by the landfill. Studies done on landfill show that many countries prefer the landfill method as it is economically cheaper (Tatsi and Zouboulis, 2002). The operation procedures in place for this management system begin with storage and separation of the SW at the source. The MSW is then transported to the transfer station where the waste is further sorted and resources are recovered for recycling. The bins used for storage have protective lids to keep pests out and protect the health and safety of the occupants (EPASA, 2010; Achankeng, 2004).

In the developed world, the solid waste management system involves high technology machinery and is an important industry that provides jobs. The frequency of collection of municipal solid waste by the council differs from nation to nation including their waste minimization drives. For instance in Adelaide, South Australia, the collection of garbage from the source is done on a weekly basis (EPASA 2010), while in North America, especially in Canada, research shows solid waste managers leaning more toward bi-weekly collection with the aim of intensifying the recycling activities by MSW generators (Ferrara and Mosisos, 2005).

The collection of the garbage is done by a one man collector who is also a driver with the use of a mechanically operated metal arm specially designed and attached to the collection truck. The special arm on the truck picks up the bins from the road side and tips them into the trucks. The trucks transport the SW to the transfer stations for further sorting for resource recovery and recycling before the final disposal in the landfill. In Adelaide, the garbage at the transfer station is compacted by heavy machinery before it is loaded on to trucks to be transported to landfill. During this process machines and human workers pick out large items that can be recycled. Other large garbage is collected by the council, individuals and private contractors. In Adelaide the bulk of garbage is collected by the actors mentioned above and is dropped off at the bulk garbage depot to be separated and resources recovered before it reaches the landfill (EPASA, 2010).

Even at the landfill the garbage is further separated and resources are recovered for recycling before it is disposed of permanently. The recycling centres in the developed world use heavy machinery with some human labour to sort the non-biodegradable garbage into different categories that can be then sold to recycling companies. In South Australia, most containers are

brought to state-wide recycling centres for sorting and compacting. The biodegradable SW for composting is transported to either an area in the transfer centre or the landfill where composting companies process the materials to compost. In Adelaide, South Australia, biological recycling is done by a company called Jeffery's which operates at the transfer centre before selling its products. The landfill and transfer stations have weighing equipment that allows for accurate recording of the MSW reaching them.

Even though developed nations generate more waste, they are able to better manage their SW than are the developing nations (Achankeng, 2004). The developed nation's citizens and government make municipal waste management a priority and so measures are taken to minimize solid waste. According to USEPA (2010), American considers municipal SW as an important issue this century; therefore SW minimization is vital in communities (USEPA, 2010). The land fill method of disposal has the potential to pollute and contaminate the environment and affect public health as it produces leachate and methane. This causes the citizens of the developed nations to raise concerns about the landfill disposal system leading to waste managers designing and constructing landfills carefully to collect pollutants to protect environmental health. To maintain and protect environmental and public health the landfills have liners to collect leachate that is left to neutralize or sent to treatment plants before discharging it back to the environment. The methane gas is either collected as an energy source or burnt off depending on the quantity that is produced at the landfill. A landfill in Adelaide's south flares the methane gas produced as the quantity is not enough to be collected for energy. There are three landfill types: bioreactors, conventional wet and conventional dry. The solid waste disposed at the landfills or sanitary landfills which are covered with soil and vegetated and are continually monitored after closure is important to avoid contamination of the environment (Achankeng,

2004). The covering of the cells that are filled is a daily activity at the land fill to manage the landfill.

In few countries of the developed world are the MSW incinerated where other disposal methods are not possible. Incineration is the least preferred method of waste minimization in waste hierarchy (SPREP 2008; Achankeng, 2004)

2.3.4. The actors and partners in the solid waste management

The concerns about contamination and pollution to the environment by inadequate management of SW and its effect on the human health have brought SWM actors together in partnership at international, national, state, municipal, community and household levels to manage the issue. These partnerships also include private sectors and non-government organizations. The partnership starts with households and individual's separation and storage of SW in bins for collections by the council. The international, national and state partners provide the financial support, policies, strategies and legislations that guide the MSW management (Achankeng, 2004). These legislations and policies allow for MSW to be put out in the open market for private sectors to utilize and manage in an efficient and cost effective way generating profit from the SW through resource recovery. Some private sectors partners are involved in the design, construction and management of the landfill while others such as manufacturers' produce goods with packaging and containers that can be recycled or reused. For instance in Adelaide, ten cents are refunded from beverage bottles and containers for recycling. This is made possible under the South Australia's Container Deposit Legislation (EPASA, 2010).

The non-government organization and educational institutions are mainly involved in the research, projects, and education and awareness drives of the solid waste management system. The contributions and participation of these actors are important in disseminating the information on policies, strategies and methods of appropriately managing the SW. This contributes to the public being well informed of the MSW management system in societies in the developed world. In South Australia, KESAB, an NGO, works with multiple partners from different levels of government, public and private sectors especially with schools, communities and municipal councils on the systems of separation, storage, collection and recycling opportunities implemented in South Australia (KESAB, 2010). This information dissemination enables the majority of the citizens of the developed nations to apply methods required to allow for an adequate MSW management system. With the established MSW management system the actors and partners are able to adjust activities and methods with the changes in their societies.

2.3.5. Legislations, policies, and strategies used in Waste management

The management of MSW has improved greatly in the developed world. The storage, collection, transportation and disposal of the MSW have been efficiently managed that the countries have embarked on the waste minimization programs and projects. To minimize the MSW and its negative impact on the environment and human health, projects and programs are developed with the strategies and policies that stem from the concept of waste hierarchy and the framework of integrated solid waste management (ISWM).

The policies, legislations and strategies developed and implemented vary from country to country, but are all aimed at reducing the quantity of solid waste reaching landfill. In Australia there is a national waste management strategy developed to encourage recycling (EPASA, 2010). This national strategy is used by the states and territories to develop individual waste management strategies. For instance, in 1996 the Integrated Waste Strategy for Metropolitan Adelaide (1996-2015) was released by the government (EPASA, 2000). This strategy set the framework for management of waste in the municipalities in Adelaide. Container deposit legislation in South Australia is a legal framework that was developed in response to this strategy. The landfill audits carried out on landfills in developed nations are done using guidelines from the national and local strategies established on MSW management.

In Europe, the strategy that governs and provide for SWM was established in the 1960s. In North America, the establishment of their strategy of MSW management was established in the 1970s (Achankeng, 2004). The nations of the developed world use the framework of integrated waste management and the concepts of waste hierarchy to develop specific policy instruments, programs and activities with their focus shifting from collection and disposal. The shift in the focus is now on the prevention, reduction, reuse and recycling of the different types of waste (Achankeng, 2004).

The minimization policies and programs are twofold. In the policies and programs for biodegradable SW, the target is on waste generators and the actors in the recovery of this type of waste through biological recycling (composting). For the non-biodegradable waste, the targets are the generators of waste in their activities of separation and storage efforts at the source of the different streams of waste. More so the target is on the actors who manufacture the materials

termed as waste. The policies and the practices drive the activities of the manufacturers to produce non-biodegradable waste with containers that are recyclable with some actors advancing by producing packaging and bags that are biodegradable to replace the old models. One such example is the beverage companies in Adelaide packing drinks in recyclable contains with a ten cent refund system under the Container Deposit Legislation (CDL) of 2000 (EPASA, 2010).

The developed nations use the Polluter Pay Principle to cover the cost of waste in private and external terms. The private cost covers the operational costing of managing solid waste by actors involved in management of MSW. The external costing is tax for environmental pollution from the discharges of solid waste (Achankeng, 2004). These two costing are known as the social cost of Solid Waste Management (Davies and Doble in Achankeng, 2004). The policies are aimed at behaviour change in the production down to the consumption lines. This involves the producers, distributors and consumers of goods that are on the market (Achankeng, 2004). The developed nations give various names to the strategies, policies, practices and legislations on solid waste management to achieve the same outcome. Since the introduction of the model of integrated waste management (IWM), waste managers have attempted ranking the options of practices in order of preference with no scientific evidence.

In recent years, the IWM has been remodelled to combine both environmental and economic assessment tools. The model that developed out of this is known as the Life Circle Inventory (LCI) to be used as a tool for SWM by managers, decision and policy makers (McDougall et al., 2003). This model is applied by the developed world to establish their legislations, policies and strategies.

The approaches of legislative tools are classified into two categories: the end of pipe regulations and strategic targets (McDougall et al., 2003). The end of pipe regulations is technical and applies to individual processes of waste management where SW is disposed. The European Directive (1993/31/EC) on landfill is an end of pipe regulation. This regulation safeguards and promotes safe disposal of waste. The strategic target legislation forms the framework of how solid waste will be managed in future (McDougall et al., 2003). This type of legislation builds on the concept of solid waste hierarchy setting targets for resource recovery, reuse and recycling operations (McDougall et al., 2003) within a given time frame. The integrated waste strategy for metropolitan Adelaide 1996-2015 falls under strategic target legislation. The national legislations from developed nations that fall under strategic target are German packaging ordinance, Dutch packaging Convention, United Kingdom Environmental protection Acts of 1990 (McDougall et al., 2003) and Australia's National packing convention of 1999 (Achankeng, 2004). These legislations have rule or guidelines on the solid waste management options and target a part of the whole municipal solid waste stream.

These legislations are translated by solid waste actors into practice. The advance deposit fee (ADF) used by manufacturers and distributors of some recyclable products applies this concept in practice. The container deposit legislation (CDL) in South Australia falls under this legislation. The applications of these legislations and practices vary from state to state and from nation to nation. In Australia, the CDL is only applicable in South Australia and not in other states and territories (EPASA, 2010). In Germany, the ADF charged is higher than it is in France.

2.4 Environmental impacts of SW and awareness in developed world

2.4.1 *Environmental impacts of SW in the developed world*

The environmental impacts of the SW in developed nations have been minimized due to the specific legislations, policies, and strategies that have been developed over the years. The whole system of the municipal solid waste management has improved. However the long-term environmental contamination caused by inadequately managed previous waste management facilities is a problem (Achankeng, 2004). There are concerns about the environmental pollution caused by the Sanitary Landfills method of disposal especially relating to contamination of groundwater, surface water and soil due to leachate leakage (Ehrig, 1983; Tatsi and Zouboulis, 2002).Even with the improved system, there is a continued search to find a long term solution to MSWM by the developed world. This is a challenge as new products are brought into the market to replace the old model and the content of the waste from new goods demands new and increased recycling.

2.4.2 *Education and Awareness*

The improvement in the system of MSWM in the developed world is driven by the education and awareness campaigns that are incorporated in the legislations, strategies and policy instruments. The programs of education and awareness campaigns on solid waste have multiple drivers from municipal/city councils, universities, schools, NGOs and community education and awareness campaigns target all the actors in the MSW system using different delivery modes to communicate with the actors. The mode of delivery can be face-to-face or by distance by means of books, pamphlets and the Internet. The mode of delivery depends on the nature of the MSW

actors and the stage of their involvement. The USEPA and EPASA use the Internet to deliver information on solid waste management systems and its practical applications (USEPA, 2010; EPASA, 2010). The website targeting individuals, households, schools, different workplaces and the general public that is easily accessible nationally and globally as well. The other organizations use the face-to-face mode to disseminate information on SW. However the target audience for this mode is the same. The face-to-face mode assists the target audience to drive specific programs through the actual setting up of projects or supporting the ones in operation. KESAB and various NGOs in South Australia conduct most of their education and awareness campaigns using this direct mode of delivery. They partner with schools, teaching students about waste mitigation and reduction activities.

2.5. Municipal solid waste in developing nations

Developing nations are mainly countries with low to lower middle income economies and are not industrialized with low standard of living (World Bank, 2010; Rogers, 2004). These groups of countries are geographically located in Asia, the Pacific, and Africa, the Middle East, South America and the Eastern European states.

The developing nations' waste generation is less than one kilogram per capita per day but varies from nation to nation and is also increasing (Achankeng, 2004). The MSW generated by developing countries is less in quantity and the composition of waste also differs from that of the developed world. However the contaminations of soil, air, surface and ground water by inadequate management of SW remains a crucial problem in the developing world. Contamination threatens human health and the health of the biodiversity. A study by the UNEP

conducted in 2006 on the Dandora dumpsite in Nairobi indicated a severe threat to public and environmental health.

The general SW generation in developing nations depends on the rate of the nations' industrialization and population size. For instance, the amount of SW generated daily in India was between 0.1kg and 0.6kg per person), while China generated about 0.5 kg to 0.9 kg per person (Buekering et al., 1999; Kumar, 2005). China produced 190,000,000 tonnes of MSW in urban areas in 2004 and it was estimated that with the same generation rates China will have produced 480,000,000 tons by 2030 with per capital waste generated between 1.2 to 1.8kg per day (World Bank, 2005). The rapid urbanisation in developing nations contributes to the increased amount of MSW (Buekering et al., 1999). These nations have inadequate waste, storage, collection, transportation and disposal that collection rates range from 20% to 80% and not all the areas in the municipalities are covered (Achankeng, 2004). In Bhutan, 50 tons out of the 70 tons of waste generated weekly are collected with the remaining quantities disposed of at illegal dumpsites. This shows an efficiency of about 72% (UNEP, 2005). The MSW management has an operational cost of up to 50% of the budget to the total amount in larger nations but less in the smaller nations with varying views on MSW (Achankeng, 2004). In India more focus is given to MSW and there is even a national organization on SW compared to PNG. The developing nations have developed and adopted policies and strategies to manage the MSW both at the local, national and regional, but most are not successful.

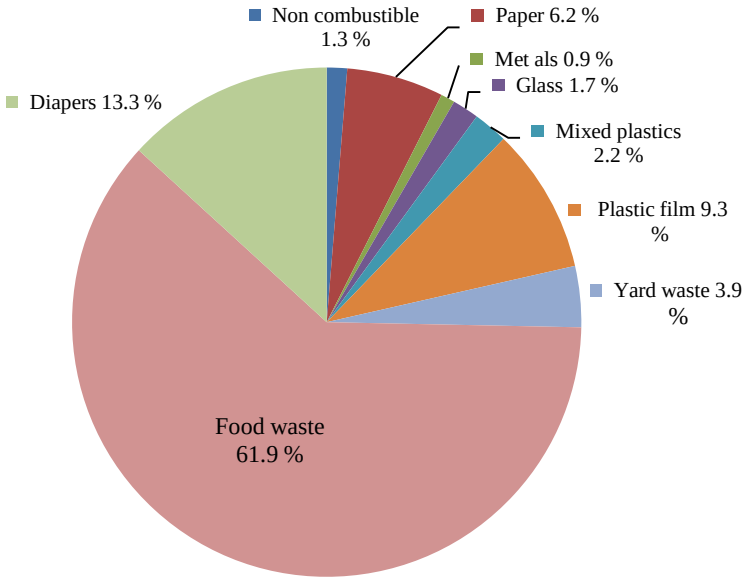
2.5.1 Municipal Solid Waste characterization

The composition of solid waste produced is mainly biodegradable waste with the amount varying from nation to nation. The rates of waste generated in developing nations also differ from nation

to nation and region to region. The literature on the MSW covers certain region of developing nations and there is limited or no literature covering some nations. In Africa, the generation rate is between 0.5 and 0.87 kg per capita per day, and in Asia the rates are from 0.64 to 0.75 kg per capita per day (Achankeng, 2004). These generation rates are determined by the nations' level of income. Higher income earners generate more waste than do lower income earners (UNEP, 2004). The other factors contributing to the increase in MSW are rapid rates of urbanization, rural urban migration, and changes in the pattern of consumption. In Latin America, the SW generated ranges from 0.5 to 1 kg per day when three decades ago the range was from 0.2 to 0.5 kg. The higher income earners produce one kg per day while the low income earners produce 0.5 kg per day (UNEP, 2010).

The data on the main category of MSW generated for the developing nations are not readily available. However studies done on individual nations reveal that the main MSW in municipalities in developing nations is domestic solid waste with percentages varying from nation to nation. In Bhutan, the domestic MSW constitutes about 70 to 80% of the total MSW (UNEP, 2010). According to MMDA/JICA (in Eugenia et al., 2002), 74% of total SW produced in Metro Manila Philippines in 1992 was municipal waste. The composition of the MSW in developing countries is about 60 to 90% biodegradable solid waste of the total solid waste generated. In Africa the biodegradable waste constitutes about 70-90%; in Asia and South America it is about 30 to 75% (Achankeng, 2004); and in the Pacific it is about 60 to 80% (SPREP, 2008). The material composition generally comprises green organics, paper, plastics, glass, metals, textiles and leathered materials (Achankeng, 2004). In Latin American nations the composition of waste is changing from biodegradable to non-biodegradable waste (UNEP, 2010).

Figure 2.4: Composition of municipal waste in developing nations



Source: Adopted from Marclus and Mwai in UNEP (2010)

2.5.2 Management of municipal waste

The collection, transportation and disposal of the MSW are probably the main objectives of the municipal council in developing nations, unlike in the developed nations, the collection, transportation and disposal systems are inefficient and labour intensive. Developing nations lack the technologies and resources (machineries and technical expertise) that the developed world has. The MSW management system does not include other facilities such as storage and weighing facilities, and transfer stations at the dumpsite. This makes it difficult to accurately calculate the quantity of MSW entering the dumpsite. The majority of the disposal sites in the

developing world are open dumpsites even though recently the countries have started establishing sanitary landfills. The open dumpsites and the burning of waste to control the volume and quantity of the solid waste without monitoring air, soil and water pollution is a severe problem.

2.5.3. Collection Transportation and Disposal

The collection and transportation of MSW is vital for all MSW systems. In the developing world the generation of SW is greater than the collection and transportation capacity of the collectors. The MSW collection and transportation services are provided by municipal councils, private companies (Achankeng, 2004), community groups and individuals (UNEP, 2005). The collection and transportation of waste is inadequate, so that it remains a challenge for the municipal councils. The average collection rate is 40-50% with most of the MSW management concentrated on this activity. In Asia approximately 80% of the MSW budget is directed toward this activity (Achankeng, 2004). In South America, the percentage of SW collected ranges from 46% to 100% (UNEP, 2010). The inadequacy of the collection and transportation derives from a lack of updated technology, finance and technical human resources.

Table 2.2: Solid waste production and garbage collection in selected Latin American countries

City	Solid waste per capita per/kg	Percentage of households with garbage collection
Brasilia	182	95
Havana	584	100
La Paz	182	92
San Salvador	328	46
Santiago	182	57

Source: Adopted from UNEP 2010

The frequency of collections depends on the nature of the waste generator. Domestic waste is collected either once or twice a week. Commercial and industrial solid wastes have either the same frequency or are collected more often depending on the scale of their operation. Private solid waste managers are engaged by municipal councils and individuals for collection during any other time. The type of transport used by the collectors depends on their financial capacity. The solid waste is transported in open-back trucks, compactors and even using simple transport like animal drawn carts (Achankeng, 2004; UNEP, 2010). In most countries the workers' health and workplace safety are poor.

The disposal of MSW in developing nations occurs in sanitary landfills, open dumpsites and incinerators. The percentage of each of the methods of disposal is driven by the individual country's capacity in technology, finance and technical human resource. Some middle income earning nations like Saudi Arabia, Mexico and Brazil use sanitary landfills in their cities (Achankeng, 2004). In Brazil, 57% of the cities use open dumps and 42% use controlled and sanitary landfill with 1% using other means of disposal. In Chile, the sanitary landfill is 78% while Mexico has 30%, and other Latin America countries have open dumps (UNEP, 2010). Most nations lack the capacity and tend to dispose the solid waste predominantly with unprotected open dumps and openly burning to control quantity of waste (SPREP, 2008; Achankeng, 2004). There is very little controlled incineration done to recover energy as the facilities for this activity is costly.

2.5.4. Waste minimization

Solid waste minimization activities through reduction reuse and recycling to recover resources are existing traditions in communities in the developing world. The minimization activities

results in SW generators generation of income at different level of waste management system (Achankeng, 2004). The waste pickers or rug pickers in India and the Philippines pick from the garbage left out by the waste generators using carts or wheel barrows before private or municipal council collection (Buekering, 1999; Achankeng, 2004). In many countries scavengers collect materials from the open dump to be recycled and reused by individuals or to be mended and sold for income. The actual data on the resource recovery for the regions are difficult to establish, however the recovery operations vary for each nation.

The recycling of non-biodegradable materials is a challenge for the developing nations due to lack of facilities and other resources. The biodegradable waste is easier to manage using biological recycling, local knowledge and facilities with proper urban planning. Many developing countries are establishing composting activities to recycle the organic waste that constitutes the largest percentage of municipal solid waste. This large scale biological recycling is proving to be expensive due to operational, maintenance and labour costs of the plants causing it to fail in most Asian, African and Latin American nations (UNEP, 1996; Furedy in Achankeng, 2004). The recycling of non-biodegradable SW is increasing with actors who are not legally engaged to perform recycling in the municipalities. These actors were not recognized until about two decades ago when some countries included them in recycling efforts as their contributions are important. The recycling activities start at the source where SW is segregated and they continue at different stage as the actors seek to reuse the materials recovered or sell them. In Latin America, the scavengers' cooperatives are huge with recognition of their involvement. According to Medina in (Achankeng, 2004) in Mexico and Bogota 12, 000 and 15, 000 families respectively were involved in the recycling industry.

Incineration, the least preferred method of SW minimization in the minimization hierarchy, is used both at the SW generation source and disposal site. The activity is mainly open burning at both stages to control and reduce the amount of SW produced or entering the dumpsite. There is minimal incineration to recover energy except for recovery made as fuel at the domestic level. Waste minimization occurs at all stages of MSWM when actors aim to recover resources. Incineration is commonly used in areas where there is a large population with high population density which makes it difficult to establish landfills, for instance in Hong Kong, Taiwan and Singapore (UNEP, 2000)

There are arguments that MSW management should move away from the proposed carefully structured system of collection, transportation and disposal by private actors to mitigate problems caused by inadequate collection and disposal. This change should include other approaches that lead to actors identifying the resources at all stages of SWM, and changing the perception and behaviour of people at the local level (Furedy in Achankeng, 2004). The approaches could include other small actors like the waste pickers and second-hand dealers who mend and sell the resources recovered.

The actors participating in the MSW management are the same as those in developed nations ranging from individuals to households, communities, NGOs and private and public organizations and institutions. These actors participate at the various multiple stages according to their need, compared to the developed world. For instance, there is more participation by informal actors such as scavengers and other community organizations in the developing world besides the recognized MSW managers. These actors participate in collection, transportation and disposal activities including MSW minimization. Most of the participation of scavengers' is

aimed at personal income and resource generation. The formal MSW managers often focus on aspects apart from economic benefits of the sustainable municipal SWM, such as the targeting of improvement of environmental and public health minimization of the impact.

2.5.5. Policies and strategies in the MSWM

The legislations, policies and strategies of MSW in the developing nations are focused on collection and disposal activities. There is little to no legal framework on solid waste reduction and minimization activities as the rate of generation of MSW in most nations exceeds the collection and disposal rates. In most cases, the minimization activities are fragmented and operated by the informal poor section of the communities seeking to generate some income from the resources recovered.

The developing nations' governments are aware of the growing developmental, environmental and health problems caused by inadequate and unsustainable MSW management. They have started developing legislation, policies and strategies to deal with these issues. In Latin America and Asia, the informal waste managers/actors are included in the strategies to increase the capacity of waste collection, transportation, disposal and recycling that formal managers/actors are limited to perform (UNEP, 2000; Achankeng, 2004). In the Pacific, the SWM strategy of 2005-2010 which has now been adjusted to 2010-2015 (SPREP, 2010) provides the framework for the policies and legislation to be developed by the nations in this region. The African continent's individual nations developed legislation to combat the SW problem. For instance in Kenya, waste management regulation was established in 2006 to address MSW issues (Marclus & Mwai in UNEP, 2010). The implementation and practical application of these legislations,

strategies and policies remain a challenge for the developing nations faced with resource constraints.

Public awareness and education is vital to bridge the gap between strategies and practices across all actors at different level of MSWM. However, in the developing nations, this gap is wide as there is limited awareness and education for the actors involved. This gap varies from nation to nation depending on their priorities regarding MSWM.

2.5.6. Environmental impacts of SW in developing world.

The lack of translation of legislation and strategies into practice means that old unsustainable practices continue where MSWM is concerned. The unsustainable and inadequate SWM practices of open dumping and burning lead to environmental degradation of water, soil and air which, in turn, impact on public health and the health of biodiversity. The pollutants are leachate, methane, carbon dioxide gases and other heavy metals from un-segregated SW. These toxic substances threaten public and environmental health. These threats are becoming a concern for citizens and governments of the developing world with an ongoing search for appropriate MSWM to mitigate their impact.

2.6. Solid Waste Management in the Pacific

The Pacific Island nations are small islands located in the Pacific Ocean covering an area of over 30 million square kilometres. The region comprises of 7,500 islands of which only 500 are inhabited (SPREP, 2009). The nations are divided into three racial groups: the Micronesians are located in the north; Polynesians to the southeast; and the Melanesians to the west of the Pacific

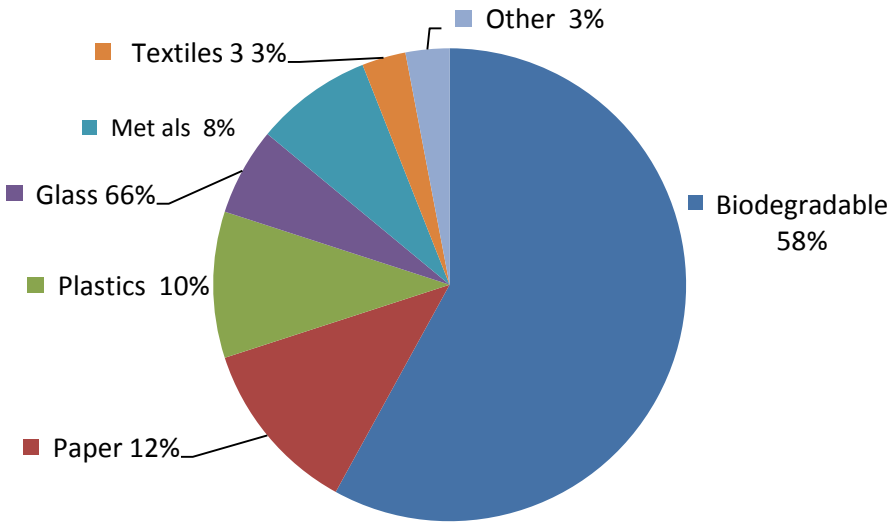
Ocean. The region's population ranges from 1, 549 in Tokelau to 7 275 324 million people in Papua New Guinea according to the 2011 national census (NSO, 2013)

The Pacific Island nations have their fair share of MSW problems. However, there is limited detailed data on the method, composition and waste characterizations of SWM produced in the region. The Pacific islands nations have a fragile ecosystem, and limited land resources owned by traditional land tenure system which is surrounded by sea. These factors make planning and executing management of MSW from collection to disposal difficult.

2.6.1. Waste Composition and Characterization

The composition of MSW is like that of other developing nations with basically a high composition of biodegradable items with increasing components of non-biodegradability. The change in the composition of materials in SW is brought about by rapid urbanization and changing patterns of consumption. Previously the people in this region consumed only food from gardens that they cultivated. Now with fast growing urban centres caused by population increase and rural urban migration, the people depend on manufactured goods. The percentages of biodegradable to non-biodegradable SW differ from nation to nation. Smaller islands with a shortage of land rely on manufactured good even in the rural villages (Roger, 2004). The SW generation rate per capita/per day is 0.66 kg with individual nations varying from 0.25 kg in Palau to 0.82 in Tonga and 0.88 in Fiji (SPREP, 2009) per day. The rate of generation for Port Moresby in Papua New Guinea is 0.41 kg.

Figure 2.5: Composition of solid waste in Pacific Island countries



Source: Adopted from SPREP 2009

Table 2.3 MSW Generation rate of selected Pacific Island nations

Number	Country	Generation rate kg/per capita
1	Cook Islands (Rarotonga)	0.57
2	Fiji	0.88
3	Kiribati (South Tarawa)	0.33
4	Niue	0.36
5	Palau (Koro State)	0.25
6	PNG (Port Moresby)	0.41
7	Samoa (Apia)	0.48
8	Solomon Islands (Honiara)	0.62

9	Tonga (Nuku'alofa)	0.82
10	Tuvalu (Funafuti)	0.43
11	Vanuatu (Port Vila)	0.53

Source: Adopted from SPREP, 2009

2.6.2. Solid Waste Management Methods, Policies and Legislation

The Regional Solid Waste Management Strategy (RSWMS) 2005-2010 that was revised in 2009 for the period of 2010-2015 was established by member nations at a SPREP meeting. The aim of RSWMS was to provide the framework to achieve the region's vision and is entitled 'A healthy and a socially, economically and environmentally sustainable Pacific for future generations' (SPREP, 2009). The RSWMS 2010-2015 focuses on the concept of Integrated Solid Waste Management (ISWM). The individual member nations are required to develop the National Solid Waste Management Strategy (NSWMS) for their country according to their needs. In Fiji, the financial assistance from donor agencies has assisted in the development of its NSWMS 2008-2010 and started its implementation (SPREP, 2009).

The RSWMS is very slow in being translated into practice in many nations in the region. The first period between 2005 and 2010 passed with few achievements in the development of NSWMS. Without the specific legislation and strategies for SWM, nations continue with the conventional open dumps and burning to control the quantity of waste in dumpsites.

The MSW management in the Pacific Islands like the other developing nations focuses on the collection, handling and disposal. The primary institutions responsible for the collection process to the disposal of MSW are the municipal councils. The participation of private and community organizations are at the recycling stage. Recycling activities are mainly for non-biodegradable

MSW. Open-back trucks are used for collection of MSW which is disposed of in open dumpsites. Traditional open burning (SPREP, 2009) and mulching were used by the countries in the region to manage the quantity of solid waste. Traditionally, the SW was organic and biodegradable, and open burning and mulching provided fertile nutrients for growing crops.

The move from open burning to landfill or open dumpsites is a challenge in the region due to limited land. Land fill disposal is the preferred method as incineration is expensive, needs high technology and technical people to operate it. Most solid wastes are disposed of in open dumpsites. However, nations in the region are beginning to develop sanitary landfills as environmental and public health problems become evident in the fragile ecosystem. For instance the Samoan government, through financial and technical assistance from the Japanese International Cooperation and Aids (JICA), improved and upgraded the Tafaigata dumpsite to an aerobic landfill using Japanese landfill design known as the Fukuoka (SPREP, 2009). However, the MSW system remains a challenge for the managers of SW, in this case the municipal councils. According to SPREP (2008):

> ..Waste collection and disposal requires a lot of resources for proper and effective management system. Therefore due to inadequate funding, limited trained and skill personnel, inadequate regulations and management with limited infrastructure support many collection and disposal services in the Pacific region have fail to perform at a desired level.

2.6.3. Environmental impact of Solid Waste

The increase in the solid waste (SW) production has had serious impacts on the health of biological diversity and the public in Island nations like PNG, and the Marshall Islands (Roger, 2004). The '[improper] waste disposal is now impacting negatively on public health, water, the environment, food security and fish nurseries in the mangroves [in the Pacific]' (SPREP, 2005).

PICs are members of Small Island Developing States (SIDS). In 1999, in the UN Assembly Special Session, SW management problem was identified as a strategic issue for SIDS (SPREP, 2005). The issue of solid waste is one of the major environmental problems that the Pacific Island countries (PICs) are faced with. According to South Pacific Regional Environmental Program (SPREP 2005): 'Disposal of wastes continues to be a worldwide problem and the Small Island Developing States (SIDS) of the Pacific increasingly share this problem'.

The PICs in the past had only biodegradable SW that was easy to manage with the use of indigenous or traditional SWM techniques such as composting and mulching. However the composition and amount of SW in the PICs has changed due to urbanisation. The rate of waste generated from consumption of manufactured goods has increased and is causing environmental problems for the Pacific Islanders (SOPAC, 2009). The PICs with small land area, lack of expertise, as well as lack of financial and technological capacity are not able to appropriately manage Solid Waste compared to developed countries (SOPAC, 2007; Achankeng, 2004).

2.7. Solid Waste management in PNG

The studies available on urban planning and environmental development are limited with dated, unreliable data. The management of MSW had no specific study done on it until 2000 when SPREP carried out the first study in Port Moresby, PNG's capital (SPREP, 2000).

There were other general country reports by JICA in 2002 and European Union in 2006 that included environmental issues in general including MSW (JICA, 2002; MWH SA, 2006). The literature on MSW in PNG is therefore limited and fragmented with no national legislation or guideline for actors in SW to use. The solid waste managers are left to use their limited resources and knowledge to embark upon the improvement of the MSWS in their localities in which many struggle to achieve their goal or fail. For instance, the councils of four urban centres: Port Moresby; Lae; Mt Hagen; and Alotau have established the twinning city relationship with cities in Australia. The four cities in Australia are Orange, the Sunshine Coast, Townsville and Cairns (Storey, 2009). A recent inclusion to this type of relationship is between the Madang council and the Campbell town council in Adelaide which is in its early stages. The research on MSW in small urban towns like Goroka is therefore not available or lacking and is limited in depth and scope. The lack of legislations and limited research to deal with the MSW problem and to drive changes in SWM in PNG has led to increased SW in the last three decades since PNG's independence. In order to adequately manage the SW, PNG needs to plan strategically and implement this plan through the development of appropriate waste management models.

2.7.1. Policies and legislations in PNG

When developed carefully, legislation and policies drive changes and improve any developmental and environmental issues. In PNG there is no specific legislation on Solid Waste Management and NSWMS. The legislation that guides the planning and policies on MSW in the

country are general and fragmented. The following legislation indicates several sections which do deal with SW (SPREP 2000):

The Public Health Act - This indicates procedures to regulate and control household waste and restrict illegal disposal of MSW except at the legal dumpsite. Anyone caught violating this law can be fined one thousand kina (K1000) PNG's currency. However the expiation system in not implemented due to lack of enforcement.

The Environmental Planning Act (Chapter 370, 1978) - This law provides for the environmental impact assessment on projects and monitors them including the development of landfills.

The Environmental Contaminant Act (Chapter 386, 1978)-It provides the instruments to regulate the importation and distribution of goods and the disposal of pollutants into the environment. It has regulation on littering, discharges from MSW dumpsites into the environment.

The Water Resources Act (WRA), Chapter 205, 1982 - The legislation is concerned with protection of natural water and resources and their management. The legislation covers regulations to control the discharge of pollutants into the water

The Amended Organic Law on Provincial Government (1995) - It entrusts the power to provincial and local governments to establish laws on municipal waste management by providing regulations.

The Environmental Management and Coordination Act (1999) is used by councils to deal with environmental issues.

The Environmental Act of 2000- Covers all the environmental issues in general in PNG

The legislations are broad, fragmented and not detailed for the solid waste managers to cover all the stages of MSW management and minimization. The legislation covers collections, disposal and pollution but fails to adequately address waste reduction and minimization**.**

2.7.2. Waste Composition and Characterization

The composition and quantity of MSW varies from one urban centre to another. The quantity of MSW generated in large urban centres is larger than the small centres. For instance, Port Moresby with 400,000 residents generates more SW than Goroka with 19,543 residents. There is no national data available on the MSW composition and characterization in PNG. This makes it difficult to plan for improved systems and to implement strategies in practical terms. The little research on MSW carried out in the country was in Port Moresby, the administrative capital of PNG.

A survey conducted by Department of Environment and Conservation (DEC) in 1985 in the Baruni dump outside Port Moresby estimated the biodegradable SW at 53% and the rate of SW generation at 0.21 -0.39 kg per/day (SPREP 2000). About fifteen years later, a SW characterization survey conducted in Port Moresby by SPREP in 2000 indicates the generation rate was 0.41 kg per person daily with each household producing 2.8 kg per day. Biodegradable solid waste constitutes the largest percentage of MSW at 63% (SPREP 2009). Table 2.4 illustrates the type of SW that was generated in Port Moresby previously.

Table 2.4: The composition of MSW in Port Moresby

Waste Type	**Weight Percentage**
Paper	11.8
Plastic	12.7

Glass	8.9
Met al	12.2
Organic biodegradable	50
Textile	1.5
Hazardous waste	2
Construction and Demolition	0.9

Source: Adopted SPREP 2000

The data on the composition and generation rate of MSW in Goroka and Wamonagu are lacking as no research has been conducted primarily on SW in the town and the village**.** The study by UN-Habitat in 2010 indicated the problems encountered in MSWM with brief highlights on the composition of types of SW generated. It is estimated that 60-65% of the total waste collected in Goroka is biodegradable (organic) which has huge potential for recycling.

2.7.3. Municipal solid waste management in urban PNG

The MSW management in PNG primarily focuses on collection and disposal of the solid waste from the source. The frequency of the solid waste collection is once a week to about three times a day depending on the source of generation. For instance in Port Moresby the domestic waste is collected once or twice a week while commercial and industrial waste is collected three times daily depending on the activity that day (SPREP, 2000). The collection and disposal services and maintenance of the dumpsites are provided by the councils and the contracting partners. The partners in MSW management depend on the size of the urban centre. In Port Moresby, the councils, private companies and community groups are involved while in Goroka mainly the councils perform that function (SPREP, 2000; UN-Habitat, 2010).

In Goroka, the solid waste collection service is provided only to formal housing residents but this is still inadequate (UN-Habitat, 2010). There are no landfill facilities for the municipal solid waste which is discarded on open dumpsites on land leased from traditional land owners. The rates charged for providing the collection and disposal services differ from urban centre to urban centre. For instance, the dumpsite in Goroka is available to the public at a cost of K 9.00 per load ($5 AUD), while in Port Moresby the residential rate is K15 ($7 AUD) (UN-Habitat, 2010; SPREP, 2000)

The municipal SW in urban centres in PNG is un-segregated SW that is collected by the urban councils and disposed of in an open dumpsite. The waste from the residential areas is left outside their yard for collection by councils in open-back trucks or compactors .The number and size of trucks that transport MSW in urban PNG depends on the resource capacity of each council and contractor. In Port Moresby, there is a fleet of nineteen trucks of which eight are compactors and the rest open-back. The capacities of the compactors range from 4.5 to 15.3 cubic meters while the open-back trucks have space ranging from 0.35 to1.5 cubic meters. Of the nineteen trucks, twelve concentrate on the collection of domestic solid waste. The collection and disposal is done by a five member team of a driver and four collectors (SPREP, 2000). This indicates that the composition of MSW in Port Moresby is mainly domestic. The information on other centres' resource capacity is not available. The waste is disposed of in controlled open dumpsites on traditionally owned land. The mixed SW is then burnt to manage the quantity of SW at the dumpsite (SPREP, 2000).

PNG's disposal of SW in open dumpsites was adopted during the colonial era and has not changed since its Independence in 1975. The developed nations who were once PNG's

colonizers have since then changed the methods of SWM to sanitary landfill since the US started using them in the 1930s. While PNG's colonizers, Great Britain, Germany and Australia have changed their approach to SW management through the use of appropriate infrastructure, management and technology, PNG's SWM has remained the same. This is evident in the organizational structure of the councils and their sole responsibility in urban centres with minimal or no participation from other actors in the MSW generation.

Councils use the legislation highlighted earlier to manage MSW in the country. In Goroka, there is a Parliamentary Act on Environmental Management and Coordination which is utilized to develop policies. A policy developed for Goroka is the *Environment and Conservation Policy Guideline* (UN-Habitat, 2010). However the implementation and enforcement of this legislation and these policies are lacking.

2.7.4. Waste minimization and Resource Recovery in PNG

The resource recovery activity is a historical practice in traditional societies in PNG. The SW minimization and resource recovery practice in the past were for primarily organic waste. The primary SW produced was either biologically recycled (composting/mulching) or reused. For instance, household vegetable peelings were disposed in gardens and near fruit trees or fed to domesticated animals. The practice is applied in rural PNG where management of SW from collection to disposal is a function of households and the composition of organic waste is high.

The resource recovery and waste minimisation activities in urban PNG are legally the function of private contractors who focus on recycling of metals and glass especially drink containers which, again, varies from centre to centre. There are about eight companies operating in the recycling of

scrap metals (SPREP, 2000). Data-bases of these businesses and their operational capacity are lacking. In Goroka, small scale recycling businesses are in operation and have to be encouraged (UN-Habitat, 2010). The actors involved in this industry are: individual households which separate the waste at the source to sell to generate income; the businesses whose function is to collect, store and sell to overseas dealers; and scavengers who collect from public places including dumpsites. In the Baruni dump outside Port Moresby, scavengers collect any materials that can be sold for recycling to earn income and be reused for individual purposes (SPREP, 2000).

There are no commercial recycling (composting/mulching) activities in the country relating to biodegradable waste. Large quantities of biodegradable waste generated from the largest source from the domestic sector in the country need to be addressed. The role of the scavengers in the collection and resource recovery activities is important in the minimization of the SW entering the dumpsite. Their activities have to be recognised and incorporated into the MSWMS. This group's incorporation into the SWM system to minimize cost and reduction of SW to landfill in other developing nations' has worked. There are some individuals and businesses that use their buying power to reduce the SW produced (SPREP, 2000). These initiatives should be encouraged for further reduction of SW in the whole community.

2.7.5. Problems and Environmental impacts of SW in PNG

PNG's change of lifestyle from traditional to modern leads to it being faced with increasing generation of SW with serious problems of improper SWM in urban centres. These problems are evident as piles of SW are disposed of and discarded along streets, roads and in front of buildings with overflowing garbage bins. The increase in the production of SW in PNG and inadequate

management of the SW in the urban centres by the urban councils is a challenge for the nation. The problems encountered by MWS managers in PNG are similar to those in other developing nations, especially the PICs. The common problems related to the operation of the SW identified in urban PNG by UN-Habitat (2010); SPREP (2000) and Storey (2009) are as follows:

1. Lack of political support to drive planning and budgeting for MSW from the top down
2. Lack of financial capacity leading to poor solid waste collection and disposal services
3. Poor environmental planning, management and enforcement of legislation leading to environmentally unfriendly practices
4. Lack of qualified personnel leading to poor planning and implementation of policies and strategies regarding SW collection, disposal and minimization
5. Lack of land for landfill due to the complicated traditional land tenure system where 97% of land is customarily owned by clans and tribes
6. Lack of training, awareness and participatory education program for managers as well as the public to promote their participation in SWM in urban PNG

These problems of MSW managers lead to practices that pollute the environment and create health risks in the urban centres. Open dumps with no protective lining to collect leachate lead to contamination of soil and water (UNEP, 2010; SPREP, 2009; USEPA, 2002). The open burning of waste discharges contaminants into the air and soil. These contaminants lead to the degradation of the environment which then becomes a public health risk. The degrading materials from the SW that are not collected breed pests and diseases which carry insects such as

mosquitoes in the tropical climate increasing the prevalence of malaria. SPREP (2008) also stated that poorly managed waste can lead to infectious and air borne diseases.

2.7.6. Education and Awareness

An important remedy for the improvement of the MSWM is to educate all actors about the use of best environmental practices in SWM. The PICs identified this factor as important and included a specific goal in the RSWMS to 'develop communication strategies that are culturally-sensitive to support the SWM activities' (SPREP, 2009). The Department of Environment and Conservation planned to launch an education program with other stakeholders to promote SW minimisation activities. The Department realised the importance of education and awareness in driving change in SWM (SPREP, 2000). The other developing and developed nations also emphasise public education and awareness as key components of effective SWM (SPREP, 2008; Buekering et al. 1999).

2.7.7. Projects on SWM in Urban Centres in PNG

To identify an appropriate SW management system there is a need to look at what was done in the field of SW management in PNG and, in particular, with the urban councils of the towns and cities. Literature indicates that city councils in Australia have a sister-city twinning program with the city/town councils in four Provinces in PNG (Storey, 2009). The four twinning relationships are Lae-Cairns, Alotau-Sunshine Coast, Orange and Mount Hagen and Townsville and National Capital District (Port Moresby). The programs were established to enhance effective decentralization processes through service deliveries by the council to the people. The

partnership differed from each other on their focus on service deliveries. Even though all four programs had to seek to address SWM problems in urban PNG, two had actually had an in depth program on SW management. These two centres were Lae and Alotau targeting the strategies of the collection and disposal system while Mount Hagen and Port Moresby focused on the infrastructure, Information Technology (IT), land use and general planning of service delivery with little focus on the SWMS operational system (Storey, 2009).

The program between Lae and Cairns concentrated on the development of an Integrated Waste Management Strategy (IWMS) for Lae city council in consultation with council members, managers, stakeholders, business and academic institutions. The project was aimed at solid waste minimization to deal with the environmental issues in the city through institutional capacity building from 2004–2014 (Storey, 2009). The project between Alotau and Noosa (Sunshine Coast) also developed a Waste Management Plan focusing on IT especially to deal with billing and improving the dumpsite through minimization of litter. This project started in 2006 with the involvement of community members on the committee. Financial assistance was sought through the partnership to commence the operation. Alotau's drive to improve its solid waste management system was aimed at achieving a healthy tourism industry in the Province. Alotau has an excellent opportunity for tourism and improper SWM would affect the industry.

Even though Lae and Alotau both targeted the minimization of wastes, their approaches and focus differed. Lae, with its focus on environmental problems in the city, used institutional capacity building to try and achieve its aims with its own funding. Alotau, on the other hand, used all stakeholders, especially community participation, with the aim of promoting the tourism industry and had funding from its partners. The result is that Alotau's Waste Management plan

on minimization of litter has been successful while Lae has not yet launched its IWMS. Alotau's partner, Noosa, had staff members who had a background in SWM and who used this expertise to enhance the project. Alotau's project –although successful in terms of having no litter around the town- does not address the SW that enters the dumpsite.

The sustainability of the project in terms of the long term financial capacity is a concern (Storey, 2009). The minimization of SW at the source through segregation and the use of the waste management hierarchy to mitigate environmental impact were not considered. Therefore, the problem of environmental and public health being affected by open dumpsites is still an issue in the urban centres in PNG. To promote source reduction and SW minimization, public education and awareness and public participation is vital as this has proven to be successful in other developing and developed nations. In order to develop appropriate SWMS, the communities' local knowledge regarding this field has to be considered. In PNG the indigenous solid waste management practices (ISWMP) can be considered for policy developments and practices in MSW. ISWMP is part of indigenous environmental knowledge IEK that 87% of the population in rural PNG uses to manage the biodegradable organic waste. The segregation and the concept of the waste management hierarchy using the 3 Rs (Reuse, Recycle and Reduce has practical applications in the ISWMP in the rural areas especially the villages.

2.7.8. Planning for Appropriate MSWM systems

An appropriate Solid Waste Management System (SWMS) is needed for PNG in accordance with the country's needs. Although there are many modern SWM models and techniques used in the world, in order to develop an appropriate model for PNG there is a need to start with local knowledge on solid waste management and its relevance to Papua New Guinea's situation.

The model should take into account the social-economic, political and physical capacity of the society. For example, there must be financial capacity and support from all level of government. The people's understanding and educational levels are vital for better information dissemination and implementation of the SWM model. According to (SOPAC, 2009; Achankeng, 2004), a country's financial, technological and human resource capacities ought to be taken into account for viable Municipal Solid Waste Management (MSWM).

The amount of waste generated, the total population and the population distribution also need consideration. These factors will determine resources, and time and space needed for a SWM model to work. For instance, knowing the quantity of solid

waste generated within a given population and its distribution will allow for an appropriate land size to be obtained for SW disposal. The SWMS has to accommodate for cultural views, cultural practices, customs and values in the country. The regional solid waste management strategy (RSWMS) aims to promote and develop a culturally sensitive national solid waste management strategy (NSWMS (SPREP 2009). In PNG, oral communication and practical application are more reliable than written communication as most activities involving the public are done by word of mouth with the public participating after observing. These practices have been in existence since traditional times. One of the contributing factors for oral communication being predominant is that the country has a high illiteracy rate. The rate is 42.7% at the national level and 45% in EHP Government, 2010; UNESCO, 2002). Therefore an appropriate SWM model would consider these factors.

2.8. Indigenous Knowledge (IK) in the world

Indigenous knowledge has been used by indigenous people around the world for many generations (Roger, 2004). IK influences all decision making in indigenous societies regarding agriculture, health, natural resource management and other aspects of their people's lives (World Bank, 1998). IK in this research is referred to as, "the local knowledge that is unique to a culture or society" (World Bank, 1998). The IK forms a network of knowledge systems that is referred to as the Indigenous Knowledge System (IKS). The IKS is a vibrant system that changed with society's practical experiences, creativity, and contact with outside entities (Flavier et. al. in World Bank, 1998). This means that there is the constant addition of body of knowledge to IKS overtime deriving from people's practical experiences from internal and external events.

IK is being utilized in many disciplines in the world to find appropriate measures to deal with issues. Some fields where IK is used are in agriculture, natural disaster management, navigational skills, and environmental and resource management. In the natural resources industries, fisheries and forestry utilize IK. Agriculture uses IK for seed species and soil conservation. Research on IK and its application in various disciplines have increased recently throughout the world. According to Lauer and Aswani (2009):

> there has been growing interest from researchers and practitioners from various disciplines on significance of IK in planning social, economic change programs and management and monitoring of ecosystem processes and functions especially in the field of international development and environmental management.

The application of IK in search of answers to global issues is now classified under the Best Practice category (UNESCO, 2010). There are global projects on utilizing IK to bring about best outcomes in any field. In Africa, a project called *Medicinal Plants and Local Community* (MPLC) focused on the conservation of medicinal plants through community participation aimed at utilizing IK for sustainable resources use (UNESCO, 2010). In Ethiopia, research on

assessment of soil erosion used IK to understand the concept. In West Africa and Asia especially in Bangladesh and Cambodia, research shows that traditional knowledge of fish-farming using cultivation of periphyton as feed for fish has been a success (UNESCO, 2002). The Australian Aborigines in the northern part of the continent use IK to manage both the land and the sea resources (Muller, 2008). The Chinese used the traditional knowledge for a restoration program in the Minjiang River water shed tributary and to Yangtze in Sichuan Province through a project called *Construction of a Protective Forest System on the Upper Reaches of the Yangtze River*. The project utilizes traditional medical plants to conserve the biodiversity in the area (UNESCO, 2002).

2.8.1 Use of Indigenous Knowledge in the Pacific

In PNG, indigenous soil conservation techniques are used by Papua New Guineans to prevent soil erosion and retain soil fertility in agriculture (Roger, 2004; Puri in Morauta et al., 1982; Woods and Humpreys in Morauta et al., 1982). Lauer and Aswani (2009) reported that in the Solomon Islands the role of indigenous fisheries knowledge was explored to conserve the marine ecosystem. Papua New Guineans use limited entry traditional fishing rights giving the villagers rights to fish within their traditional fishing zones. This practice enables fewer people in certain sea areas where marine resources are managed through fishermen being able to catch enough fish for their families and to share the extra with other villagers. This practice then maintains fish stocks in their fishing grounds. Johannes in Morauta et al. (1982) stated that adopting limited entry practice by the Fisheries Department in PNG would control the catch rate and alleviate the pressures of overfishing. IK was also used to predict the impact of human activities on the biological diversity in the Hewa in PNG 2002 (UNESCO, 2010; Thomas, 2008).

2.8.2. The Indigenous Societies in PNG and their relationship with the Environment

In Papua New Guinea indigenous society, majority of the people live in the villages in tribal and clan groups and communally own 97% of the land under customary land tenure system (Anderson, 2015). Through the customary land tenure system the land-use rights are inherited from a father by his children in a patrilineal lineage and a mother by her children in a matrilineal lineage. In a patrilineal society the principle authority over land are males (Anderson, 2015) and in a matrilineal society the principle authority over land are females (Anderson, 2015) with the assistance of their brothers. This gender based land use rights creates primary and secondary rights (Anderson, 2015) in the form of main clans and sub-clans to access the land and sea and the resources on it.

The customary land tenure system enables the clan and tribe to manage the land rights and the use of land for their livelihood and survival with the authority of the management and control resting with clan leaders (Anderson, 2015) or tribal leaders.

The management and control of land through customary land tenure system by indigenous community leads to a development of a concept where the current generation become custodians of the land where the land is held in trust for the future generation to ensure their livelihood (Anderson, 2015). This principle of land management and control also is known many African cultures (Anderson, 2015) as well as the other Pacific Islands. This principle is also a main component of Papua New Guinea's constitution in its Preamble the National Goal and Directive principles stated here '*We declare our fourth goal to be for Papua New Guinea's natural resources and environment to be conserved and used for collective benefit of us all and be replenished for the benefit of the future generations*' (PNG National Government, 2015). The

customary land tenure system's main focus is to retain the livelihood of its members in family units with strong social inclusion and there is high degree of flexibility and adaptation (Anderson, 2015).

With the established land management system the indigenous communities develop their own customary laws that govern the extraction and use of resources within their territory. The customary law also includes the system of solid waste management, pollution prevention, over exploitation and penalties for infringements of the customary laws (Anderson 2015). The customary laws are linked to the land tenure system where the clans and tribes care for their natural environment for the survival of their communities. According to (Anderson, 2015) the customary land tenure system for indigenous communities is not just its relationship to individuals occupation and use of plot of land but a system that includes land-based [and marine] resources used in common such as water, forest [and fish]. The indigenous communities' relationship with the environment focuses on the principle of sustainable livelihood (Anderson, 2015). This implies that the land and the natural environment on it are important for the indigenous people whose livelihood depends on the resources. Hence the indigenous people have devised appropriate methods to protect, conserve, maintain and sustain their environment. The land and the resources also provide the social security for the members of the community as they can cultivate the land and extract the resources for their own use or for commercial purposes in the current communities due to indigenous communities' ability to adapt to changes (Anderson, 2015). Hence there is also possibility of using the traditional solid waste management system to manage new and introduced categories of solid waste in their societies.

2.8.4 Review of literature on Indigenous Solid Waste Management Practices (ISWMP)

The literature on IK includes vast fields in both the natural and human environment. In the field of human environment, the planning, organization and operations of daily activities are covered. The ISWMP falls under the human environment. There is a lack of literature in ISWMP even though this practice has existed in the indigenous community for thousands of years. In any human consumption the by-products produced are waste. The only significant research of IK on ISWM was in the Republic of Marshall Islands (RMI) by Roger (2004) for the World Bank. The research data were collected from four villages on the traditional composting and mulching practices of organic (biodegradable) SW. The indigenous SWM technique of segregation of waste at the source was used to gather materials for mulching and composting. This was done in collaboration with the village leaders. The research results indicated that promoting the ISWMP improved the SWMS in villages in RMI through the reduction of total SW to the landfill, and improved soil fertility and water retention in the sandy soil that villages were located on.The project also promoted the Marshall Islanders' traditional canoe making to minimize the use of non-biodegradable materials like fibreglass and aluminium (Roger, 2004). The traditional biodegradable materials used for the building of canoes could be easily reused as fuel, or biologically recycled as compost compared to the non-biodegradable materials such as aluminium and fibreglass. The research in the RMI was aimed at reviving and encouraging the Marshall Islanders to use traditional SWM techniques to manage biodegradable waste, thus reducing the total output of waste generated and disposed. According to Roger (2004):

> Traditionally it was vital for Marshall Islanders to care for the environment and resources for the benefit of future generation. However due to the processes of urbanization and modernization the values and practices of caring for environment were diminishing. This was due to changes from traditional informal education to formal education where vital IK held by older people were not taught in schools. In addition the increased consumption of manufactured goods than tradition organic food produced both biodegradable and non-biodegradable waste that people did not know how to manage.

The modern financial demand and break down of traditional practices due to the cash economy was a contributing factor to the non-practice of traditional techniques of SWM in the RMI. This diversion from traditional values and practices to a modern lifestyle can be problematic area in terms of indigenous practices. In villages in the RMI the composition of SW was mainly biodegradable. The promotion of traditional segregating methods at source and application of traditional mulching and composting techniques enabled villages to reduce their solid waste. This indicates that modernization has disrupted the indigenous systems that people depended upon in the past. However, these systems can be utilized to find solutions to local problems. The research empowered the village leaders' status and changed people's attitudes and behaviour towards management of SW.

This study also promoted IK as a tool for the RMI government to develop policies, strategies and make decisions on SWM in the country. Furthermore, the research provided the platform for policy and decision makers in the country to use the traditional SWM project as an example to tackle other related issues. The study also brought to the forefront the traditional values of respect for environment and restrictions through limited harvesting of resources (Roger, 2004)

The study on the RMI however, was limited to biodegradable waste and biological recycling using ISWMS at the village (rural) level. It did not incorporate the other types of solid waste , especially the non-biodegradable, with prevention, reduction, reuse, recycling, and incineration to recover resources in the urban setting. The above-mentioned processes are part of the waste management hierarchy in Integrated Waste Management (IWM) (Beukering et al., 1999, p. 4). The waste management hierarchy is a model that is used to prioritise solid waste management (Adams et al., 2000). The Integrated Waste Management (IWM) hierarchy aims at minimisation

and reduction of solid waste. The public education and awareness of ISWMS to drive and sustain the SWM system was not covered in the research.

Research into the use of ISWMP in traditional societies in PNG is not available. However, 87% of the rural population live in the rural communities rely on traditional practices to deal with their activities including their consumption of goods and production of SW on a daily basis. Consumption of goods and SW production are inextricably linked in any society. Therefore, all societies will have some practice of managing waste. The investigation of ISWMP in PNG in this study will contribute to the development of policies that have local knowledge content and will promote best practices of IK.

2.9. Conclusion

The complexity of MSW and the nature of the waste stream differ between developed and developing countries. The techniques and methods of the SW systems, nevertheless, are the same in both developed and developing world. However, the developed world uses the principle of waste hierarchy and integrated solid waste management to develop legislation, policies and strategies to drive the management of SW in the urban areas. The infrastructures and practices are guided by specific goals and strategies. The use of high technology, large machinery, well established consumers, and public participation focus on waste minimization and reduction activities. The participation of all stakeholders and actors is promoted by effective communication between SW managers and SW generators through education and public awareness that promotes environmentally sound SWM practices.

The developing nations have utilized the conventional methods used by the developed world, but these conventional methods are challenging due to resource constraints. The developing nations use non-conventional methods to manage SW, as resources and legislation to drive the practices in SWM are lacking. The participation of scavengers and community based organizations at all stages of MSWM is common in developing nations where MSW generation exceeds the collection and disposal rates. The research into solid waste in PNG is lacking and the information and legislature are fragmented and out of date.

The MSW management in each of the developing nations operates differently according to their understanding and needs. The involvement of scavengers in Asia and South America are recognized and incorporated into the formal MSWM. The scavengers' role in the MSWM system is vital as it promotes the concept of partnership in management of MSW. In Africa and the Pacific, scavengers' activities, especially at the dumpsites and bins on the roadsides, are not acceptable. Culturally acceptable indigenous practices in the Pacific, especially in PNG, include the segregation of waste materials at the source; and the reuse or (biological) recycling by the producers to share with other families and relatives. In addition, effective communication through public education and awareness is vital in changing behaviours and attitudes of people towards proper MSWM.

In PNG, MSW policies and strategies should include IK and practices that are culturally acceptable, but there should also exist the opportunity to learn from practices of other developing nations. The participation of other MSW partners should be promoted with public education and awareness built into these policies and strategies.

CHAPTER THREE:

METHODOLOGY

3.1. Introduction

This chapter focuses on the techniques used to gather information about the solid waste management (SWM) practices in Goroka town and Wamonagu village that has been researched. The research techniques used in this study rely on the type, aim, focus, scope and the context in which the research is conducted. The researchers' perceptions and knowledge about the research and the research area also determine the methodology engaged in the research (Winchester in Achankeng, 2004).

The scope of this research on municipal solid waste management and indigenous solid waste management covers the generation of solid waste and the methods of storage, collection,

handling, transportation and disposal. The waste characterization at the generation point is important to determine the type and quantity of solid waste (SW) generated. The strategies, plans, policies and legislation that regulate SWM through public and private actors in municipal solid waste (MSW) are included in this chapter. The participation and awareness efforts of the government institutions, public and private actors in the MSW are important drivers of behaviour change for the SW generators. In addition, the impacts of the methods engaged in municipal solid waste management (MSWM) on the environment and public health will be covered in this chapter.

The level of involvement and participation of the actors in the activities related to solid waste management differ from one actor to another. The extent of the actors' involvement depends on their resources, purpose, and organizational and individual values and concerns of the issue. The primary MSW generators in the urban centres in PNG are individuals, households, public and private institutions with activities ranging from waste production, storage and primary collection for disposal by council collection staff. There is also some reuse, recycling (composting and mulching) and direct disposal to open dumps. In rural areas (villages), the actors in the primary SW production are individuals, households and communities at large. The activities by the primary waste generators in these villages include generation, segregation, storage, collection and disposal. Therefore, the techniques involved in the methodology for this research will include multiple methods to collect data.

3.2. Methods of data collection in the present study and rationale for their application

The methods used for collecting the data comprised of in-depth interviews (based on structured questionnaires), focus group discussions, and observations by the researcher of SW collection

and disposal by the households in Wamonagu village and Goroka town council, as the study is essentially a qualitative one. In addition, some secondary data about the population and socio-economic characteristics of Wamonagu and Goroka were obtained from relevant government and non-governmental records. Household interviews were carried out as households are the primary source of solid waste generation. The face to face interview method was considered appropriate as literacy rates are very low. The literacy rate for the province is 43.9%, with a higher literacy for males (51%) than females (36.5%) (NRI, 2010). In-depth interviews were used to gather specific data that are needed for the study and which the general household interviews would not capture. Specific in-depth interviews were also conducted for council staff, education officers and provincial environmental officers to gather relevant data vital for the study. In addition, three focus group discussions were conducted to capture the knowledge and experience of the youth (male and female aged 18-24 years) and other, mostly married women who have information relevant to the study but were not included in either the household interviews or in-depth interviews. Focus group discussions are valuable as they stimulate debate and interaction between the participants on the particular subject of the focus group. The focus group discussion was targeted to gathering information from people who were not very comfortable with face to face interviews (mostly women) either due to cultural or other reasons. However, they were active participants in solid waste management, especially at the household level.

The structured in-depth interview questionnaires were used by the researcher to interview a member of each household at the study sites. The participants were asked to answer approximately six pages of closed and open-ended questions. The questions were based on SWM practices by households at Wamonagu village and Goroka town; actors involved in the SWM,

the resources used in managing SW, constraints of SWM in the Goroka and Wamonagu, transfer of knowledge and skills on SWM practices and awareness campaigns on the proper management of SW. There was also a specific in-depth interview questionnaire for the elderly people at Wamonagu village to gather data on the changes in the indigenous solid waste management practice (ISWMP) past and present. Furthermore specifically constructed in- depth interview questions were used to interview council staff, education officers and the provincial environmental officer and the provincial administrator. The questions were aimed to gather information on the existing SWM system, resources, existing local knowledge, SWM constrains, education and awareness, curriculum development and stalk holder partnership and participation. There was no interview conducted for the provincial administrator due to the officer's unavailability resulting from a busy schedule. The focus group discussion questions were developed and used to collect information mainly on their participation in SWM and the outcome of their participation for them individually and their community. The last method was "observation by the researcher" to study various methods of SWM related to collection handling and disposal processes at Goroka town by the council. There were several observations done on the collection and disposal of waste to confirm the information gathered from the council staff as well as to fill the knowledge gap that could have been missed through the formal interview process.

3.3. Selection of the study site and its rationale

Papua New Guinea (PNG) has three cities and 19 towns that are the administrative capitals of the 22 provinces. There are three cities in PNG -Port Moresby in National Capital District (NCD), Lae in Morobe province (MP) and Mt Hagen in Western Highlands Province (WHP) - with populations between 60,000 to 400,000. The towns have populations between 1,000 and 23,000.

There are also smaller towns in each of the provinces commonly identified as the district administrative towns. There are 89 districts in PNG with all of them having their own district administrative towns. In all the districts there are villages, all established on their customary tribal or clan land. The geographic areas and population of the villages differ from each other. Some villages have a few houses with a population of between 20 and 50 people. Others have more houses with populations of up to 500 people. The present study needs to include an appropriate number of cities, towns and villages to be able to generalise the result. To do this, however, would mean that more time and resources have to be available for this to be realized. This study has limited resources and a restricted time frame to work with. Hence use of case study sites was considered the most appropriate to use in this research. Two sites were selected for this case study, of which one is urban and the other rural (village). Although the findings of a case study may not be generalised in principle, they can provide important insights into typical solid waste management knowledge and practice including indigenous knowledge and practice. The sites are both located in the Eastern Highlands Province (EHP). EHP was selected as it is the most central province in PNG with high mobility of people moving through EHP between the coastal provinces of Madang and Morobe Provinces and the seven other highlands provinces. With high mobility of people through EHP the trading of goods and services in the towns in EHP to serve the residents and the commuters is higher than the other Provinces. Therefore the amount of SW generated would be higher compared to other provinces. In addition two towns in EHP, Kainantu and Goroka has huge problem with management of SW that Kainantu was classified the dirtiest town in the Pacific Region. Hence EHP was selected for the research to be carried out to investigate issue of poor MSWM. The urban study site is Goroka town and the rural site is Wamonagu village in the Unggai/Bena District. Goroka is considered to be a town as

its population is 19,523 (which is below 60,000, the minimum population for a town to be classified as a city), while Wamonagu village has a population of about 500 people. This will allow for a comparison and contrast of similarities and differences in solid waste management techniques in diverse settlement types, namely urban and rural. Goroka town and Wamonagu village were chosen;

(i) As the researcher is familiar with these sites' environment, people and the language spoken there. This made mobility of the researcher and translation of interview questions easier, especially for older respondents.

(ii) Another important reason for selecting these two specific sites was to minimize the cost and time taken to travel between these sites.

Knowing the environment, people and the language gave added advantages to this research and the researcher as this definitely minimized constraints associated with the language, time and cost of conducting the research

Goroka was chosen over the other 18 other capital towns and three cities in PNG for the following reasons:

(i) Solid waste is a major concern for the town as it is in all other urban centres with evidence of large amounts of solid waste discarded around the town

(ii) It has the 4th largest population of any town or city in the country and has a very high occurrence of water borne diseases (diarrhoea and typhoid) compared to other urban centres

(iii) Goroka is serviced by an airport that takes two Air Niugini flights daily from Port Moresby, the nation's capital city. The national highway (Highlands Highway) passes through Goroka to six other highland provinces; therefore, the movement of people from the coast to the highlands and vice versa is very high unlike that in the other towns

(iv) Other administrative provincial centres have had some research (although very minimal) conducted on methods of improving the management of MSW, but Goroka has not.

(v) The town has a high population density of approximately 2,789 persons per square kilometre which is higher than that of other towns. Thus, it has land shortage issues relating to obtaining new sites for landfill

In PNG, there are huge difficulties in accessing transportation and communication. The accessibility problem is due to the fact that PNG has some of the most rugged terrain in the world. This has made building of roads difficult, thus leading to the use of air transport as the only means of travel that connects all provincial capitals and most remote areas that are not accessible through land and sea transport. According to a report by the World Bank (2010), air transport is well-established in PNG due to the country's rugged terrain, the remoteness of its rural population, and the difficulties of developing accessible road networks. However, this advantage comes with a disadvantage as the cost of air transport is high for the average Papua New Guinean and is dangerous due to unpredictable weather conditions (Steve Marshall19 /08/ 2008 in ABC). Sea transport on the other hand, though cheaper than air and road transport, is slow. This makes communication difficult. However, the two sites in this study are easily

accessible as there are road links between them. Moreover, Goroka can be accessed easily from Port Moresby.

As for Wamonagu, there are two main reasons why this village was chosen: (i) it is linked to Goroka by road and (ii) all the villagers are subsistence farmers who still use their traditional or indigenous knowledge and practice to sustain their livelihood. The SW that is generated are managed using ISWMP at the household level

Wamonagu is about two hours' drive from Goroka depending on the road condition. The inhabitants of Wamonagu still live a traditional life. Most of their daily activities are conducted using indigenous knowledge. This includes the knowledge and practice of solid waste management. The movement of people between the two settlements is significant. For instance, the villagers from Wamonagu travel to Goroka to obtain basic goods and services such as groceries, hospital and banking facilities. These frequent travels also help the villagers to see and understand some of the critical solid waste issues of Goroka.

3.4 Sampling procedure and recruitment of participants

The sampling procedure and recruitment of the sampled population is vital for the research. Hence the procedures used for sampling and recruitment process for interview participants are discussed below in sections 3.4.1. Selecting a representative sample size is vital. Large sample sizes increase the accuracy in the research results. However, other studies show that limitations in time and resources could not allow the 95% required with a 5% sampling error (Achankeng, 2004).

3.4.1. Sampling of the research participants.

The sampling frames for the study were obtained from the records of the Goroka council and Wamonagu ward council. The sampling of population for interviews in Goroka town and Wamonagu is discussed in this section. They consisted of the total number of households in these two places, from which the required number of households were selected for interview.

There were 1,642 households in Goroka town and Goroka town was classified into three regions – (i) North Goroka, consisting mostly of educational institutions and houses in which people employed in the education sector lived, with some houses belonging to business people (417) , (ii) Town and Seigu, which is the central business district of Goroka, and consisted of houses mainly occupied by people working for the government and some businesses (309), and (iii) West Goroka, which is a residential area of people of mixed occupations (916). By the above classification, it was hypothesised that households in each of the three regions would display different practices of solid waste generation, collection and disposal. It should also be noted that each of the three regions were homogenous within themselves in terms of the general socio-economic characteristics and would have little variation in terms of solid waste generation and disposal within themselves. With this in mind, and given the constraints of time and other resources, it was decided to select a sample of household from each region according to its total number of households. Thus, the final number of households selected in Goroka consisted of 27 households in North Goroka, 23 in Town and Seigu and 30 in West Goroka.

Wamonagu village has houses built in a linear pattern along a road on either side of the road that runs from east to west, therefore the houses were divided either north or south of the road. Wamonagu which contained a much smaller number of households than Goroka with approximately 50 households with 20 households selected for interview. There were 12

households selected from the north side and eight from the southern side as there were more households on the northern side than the southern side. However one of the household interview recordings was not clear therefore was invalid for analysis. The villages in PNG generally have a population of about 200 to 500. This population records are difficult to access due to lack of proper record keeping

The number of strata differed according to the pattern of the two settlements. The method of sampling used was probability sampling which started with stratified sampling to choose the households for both Goroka and Wamonagu.

Stratified and systematic random sampling was applied here. Firstly, stratified sampling was applied for fair recruitment of households from the suburbs or sections and to minimize the error from just using random sampling. Random sampling allowed for the households in the sample population with the equal opportunity of being selected which limits bias selection. This sampling was appropriate for the study as its target was to gather information from the wider community and was not only limited to a selected group of people. The final participants for the household interview were selected with an equal number of males and females. That meant if the first household had male participants than the next one selected had female. The selection of which gender participated depended on both couples consent where household heads were married. After stratified sampling, a simple random sampling technique was used to obtain the final households to be interviewed using random digit sampling or tables.

In PNG the households are classified into two categories: private households and common households. Private households consist of families living together (Achankeng, 2004), while common households include shared accommodation such as boarding schools, hostels in Goroka,

and men's houses[1] in Wamonagu. In this study, participants from common households were excluded. In case of a household with a married couple, either the husband or the wife was selected for interview (which was also determined by the availability of the household member). However, for households with only one household head (single parent and unmarried person), that person was interviewed. Moreover it was also decided that equal numbers of males and females be interviewed. The sample size for households in Goroka and Wamonagu are 80 and 20 respectively.

3.4.2. Sampling for the other in-depth interviews

The participants for the non-household in-depth interviews were selectively chosen. The selectively chosen participants allowed for collection of information from people who might not be selected otherwise. Even though there might be some elements of bias in the selection this method is vital to get the maximum information for the study. There were ten non- household participants selected for in-depth interviews in Goroka. These participants included two town council staff, a provincial administration staff and six education officers and provincial environmental officers who had relevant information on municipal solid waste management, funding, SWM policies and SWM education and awareness programs. In Wamonagu, there were five elderly participants from the initial six participants that were selected. For the non-household in-depth interviews, ten participants were recruited for Goroka and five participants for Wamonagu. The ten non-household in-depth interview participants in Goroka were selectively chosen and contacted for their consent to participate in the interview with one not participating resulting in nine participants. The participants were officers involved in the policy

[1]Vatican Museum, The Ceremonial Men's House. Retrieved August 25, 2008, http://mv.vatican.va/3_EN/pages/x-Schede/METs/METs_Sala02_02_01_018.html.

and decision making processes and people who deal with SWMS in town. There were also officers in the educational institutions that were in teaching and writing of curriculum taught in the educational institutions. The five elderly participants for Wamonagu was selectively chosen as there were few elderly population in Wamonagu

3.4.3 Sampling focus groups

There were six community groups in Goroka that were identified and selected from the pool of women and youth groups in Goroka town. Four of the community groups were church based groups and two were not. The leaders of the six community groups were contacted for information and approval to access the members of the community groups for selection purposes through written letter of approval. Out of the six community groups contacted, the leaders of one youth group and two women's group approved the participation of their member in the focus group discussions. The other three declined the participation of their members for the focus group discussion. Systematic sampling was used to select 10-12 members for each focus group. The youth group had 11 member selected with all giving their consent to participate. However one withdrew due to medical reason therefore there were only 10 participants. The two women's groups had 11 and 12 participants each for the focus group discussion. There was no focus group for Wamonagu as the population is small and the other two data collection techniques provided appropriate data.

The composition of the focus groups was homogenous for two in terms of gender but not for the other one. The youth groups in the churches consists of both male and females therefore each gender was equally represented in the focus group. Having a heterogeneous group is vital as it allows for the different view from the two genders that is not captured in a homogenous group.

To make sure that there was minimal difference in the members of the youth groups the members selected were aged between 18 years to 24 years with minimal age gap to allow for easy discussions. Having these groups also minimized the power difference and cultural differences where one social group dominates the discussions. For instance, in PNG where the decisions in the society are dominated by older men, a heterogeneous grouping could be a hindrance as the discussions could be dominated by males. The rationale for selection of groups differs from each focus group. For the women, culturally in PNG, and especially in the highlands settlements like Goroka, women would not openly express themselves unless they are encouraged to do so. They are able to express themselves better in same gender groupings, therefore, creating an avenue for active discussion during the focus group discussions which is ideal to bring out information that might not be revealed in individual interviews. The youth groups are selected as their voices might not be represented in the household interviews. Culturally, youths cannot express their views openly in public, yet they constitute the largest population in PNG. Therefore, the focus group discussions will give them the opportunity to discuss the issue on SWM as a group where they could not do individually or in front of dominant people. There would not be any focus group participants in Wamonagu as the population size is small.

3.4.4. Sampling for observation

Observations conducted by the researcher were only conducted to investigate activities related to collection, handling and disposal of solid waste by the council staff in Goroka town. In Wamonagu village observations were conducted for four days in two weeks for two selected households out of the about 50 households and these observations were mainly about collection and disposal activities done by the households. The observations were carried out to establish

system used by households in Wamonagu and the Goroka town council on how the SW were collected and disposed and the impacts of this SWM practices. In Goroka, observation was done with the collection and disposal staff of the town council. The observations focused on collection, handling and disposal of waste from the source of generation to the dumpsite. This took four days during the council collection days with in four weeks.

The in-depth interviews from households and non-household participants were recorded using the tape recorder and other relevant notes taken for one hour. The focus group discussions were also recorded with notes kept on the non-verbal communication that occurs between the members during the discussion. There were two sessions of discussions that ran for two hour for each focus group. The observations were well done with notes kept on the collections, handling and disposal done by the council staff in Goroka and the households in Wamonagu. The observation ran for about two hours each collection day.

3.4.5. Communication and recruitment

The recruitment of participants and the procedures used to recruit the research participants are important. Hence the procedures used to recruit the participants for the research are discussed in this section below.

The method of initial communication and the recruitment of, participants for the two sites were slightly different. The difference was due to the nature of the sites and the differences in how communities are organised in the two sites. The first stage of the recruitment included contacting relevant people and organisations verbally and through letters of approval from the relevant council official to gain access to the research sites and the participants. To ensure getting enough

interest for household in-depth interviews, non-household in-depth interviews, and for focus groups, participants were reimbursed for their time and travel costs at both sites. Culturally, a reciprocal relationship is important where people's time and effort are reimbursed when they offer their assistance, without which it would have been very difficult to recruit and involve participants at the two research sites. The purpose and benefit of the research to their community and the nation were also explained to the participants.

3.4.6. Recruitment of participants in Goroka

In Goroka, Provincial Statistical Officer, Provincial Planner and the Town Council Manager were contacted to gain access to significant documents such as the town plan and ensure the participation of council staff and the town residents in this research. The documents on the plan and population of the town were used to select the houses for both the household and non-household in-depth interviews that involved government officers. The households were selected from the three sections of the town (North Goroka, Town –Seigu and West Goroka. The non-household in-depth interviews were conducted with the representatives of different stakeholders. The participants of the non-household in-depth interview included two council staff, six education officers from both public and private institutions, and the provincial environmental officer. The interview that was planned for the Provincial Administrator did not eventuate. The method of selecting the household heads for interview in Wamonagu and Goroka and the in-depth interview participants for the government and non-government officers in Goroka plus the participants to the focus group members are discussed later in section 3.5.5. The following procedures were followed to contact and later recruit the participants:

(i) The household heads were contacted and their consent were obtained prior to the interview, either verbally and/or in writing depending on whether they could read and write. There were 17 household individuals who had no education to having education up to year six who gave verbal consent. Out of the 17 individuals 13 were from Wamonagu and four were from Goroka. Where the households had both husband and wife only one of them was chosen for the interview when they both agreed on who would be the one to be interviewed. However, where the household had a single parent or unmarried person, that person was selected to participate in the interview.

(ii) For the non-household in-depth interviews the participants were officers of , specific institutions from both the private and public sectors, such as educational institutions, town councils and provincial administrations were identified and their relevant officers were contacted, selected and their consent was obtained in writing.

(iii) Focus group participants were contacted by obtaining the organisation leaders' consent to access their members. The number of organisations contacted and the number of members selected are discussed in 3.5.7

The focus group discussions were conducted with members of the groups that agreed to the request by the researcher. The participants were then contacted by the researcher and the research assistant to provide them some further detail about the proposed discussion. There were three focus groups selected. Two of the groups were women's groups from two different church denominations. The other group was a youth group from the church. The women and youth groups in churches are the common type of groups that organise and meet for worship regularly, who were easier to contact. There were a few other community groups that comprised of women and youth who did not belong to a church organisation, but they declined their participation. The

focus group participants were recruited by organization heads; in this case the church boards and leaders. Through these leaders the participants were identified and contacted for their consent verbally as well as in a written letter to explain the purpose of the project. A total of 33 participants were selected for the focus group discussions. Interestingly all the participants initially contacted in Goroka for this study indicated their willingness to participate. Their contact details were obtained and used to set the appropriate time and location for interviews. All the participants were contacted either through their mobile phone or through face to face in their houses as communication through emails and postal boxes were not readily available in PNG. However, a total of 80 households were finally selected for interview in the time available with 10 non-household in-depth interview participants from government and private organisations.

3.4.7. Recruitment of participants in Wamonagu

To access the population in Wamonagu village to participate in the study the council and village elders were contacted through consent letters and verbal communication. In PNG, the best way to communicate to people in a village is via oral communication in a group. Therefore, a village meeting was called by the village councillor in consultation with the clan leaders at Wamonagu. At this meeting, the researcher explained the purpose of the project with the approval of the clan leaders. During the meeting it was explained that the researcher and the research assistant were to contact the selected households and individuals for their participation. Only those people who gave their consent to participate in the interview were contacted by the researcher and research assistants and were interviewed. A convenient time was arranged with the household heads for the in-depth interviews. It was important to get the views of village elders (usually aged 60 years

and over) on how the composition of solid waste and their disposal have changed over time. With the help of the village councillor and clan leaders, six village elders were identified of whom only five could be contacted and interviewed.

The willingness and consent of all participants were obtained both verbally and in writing. In most cases, it was culturally acceptable to obtain verbal consent of the participants. The villagers were informed about the process of recruiting the households for interviews. A total of 20 household participants were selected in the village, but only 19 interviews were valid as the recording of one interview was not clear to be used for analysis.

3.5. Data collection through Secondary sources

The data for the research was collected from primary and secondary sources. The sources of data collection started with secondary sources of information that were collected initially from the libraries of these institutions: the University of Goroka (UOG); the Melanesian Institute (MI); the Research and Conservation Foundation (RCF); and the Institute of Medical Research (IMR) in PNG through books and journals in the libraries. The Flinders University Library and the National Australian Library were consulted to gather more information on the research topics through books, journals and other electronic sources. The libraries also provided access to the graduate dissertations and theses on the topic of solid waste in both hard copy and electronic versions. The Internet was used to access websites of government institutions, private institutions, community based organizations (CBOs) and Non-Government organizations (NGOs) in PNG and the world, to gather data on the publications and official documents related to the field of study.

These secondary sources provided information on the issues in municipal solid waste management (MSWM) in the world and the theories, concepts, principles and the strategies that are used. The secondary source of data also provided information on ISWMP, IEK that are used in the field of SWM but also in a broader sense in other field of study as well. From the information gathered through the literature, the research gap was established for this study. The appropriate methods to be engaged in collecting primary sources data were then developed through this process of data collection. The secondary source of collecting information continued as hard copies of other data from organizations without internet access were obtained and secondary sources of data collection continued until the thesis was finalized for submission.

For the primary source data collections, there were three different techniques used for data collection. The techniques were in-depth interviews with the use of structured interview questions for household and non-household interviews. The second technique is the use of focus groups where questions were formulated and used for discussions which is actually a group interview. The third technique used was the observations that were done to investigate the SWM method at the two study sites, especially regarding collection handling and disposal processes and notes were kept of the observations made to collect the relevant information.

3.6. Method of data entry and analysis

The in-depth interview data from the study were transcribed using formulated word document and excel spread sheet. These transcribed data was entered into the NVivo software. The focus group discussions were transcribed also using a formulated word documents and entered into NVivo. The final data set that was entered came from the notes of observations done on the

separation, storage, collection, handling/transportation and disposal of solid waste during council collection and disposal in Goroka and at Wamonagu village by households.

After the data was entered into NVivo it was systematically coded into themes before the analysis. The data analysis included the Microsoft Excel application to generate tables and graphs. The data analysed allowed for the discussion of the thesis with established findings and conclusions with recommendation drawn from the results.

The data entry and coding took longer than anticipated due to some technical problems where the initial transcribed data was lost. Therefore it took about 4 month before the analysis and interpretation of the data. There were a total of 80 household and in-depth structured interview questionnaires coded and entered into NVivo. The other data set that were coded and entered into the NVivo were the discussions from the three focus groups and the observation note from collection and disposal processes. From this data entry, different aspects of municipal solid waste in Goroka and Wamonagu were analysed for discussion and for the write up of the thesis.

3.7. Conclusion

The multiple techniques and methods utilized in this study reflect the complexity of the municipal solid waste. To gather adequate data from all actors in the municipal solid waste area, research methods such as structured questionnaires for in-depth interviews, focus groups and observations were used. The process of identifying and recruiting the sample population was conducted using techniques that allowed for minimal error. The software used for the data entry, coding and analysis, NVivo was appropriate for the qualitative research that was carried conducted in this study. The methodologies used generated the data and established the final results needed in this study.

CHAPTER FOUR:

TRADITIONAL WASTE MANAGEMENT AT WAMONAGU: KNOWLEDGE, PRACTICE AND CHALLENGES

4.1. Introduction:

Modern societies throughout the world have developed from traditional societies where their lives intertwined with the natural environment around them. Today there is only a small population of people in the developed world whose livelihood can be termed traditional or indigenous and in developing world it is on the decline. These traditional or indigenous societies have cultural practices intertwine with the knowledge of their human and natural environment. These intertwined traditional or indigenous knowledge systems have enabled the indigenous people to live harmoniously with the environment due to their simple way of life.

In indigenous or traditional societies people extract resources from the environment and use the raw materials without complicated manufacturing processes. The consumption of materials in

indigenous societies and the solid waste produced are predominantly biodegradable or organic in nature. This biodegradable solid waste is managed using different techniques or methods of waste management that have been a part of the people's way of life for many generations.

This chapter will discuss mainly the indigenous solid waste management practices (ISWMP) in the past and present by households at Wamonagu village in the Eastern Highlands of Papua New Guinea (PNG). Wamonagu is a rural village in PNG whose population is indigenous and who is focused around subsistence agriculture. This chapter will also discuss how the knowledge and skills of ISWMP are transferred from one generation to the other. Finally, the management of solid waste in public areas will be discussed with the focus on the group of people who are responsible for its collection and disposal activities.

4.2. The People of Wamonagu village

The households of Wamonagu belong to different tribal groups or clans. From the household interviews that were carried out as part of this research, members of four tribes or clans in the village were interviewed. Table 4.1 shows that there were slightly more respondents from the Waseme tribe interviewed at Wamonagu than those of the other three tribes. Although there was no official record of the composition of the population based on ethnicity in Wamonagu village, the distribution indicated in the sample (see Table 4.1) reflects to a large extent that Waseme and Inorome were the tribes which constituted the majority of the households in that village. This was also observed by the researcher during the fieldwork.

Table 4.1 People in each tribe at Wamonagu

Tribe/clans	Population interviewed
Waseme	8
Inorome	6
Morefofo	4
Burene	1

Source: Field work, 2011

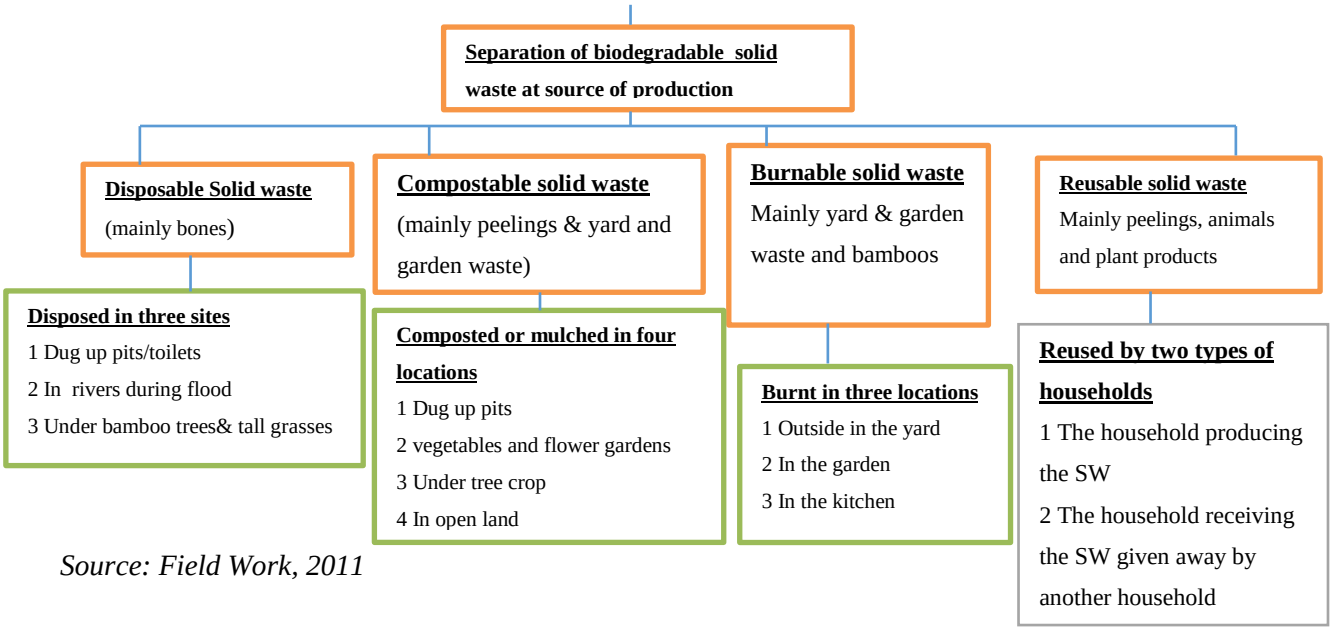
The majority of the household heads (13 out of 19) interviewed are aged between 21 and 40 years. In indigenous village communities like Wamonagu in PNG, most of the adult children live with their parents only until they are married. They prefer to start the family having their own households. Therefore 68% of the household heads interviewed were young adults aged between 21 and 40 who were married and had their own households.

4.3. The Indigenous Solid Waste Management Practice (ISWMP) in Wamonagu Village in the past

The solid waste at Wamonagu village is managed using indigenous knowledge that is passed on from one generation to another. The ISWMP involves generation, segregation, storage and disposal of solid waste at the household levels as well as in public areas. The solid waste was segregated and classified into different categories which are discussed below in Figure 4.1 showing the ISWMP. This ISWMP that was used in the past to manage the solid waste is still being used by the households at Wamonagu village today with biodegradables being the predominant solid waste even though there is some production of non-biodegradable. The ISWMP used today is discussed later in this chapter.

Figure 4.1: ISWMP at Wamonagu

ISWMP at Wamonagu in the past



Source: Field Work, 2011

The ISWMP that was developed and used in the past by the ancestors of the Wamonagu people began with the solid waste being managed in the household starting with the segregation and disposal to segregation and solid waste reduction and then to resource recovery activities. The solid waste management system and mechanisms were focused around the domestic activities of the households that benefited them, their environment and the community in which they lived. The benefits involved better agricultural products, clean healthy homes and a natural environment. The ISWM begins with the generation of solid waste and its separation into different categories in the household. These main categories of solid waste were: Disposal; Compostable; Burnable; and Reusable.

In the past, these categories were used by households to group the solid waste, store it in string bags for a day or two, and later disposed, composted, burnt and reused. The type of solid waste that was disposed of previously was minimal and restricted to only very hard items such as bones that were not of any use.

The other three categories of solid waste were used to carry out resource recovery or solid waste reduction activities for the benefits of the households. For instance, peelings were mainly composted in the gardens, reused to feed animals, and at other times just discarded anywhere as they degrade easily while dry and hard wood materials were burnt to retrieve energy for cooking.

In the past, all the equipment for the solid waste management activities were provided by the households. The land on which the disposal site was located and the resource recovery/solid waste reduction activities such as composting and burning were carried out is owned by the households. This made the solid waste management easier as the practices of managing the different types of biodegradables were in place and all the resources for the SWM were available and easily accessed locally.

The process of ISWM, with the knowledge and skills associated with the SWM processes is passed on over time through different generations. Therefore that same knowledge of ISWMP still exists today and is in use by the Wamonagu people. However due to modernisation and introduction of a cash economy, the type of manufactured goods that are consumed now has brought some changes in the composition of solid waste from predominantly biodegradable waste to some non-biodegradable manufactured solid waste. This change is discussed later on in the chapter. However before the processes of the ISWM and the knowledge and skills associated with this can be addressed, it is important to discuss the composition of the different types of SW currently generated in Wamonagu village.

4.4. Solid Waste Composition in Wamonagu village

The type of solid waste produced and the quantity of its production determines the solid waste management system in a given society and the challenges faced in managing these solid waste

streams. The two types of solid waste are biodegradable and non-biodegradable. As stated earlier, for this research, nineteen household heads were interviewed in Wamonagu village and their responses are discussed in relation to the types of waste stream that the households produced the most and the least. In addition, the different types of biodegradable and non-biodegradable solid waste are discussed according to the responses of respondents.

The common solid waste that all households produced was biodegradables and the least common was the non-biodegradables according to the interviewed respondents. The bulk of the SW at Wamonagu village consists of biodegradable SW as the villagers are subsistence farmers and so cultivate and grow crops for their own consumption only selling surplus crops. The only cash crop that villagers have is the coffee that is planted and harvested annually to be sold in Goroka town, the capital of the Eastern Highlands Province.

The biodegradable solid waste generated was mainly from food crops, yard waste and the waste from other resources that were extracted for their consumption from the natural environment such as forests. The non-biodegradable solid waste that the households produced the least at home, were empty tins cans, plastics bags and plastic bottles. This household generated non-biodegradable solid waste occasionally only when they visited Goroka town and bought goods from the shops. Therefore the amount of non-biodegradable solid waste that this household generated was less compared to the large amount of biodegradable that were generated daily. All respondents stated that the type of solid waste they produced the least was non-biodegradables.

This is evident in the responses of two respondents regarding the production of these two types of solid waste:

'The rubbish from the shop like the plastic packets of goods and the empty tin fish cans we produce the least. We produced non-biodegradable solid waste only once in a while. When we go to Goroka town we buy the store goods and bring them home so we have less plastic packets and tin fish cans.'

'The rubbish that we produce the most is the peelings from vegetables that we harvest from our gardens.'

The two main solid wastes produced by the households are discussed individually in sections 4.4.1 and 4.4.2 with classification of the biodegradable and non-biodegradable solid waste into more specific categories. This further classification enables the establishment of the specific biodegradables and non-biodegradables that were generated by the households interviewed in Wamonagu village.

4.4.1 Biodegradable Waste

The biodegradable solid waste that is produced by the households interviewed at Wamonagu was classified into different categories as shown in Table 4.2.

Table 4.2: Domestic Biodegradable Solid Waste Types in Wamonagu Village

Types of biodegradable SW	*No. households producing waste*
1. Peelings and other vegetable waste (food consumption)	19
2. Yard and garden waste (cleaning and gardening)	15
3. Bamboo and wood waste (food preparation)	9
4. Raw building materials (building of houses and other structures such as fences)	9
5. Food leftovers (food consumption)	5
6. Ashes of burnt organic waste (gardening)	3
7. Coffee waste (cash crop production)	3

8. Animal bones and fats (food consumption)	2

Source: Field work 2011

The findings from the interviews presented below show that the bulk of the biodegradable solid waste generated is from vegetables as the households daily food consumption are of crops from their food gardens. This is evident in one of the respondent's responses below.

'The solid waste that my household produced the most is the peelings of food crops from the garden as we consume a lot of vegetables and the garden is where our main food sources are from'.

From these different categories of biodegradable solid wastes, the majority of the household generated a combination of two or more categories. These biodegradable solid wastes ranged from combinations of two biodegradables to a combination of seven biodegradable solid waste generated by the households.

The other biodegradable solid wastes produced by the households depended on their daily activities and consumption. Therefore the next common solid waste produced by the households at Wamonagu is yard and garden waste that is linked with the gardening and cleaning activities the households performed in and around their yards. This shows that that the households interviewed are involved in cleaning their yards and gardens near their houses constantly.

The third common biodegradable solid waste that about half of the households generated were bamboos and wood waste and raw building materials that were used for food preparation for the former and building houses and fences for the latter. The bamboo is used for fetching water and cooking while the wood waste is mainly from chopped firewood which is the households' main source of fuel. Raw materials such as timbers, vines, kunai (Imperata cylindrica) (Hartemink and

O'Sullivan 2001), used for building houses and other structures, became part of solid waste generated by households. As subsistence farmers living in a rural village, the households interviewed at Wamonagu get materials for their daily needs and activities from their natural environment. Therefore solid waste from raw materials refers to all the biodegradable solid waste generated from resources extracted from the natural environment. For instance, a respondent commented that his household produced biodegradable waste when they are repairing their house which is made from bush materials.

4.4.2. Non-biodegradable Waste

The non-biodegradable manufactured solid wastes were not generated through a traditional life style in the rural indigenous societies in the past. That is, the period before Western influence. However, with a current change from a traditional to modern society the composition of SW produced has changed from predominately biodegradable to some composition of non-biodegradable in the developing world (Roger 2004; SPREP 2009). This transition has also impacted the rural villages like Wamonagu with households producing non-biodegradable solid waste occasionally when they travel to the urban centres like Goroka to sell their surplus vegetables and coffee beans then buy and bring back manufactured goods for their consumption. The composition of non-biodegradable solid waste at Wamonagu village is simple and classified according to their material composition and common name given to the items.

Table 4.3: Domestic Non-biodegradable Solid Waste Types in Wamonagu Village

Types of non-biodegradable SW	*No. households producing waste*
1. plastic bottles and empty tin fish can	3
2. empty tin fish cans only	10

3. plastic bottles, empty tin fish cans and plastic bags	6
4. Old fabrics (use of garments)	1

Source: Field work 2011

Table 4.3 shows the different types of non-biodegradable SW that is generated by the households at Wamonagu village. The three common types of non-biodegradable solid waste that the households produced were plastic bottles, plastic packages or bags, and empty tin cans. Even though there were three types of non-biodegradable SW generated, when their material composition is taken into account, there are only two types of SW generated by the households and they were plastics and tin cans as the bottles are from cooking oils that is made of plastics.

All the households interviewed mentioned that they occasionally produce empty tins from tinned-fish that they bought with just over half of the households interviewed producing only empty tin cans while the rest produces a mixture of plastic bottles, empty tin cans and plastic packages/bags as shown in Table 4.3. These non-biodegradables were not produced daily but occasionally as the households are subsistence farmers therefore consuming vegetables grown in their gardens daily. This is clearly illustrated from the response of a respondent quoted here.

'Sometimes when we go to town we have rubbish from store goods such as plastics from rice, oil bottles, salt plastics and empty tin of fish. On a daily basis we have peelings from vegetables from the garden'.

All the households interviewed responded in the same manner as this respondent. Therefore the consumption pattern here shows that the households buy tinned protein occasionally to add to their diet that mainly consists of vegetables.

4.5. Current Indigenous Solid Waste Management Practice and Knowledge in Wamonagu

The households interviewed in Wamonagu village use the indigenous solid waste management knowledge (ISWMP) and practices passed through generations from their ancestors to their parents and down to them. The knowledge and practices of solid waste management are embedded in the daily lives of the villagers. One respondent is quoted here to demonstrate a common response that all respondents gave:

'*These methods of managing SW are part of our lives and have been used for a long time by our ancestors, our grandparents, our parents and we are using them now'*.

There is a very clear message that the ISWMP and knowledge existed in the village over many generations and it is part of people's everyday lives**.** These solid waste management practices and knowledge are basically to manage the biodegradable solid waste. Therefore the system of solid waste management practices developed by the Wamonagu villagers were simple and did not involve any complicated technology to design the final disposal sites as shown in Figure 4.2 and described in next section.

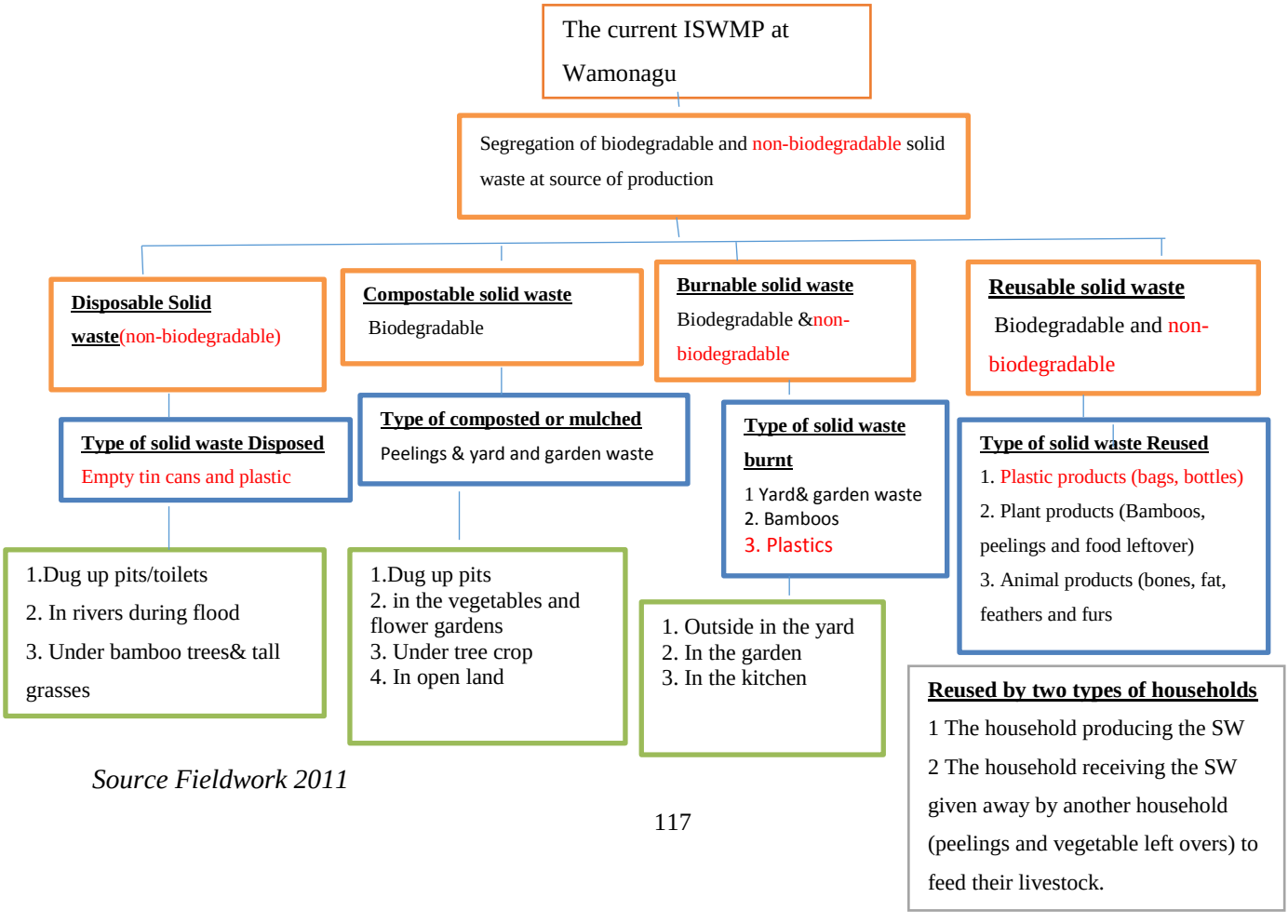
4.5.1. The ISWMP Model

In the past, ISWMP and knowledge were used to manage predominantly biodegradable waste. The same knowledge is used to manage the solid waste in Wamonagu village today. However due to modernisation and introduction of a cash economy, the type of goods that are consumed has brought some changes in the composition of solid waste from largely biodegradable SW to household generation of some non-biodegradable manufactured solid waste as shown in the solid waste management model in Figure 4.2. The processes of managing domestic solid waste using ISWMP are the same; however the composition of the type of solid waste has changed. The changes are shown in the colour red in Figure 4.2. The households use the knowledge and practices that they have acquired from their parents on ISWM with some adaptation to cater for

the new type of solid waste that they have to manage. The model in Figure 3 shows the household solid waste management knowledge as a system from which household solid waste practices are derived.

The management of solid waste for households at Wamonagu begins with the generation and separation of the solid waste. This solid waste is separated into different categories at the source of generation. In this case, as the solid waste at Wamonagu village is basically generated at the household level, its separation into different categories is also done at the household level. The solid waste, according to the households interviewed, is separated into four major categories which are *disposable, burnable, compostable, and reusable* .These five categories of solid waste are discussed further in this section.

Figure 4 2: Model of the current ISWMP at Wamonagu



Source Fieldwork 2011

The disposable solid waste that is, in nature, of both biodegradable and non-biodegradable is disposed permanently by the households at three different types of disposal sites. The other three categories of solid waste are waste reduction and resource recovery categories and are mainly for biodegradable solid waste. Therefore the solid waste in these four categories are further managed through solid waste reduction and resource recovery activities such as composting, burning, reusing and giving away. By using these different waste reduction and resource recovery techniques, there were environmental, agricultural, and financial and health benefits for the households and the village community. These benefits are discussed later in this chapter. The processes and different stages of managing SW at Wamonagu are illustrated in Figure 4.2, with all the processes being similar to the illustration in Figure 4.1, except that non-biodegradable or inorganic solid wastes are now being disposed at disposal sites that once had only biodegradable solid wastes. This knowledge of the processes of ISWM used at Wamonagu from separation to disposal and the reduction activities such as composting, burning, reusing and giving away of SW are discussed in separate sections in this chapter. However, to carry out the solid waste disposal and waste reduction/resource recovery activities, the households use several types of equipment to assist them as discussed in the next section.

4.5.2. Equipment used for storage of solid waste and quantity of solid waste

The equipment used for the storage and transportation of households' domestic solid waste were mainly bags. The quantity of the solid waste produced by the households depended on individual households. The storage equipment used by the households and quantity of the solid waste bags produced are discussed in this section.

4.5.2.1 Equipment used for Solid Waste

The households produced and managed their own solid waste at Wamonagu. Therefore storage equipment needed for storing, transporting and disposing the SW were also provided by the households. All the households that were interviewed responded that they provided the storage equipment themselves and the main type of equipment used for storage and transportation of solid waste were bags. However, apart from using the bags, one participant indicated that her household also cut out the fabrics of an old umbrella to store and transport solid waste.

The bags that the households used were of three types: (i) old string bags (ii) empty rice bags and (iii) stock feed bags. The string bags are made from either the fibres of barks of certain trees in the forest or manufactured nylon and wood. The stockfeed bags are slings or empty stockfeed bags that are cut and sewn up to be sold at the markets in Goroka town purposely as carry bags. This bag has a sling and is commonly used by households in Goroka town to carry vegetables from the market to their residents. Therefore it is also known as a market bag. These empty stocks feed bags and market bags are bought by the individual households or given to the households by their relatives in town to be used for carrying their garden produce and which are later reused as solid waste bags. The final types of bag are the empty rice bags that are reused after the rice has been consumed.

The type of bags used by majority of the households is made from empty stock feed bags and a minority of the households use string bags to store solids with the exception of one household that uses stock feed bags as well as string bags for solid waste storage. Of the majority of households that use bags that originate from stockfeed of chickens, about half use market bags and the rest use the empty stockfeed bags with one household using both market bags and empty

stockfeed bags to store solid waste. Of the minority of households that use string bags to store solid waste, some use bags made from fibres gathered from the forest while the others use string bags made from wool or nylon fibres sold in the shops in Goroka or other urban centres. Therefore the common equipment used by the households were empty stockfeed and market bags.

The use of bags by the households shows that all households reuse bags that were previously used for other purposes. The most common bags used are those made from manufactured fibres while bags made from traditional fibres are less commonly used. In the past, the string bags made from traditional fibres were the only bags used for storage of solid waste. However today, households use both types of bag for storage of solid waste.

(i)Cost of the bags used

Wamonagu households used bags made from manufactured materials as well as those made from traditional fibres. Therefore, depending on the type of bags used and their availability the households in Wamonagu paid for the bags they used. The majority of the respondents pay for the bags to carry and store items while a minority did not pay, the exception being one household which had a mixed response. The majority of the households buy empty stock feed bags and market bags sold at the market with only one household either paying or not paying for them depending on whether the bag is made from manufactured materials. The rest of the households did not pay for bags as they either made the string bags themselves from traditional fibres or used the empty stockfeed bags or market bags given to them by their friends or relatives when they visited Goroka town.

The bags have different costing depending on their size and whether or not they are hand-made by the households using traditional fibres or the manufactured wools sold in the shops or the empty un-sewn stock feed bags and sewn stock feed bags called market bags. The cheapest bag was the string bag hand-made from traditional fibres, while the bag that cost the most was the hand-made string bag made from the imported manufactured materials. However a majority of households spend K1.00 to K2.00 buying the market bags sewn from empty stock feed bags. Even though the string bag made from traditional fibre does not cost any money, the process of making one is time consuming and just one household used this type of bag to store solid waste (Table 4.4).

Table 4.4: Type and cost of bags used in Wamonagu

Type of Bags	**Size**	**Cost in kina**
Market bags (sewn stockfeed bags)	Small	K1.00
	Medium	K2.00
Empty stockfeed bags	Large	K3.00 -K4.50
String bags hand-made from wool	Medium	K5.00-K10.00
String bags hand-made from traditional fibres	Any size	No monetary cost

Source: Field work 2011

It is clear from these findings that the primary purpose for buying and reusing the empty stock feed bags is not for storage of solid waste, but is for storage for coffee beans and carry bags for vegetables. The bags are only used as garbage storage bags when they are old before they are discarded. The size of the bag used for solid waste storage depended on the amount of solid

waste produced by individual households. These are therefore classified according to their sizes in the next section below:

4.5.2.2 Quantity of Household Solid Waste generated and Bag Size

The amount of solid waste generated by households depends on family size, and the rate and pattern of their consumption. For instance, a 2001 study by UNEP in India showed that when the population increased, the amount of municipal solid waste also increased (Troschinetz and Mihelcic, 2009). The quantity of domestic solid waste produced is measured in number of bags produced by a household. The size of each bag depends on consumption rate and family size. The bags were compared to bags of rice with which the households were familiar.

(i) Size of bags used to store household solid waste

The bags used by Wamonagu households to store the domestic solid waste are mainly for the solid waste produced inside the house. The size of bags that households use can be compared to the size of rice bags as far as volume (not necessarily weight) is concerned. The household bag sizes are classified in two categories: (i) bags equivalent to rice bags ranging between 5kg-10kg; and (ii) bags equivalent to rice bags ranging between 10kg - 20kg. While almost all households provided bag size, one household responded that the size of bags depended on the rate of consumption with some households also reflecting the same view

The majority of the households used bags which ranged between 5kg to 10kg with bags that were equivalent to a 10kg bag of rice being the most common bag size used by households. Using a 10kg bag size to store solid waste daily reflects the consumption of predominantly vegetables for their meals. The number of garbage bags that households produced depends again on their consumption rate. This is discussed below.

(ii) Quantity of solid waste produced in bags

The number of garbage bags generated by households range from half a bag to two bags per day as listed below. The majority of the households produced one bag of SW per day with a minority producing half a bag and two bags of solid waste daily. Even though all the households gave the number of garbage bags they produced daily, a few households also commented that the number of garbage bags they produce daily depends on the amount of vegetables brought from the garden and consumed.

The solid waste type that the households stored in these bags was predominantly biodegradable vegetable (food) waste as tinned, bottled and packaged food, from which the non-biodegradable solid waste is generated, is consumed only occasionally and thus are kept in the cooking area separately and disposed of as individual items. Therefore, the volume of solid waste generated each day by Wamonagu households ranges from bags that are equivalent to 5kg to 20kg rice bags with most households producing a garbage bag the size of a 10kg bag of rice daily depending on the amount of vegetables brought home from their gardens and consumed. The volume of solid waste produced by households at Wamonagu is therefore given here in terms of bag sizes but, the actual weight of the solid waste produced is not established.

The bags that the households use are for storage but at the same time used to transport the solid waste to be disposed of or to manage activities related to the solid waste reduction/resource recovery after the segregation. The segregation of solid waste into different types of waste is done before disposal and reduction/resource recovery activities are carried out. This process is discussed below.

4.6 Indigenous Solid Waste segregation, storage, collection, disposal and reduction at Wamonagu

Wamonagu households use indigenous knowledge and practices passed down to them through their ancestors to manage the solid waste. The process of indigenous solid waste management involves the application of different solid waste management techniques or practices that exist in their indigenous knowledge system.

4.6.1. Segregation:

All households segregate their domestic solid waste into five different categories in their houses both inside and outside the house. The solid waste that is generated from the yards and gardens is segregated outside the house. These categories of segregated solid waste are listed below and are part of the overall indigenous solid waste management process illustrated earlier in Figure 4.2.

a) Disposable waste
b) Burnable waste
c) Compostable waste
d) Reusable waste
e) And give away waste

4.6.2. Storage:

The solid waste that is stored and later collected for disposal by the households after segregation is mainly non-biodegradable solid waste such as empty tin fish cans, oil bottles and plastic packaging from manufactured goods purchased from the shops. However the biodegradable solid waste that is sometimes disposed of includes hard items such as bones and hard logs. The type of disposal sites that households use depends on individual households. Before the disposal of the solid waste is addressed, collection and storage is discussed.

The proper storage of solid waste before collection and disposal is crucial for any solid waste producer to prevent environmental and public health issues. The household storage of solid waste in Wamonagu village is discussed here in relation to the duration and method of solid waste storage. The domestic solid waste is stored in two different ways by the households at Wamonagu. Firstly, the solid waste is either segregated into two separate piles and stored in two bags, or is kept in two piles of biodegradable and non-biodegradable solid waste.

The duration of SW storage in households in Wamonagu is closely linked to their collection and disposal patterns. The households store the domestic solid waste from a few hours after the generation of solid waste to two days after its generation. The duration of solid waste storage is classified into four groups: (a) disposal straight away after generation; (b) disposal after half a day; (c) disposal after a day; and (d) disposal after two days. The majority of the households gave a single time frame with a minority giving two time frames as shown in Table 4.5. Again almost all households dispose of the solid waste within a day with the exception of one who dispose it of within two days. Below are three respondents' comments regarding the time taken for them to store domestic solid wastes after generation and later disposing the SW. The responses below represent the daily practice by the majority:

'In my house we do not store the solid waste for long. When we are preparing our meals while our food is cooking one of my family member collects the solid waste and dispose it straight way. Therefore it is stored for about 1hour while we are cooking'.

'We hardly store the solid waste in the house. As soon as we finish cooking we collect the tins dispose it in the pit and peelings under the banana trees'.

'It does not take a day. It takes about an hour before we dispose the rubbish and that is straight after cooking and we burn the tins before disposing. This is because when the empty tins and peelings are kept longer, the peelings and left over content of the tinned food will rot making us sick'

The majority of the households interviewed for this study generate, store, collect and dispose of their household SW daily even though the length of time taken to do this differs as the solid waste is disposed of from straight after production to 24 hours after the generation of waste.

4.6.3: Collection of Solid Waste

The collection of solid waste from its point of generation to the disposal sites is a vital process that needs resources and effective systems to be put in place for it to be functional. In Wamonagu, all households collect, handle, transport and dispose of the solid waste generated as individual households. This is because, as a rural village community in PNG, people's lives are based around subsistence farming on a daily basis; therefore, their use of public space is limited. As a result, the generation of solid waste in public areas occurs during special public events that involve the whole village community. The public areas in Wamonagu include community meeting areas, church and school grounds that are located in different villages. The generation and collection of solid waste in public areas will be discussed later in the chapter.

4.6.3.1. *Household members responsible for collection and disposal of domestic solid* waste

All members of the household are responsible for the collection and disposal of the solid waste in their individual households. However the onus of domestic solid waste collection falls particularly on the female members of the households who manage their day to day operations. Therefore the households maintain ownership of the management of solid waste from the generation to disposal. The involvement of all members of the households is an advantage for the

younger members who would acquire these vital knowledge and practices of indigenous solid waste management.

4.6.3.2. Frequency of solid waste collection

The majority of the households in Wamonagu collect and dispose of their domestic solid waste once every day with only a few households collecting and disposing twice a day or after two days. From the total households interviewed few of them also commented that the number of times their households collect and dispose the domestic solid waste depends on the people visiting them and their consumption rate.

4.6.4. Solid Waste Disposal

This practice of disposing solid waste is healthy and effective. If the solid waste is stored for long periods, it rots, emanating a stench that attracts disease carrying pests and insects that could make household members sick. The collection of solid waste from its point of generation to the disposal sites is a vital process that needs resources and effective systems to be put in place for it to be functional. In Wamonagu, all households collect, handle, transport and dispose of the solid waste generated at individual households. This is because, as a rural village community in PNG, people's lives are based around subsistence farming on a daily basis; therefore, their use of public space is limited. As a result, the generation of solid waste in public areas occurs during special public events that involve the whole village community. The public areas in Wamonagu

include community meeting areas, church and school grounds that are located in different villages. The collection and generation of solid waste in public areas will be discussed later in the chapter. The solid waste generated and classified as disposable waste is disposed of in four types of sites as listed below. The households either use the natural environment or dug up pits as disposal sites.

(i) Dug up pits especially for disposal of solid waste

(ii) Pit toilets where households sometimes dispose empty tin cans

(iii) In the River during the floods

(iv) Underneath bamboo trees and tall tough grasses

The dug up pit and pit toilets are the common type of disposal sites used by households to dispose of non-biodegradable solid waste. Each household has a pit where they dispose the non-biodegradable solid waste comprising mainly of empty tin cans. The pits are covered with soil when full and the households dig new pits at a new location for disposal of domestic solid waste. This indicates that to control and manage the disposed solid waste in the pits, the households cover the dug up pits and old pit toilets with soil and leave them for new ones. Only a few households use rivers, the bases of bamboo trees and tall grasses as disposal sites.

All members of the household are responsible for the collection and disposal of the solid waste in their individual households. However the onus of domestic solid waste collection falls particularly on the female members of the households who manage the day to day operations of the households. Therefore the households maintain ownership of the management of solid waste

from the generation to disposal. The involvement of all members of the households is an advantage for the younger members who would acquire these vital knowledge and practices of indigenous solid waste management. A quote from a respondent regarding collection and disposal of domestic solid waste involving children is given below:

'My children started doing some collection and disposal of domestic solid waste at the age of 5 years'.

The children's involvement in the collection and disposal of solid waste at the age of five helps them to learn and have a deeper understanding of the concepts and practices of indigenous solid waste management as they grow older. It is through domestic activities that children learn both directly and indirectly very important life skills that are not documented in traditional rural societies.

The majority of the households in Wamonagu collect and dispose of their domestic solid waste once every day with only a few households collecting and disposing twice a day or after two days. From the total households interviewed few of them also commented that the number of times their households collect and dispose the domestic solid waste depends on their rate of consumption

The households that disposed of non-biodegradable solid wastes in different types of disposal sites had one aim which was to keep their households safe and healthy from illnesses according to majority of the views.

Below are comments of two respondents giving the reasons for the households' use of bamboo trees and rivers as disposal sites.

'The empty tin cans disposed under the base of bamboos trees is so that it would not cut our feet or make us sick. This is because the bamboos grow close to each other and no one can get in between the bamboo easily and so it is safe to dispose empty tin cans there'.

'I have seen the households living near the river dispose the empty tins and peelings into the river during the floods so the rubbish can be carried away. This was a practice in the past and is being used now. But I do not dispose rubbish in the river as my house is away from the river'.

This respondent's household does not dispose of the solid waste into the river during floods as the location of his house is away from the river. The disposal of solid waste into the river during the flood may seem to remove it from the village. However it can be deposited down-stream or end up in the ocean. This practice is hazardous as it degrades the water quality through the release of toxic chemicals from the non-biodegradable solid waste into the river affecting the people using the river downstream and the life of aquatic organisms from the river and the ocean. This is an environmental and public health concern of which the households may not be aware of.

With disposal of only biodegradable solid waste in the past before the introduction of manufactured non-biodegradable solid waste, means that the households lack the knowledge of the environmental and health risks of chemical contamination that this new type of waste solid poses for their households and the community at large.

The disposing of non-biodegradable solid wastes such as empty tin cans and plastics packages in a pit that is not designed properly with plastic lining to collect the leachate, poses threats to the environment and to the public health. When the disposal site is not designed to collect the leachate, the toxic waste seeps into the ground and can pollute the soil and underground water as well as running of and contaminating the surface water. Adding to the risk is the fact that each

household has individual disposal sites that could lead to leaking of leachate into the environment all around the village as houses are built on dug up and flatten land on hillsides. Therefore runoffs and infiltration during the rainy season would carry the toxic materials with it contaminating rivers and creeks located at the bottom of the hills and mountains from the surface runoff and the underground water. The contamination of the rivers and creeks would threaten public health as the quality of the water degrades and the villagers could lose a vital resource needed for their survival.

The location and proximity of a solid waste disposal site for the people and environment around it must be selected with great consideration of its impacts, both negative and positive on the health of the people and the environment. In indigenous societies where solid waste was predominantly biodegradable in the past, the chemical contamination was not a concern as the biodegradables degrade easily into the environment with low to no release of toxic chemicals compared to non-biodegradables. However, in this modern era even though the rural indigenous societies in PNG still have a large proportion of solid waste generated being biodegradables, there is also some production of non-biodegradables. Therefore the sites identified for disposal need careful considerations to some degree. Apart from selecting locations and distances of the disposal sites, the costing of the sites selected has to also be considered. The location, distance and payment of the disposal sites are discussed here.

Households have individual solid waste disposal sites located within the village. These disposal sites are located at different distances from the respondents' houses ranging from five to twenty five metres. The majority of households (13) have disposal sites at a distance approximately between five to ten metres away from their houses while the rest of the households (6) have

disposal sites at approximate distance of eleven to twenty five metres from the house. All households held a common view that the disposal sites are in suitable locations and therefore do not have any negative impact on the health of their household members and the village community. The responses below show the common view of the households:

'Our disposal site is away from the other houses and we keep it well so it would not make us or other villages sick and so does not affect people's health'.

The households in Wamonagu village are cautious about the quality of their water especially the rivers and creeks that they have in the village. The households have their disposal sites away from the water sources. The majority of households have their disposal sites far away from the water sources but were not sure about the actual distance while a minority of the households gave an approximate distance of three hundred to four hundred metres. Again the views of the households were that their disposal sites are at a suitable location far away from the water sources and so their source of water is not polluted by the solid waste. The following quotes from respondents represent the general views of the households in relation to the disposal sites and the water sources:

'My family do not dispose the rubbish close to the river or in the river that is use for washing, cooking and drinking and that out leaders in the past and present forbids the disposal of solid waste in the river and they organise the village community to clean the river and roads to keep the village clean'.

'Water is our life so we have to keep it safe for us to use therefore we dispose solid waste away from the water so it is not polluted'.

The villages also have a general understanding of the decaying solid waste and the attraction and breeding of pests and insects and their relationship to illnesses. The response below illustrates the Wamonagu villagers' perception about the transmission of disease through smell. The

concept of transmission of diseases through smell indicated the people's general understanding of diseases that are related to breeding of insects and approaches that are applied to prevent the contraction of the diseases.

'The houses in the village are not close to each other and when we dispose only a small amount of rubbish in the pit it prevents the bad smell and so the people do not get sick from it as insects do not breed and carry diseases around'.

This further indicates the indigenous community's concept and knowledge of health and hygiene and how ones action threatens the health of the community with appropriate strategies in place to prevent the transmission of the diseases in the community.

The cost of paying for the land for a disposal site is important. However in indigenous village communities in PNG the land is communally owned in clan and tribal groups. The individual members of the clans and tribes have rights to use the land. The households in Wamonagu do not pay fees for the land on which they dispose their solid waste as their tribe or clan owns the land and individual households have the authority to create a disposal site for their solid waste. This is evident in the responses below:

'We do not pay any fee for the disposal site as it is our land and no one will ask why we are disposing the rubbish there'.

'It is our land and the dumpsite is in our area so we do not pay'.

For the respondents, communal land ownership and having land use rights are important for households as they are able to dispose of their solid waste at disposal sites within the boundary of their tribal land without confrontation from other people for payment.

4.6.5. Reduction/resource recovery methods

Resource recovery activities are part of the separation, storage, and collection processes of the ISWM. The solid waste that is separated into four categories at the source of production by households has three categories that involve resource recovery activities. The following three categories of SW apart from disposal category are used to reduce the SW: (a) compostable, (b) reusable and (c) burnable. From these three categories of resource recovery, solid waste reduction activities are carried out by the households through (i) composting, (ii) reusing, (iii) and burning. All households responded that these resource recovery or reduction activities were traditionally used and are still being used by them. It is through these resource recovery methods that households reduce solid waste that ends up in the disposal site and recovers crucial resources, maintains the health of the environment and that of the households and village community. In addition to these activities a few households cooked their vegetables without peeling hence reducing the production of solid waste as is shown in Table 4.5.

Table 4.5: Traditional Waste Reduction Methods

Indigenous resource recovery/solid waste reduction activities	No. of Households
1. Burning	19
2. Composting or mulching	19
3. Reusing	19
4. Cooking vegetables without peeling	2

Source: Field work at Wamonagu village, 2011

The three main resource recovery/solid waste reduction methods are burning, composting and reusing. It is evident that households in Wamonagu village did not traditionally have recycling

activities for non-biodegradables, therefore the knowledge and practices of this resource recovery activity is missing in their domestic solid waste management system.

The households use a combination of all three main resource recovery/solid waste reduction activities to manage their domestic solid waste with only two households using a combination of the three main resource recovery activities as well as cooking vegetables without peeling.

The boiling of unpeeled vegetables is significant as the practice of not removing the skin reduces the peeling and vegetable waste which is the main component of biodegradable solid waste generated by the households daily.

This method of cooking that reduces the production of solid waste is used less often as all households in the village now buy and use the manufactured cooking pots. The introduction of manufactured utensils means this type of traditional cooking is used only occasionally however important it may seem. Moreover cooking unpeeled vegetables in a tree stump means that stump can easily and naturally degrade into the environment without harming it. The households' use of manufactured steel pots would mean that fewer trees are cut for this method of cooking, thus conserving the trees. However as households do not take part in any recycling activities it would mean that useful metal resources are disposed into pits and important resources are not recovered.

4.6.5.1 Composting or Mulching Solid Waste

The composting or mulching of biodegradable solid waste is one of the three main resource recovery methods by households in Wamonagu village. Composting and mulching is biological recycling whereby biodegradable solid waste decomposes into the soil hence improving the soil

structure, composition and fertility (Sharma et al., 2010; Kessler et al., 2011). Composting is one of the main resource recovery methods apart from recycling that councils in towns and cities of developed countries used to manage the solid waste. The composting of solid waste brings many benefits for the people involved in the activities. In the world today, especially the developed world, the biodegradable solid waste is composted or mulched and sold to consumers. In USA, there is a high demand for compost and engineered soil for growing (Kessler et al., 2011). This makes composting and mulching an important resource recovery activity. Even though composting has benefits for the soil and economic values the production of methane gas through its activity raises concern (Sharma et al., 2010).

(i) Types of biodegradable solid waste composted or mulched

All the Wamonagu village households compost or mulch their biodegradable solid waste. The most common biodegradable solid waste that is composted or mulched by all households is vegetable peelings and wastes.

(ii) Type of site where the biodegradables are composted

The composting and mulching in rural subsistence villages such as Wamonagu in PNG is a simple activity. The sites are identified by the households for composting on their own land. These biodegradable solid wastes are composted or mulched in three types of sites: (a) in vegetables and flower gardens (b) under tree crops and (c) in a dug up pits.

The biodegradable SW is composted in a dug up pit that is later covered with soil and crops plant over the pit. Crops such as bananas, yams and sugarcanes are grown in this covered up compost as stated by a male participant. Composting in a pit is a method used to improve soil fertility and structure in a sandy soil to help retain water to grow banana trees. This started in Kiribati and

was called the banana circle composting method which SPREP encourages other Pacific island nations to use to manage the organic waste (SPREP, 2005). This compost pit used by villagers has the same concept as the banana circle used in Kiribati.

Table 4.6: Three main biodegradable composting and mulching sites

Composting and mulching	Households
1. In a dug up pit	3
2. Under tree crops	11
3. In vegetable and flower gardens	14

Source: Fieldwork 2011

It is clear from table 4.6 that the single most common site for composting and mulching of biodegradables are in the garden. Only a few households composted biodegradables in a dug up pits. The composting under tree crops in this case is mainly under the banana and coffee trees. The biodegradable solid waste that is mulched in the three sites consists mainly of peelings of vegetables. All households that composted or mulched in the gardens and under tree crops simply threw the biodegradables into the gardens, under tree crops and on bare ground in their gardens. This practice is called mulching as ‘mulch is a layer of biodegradable solid waste such

as decaying leaves, small pieces of wood, or manure added to the soil round plants in order to protect them and help them to grow' (Collins dictionary, 2013). Composting on the other hand is done when a mixture of biodegradable or organic solid waste are kept in one location that degrades and later the mixture of rotting biodegradables is used as a fertilizer. This product is called compost (Audio English dictionary, 2013).

The use of one compost site makes it easier for the members of the household to mulch or compost especially when children are involved in the practice. The biodegradable solid waste composted and mulched mainly in the gardens and under tree crops adds nutrients to the soil and improves the soil structure and fertility that maintains the soil health hence improving the crops growth and yield (Brown and Tworkoski, 2004). The households do not have access to the manufactured fertilizers as they do not have shops in the village that sell them and it is expensive for subsistence farmers. This practice is beneficial for households as it reduces their cost of buying fertilizers as well as improving the quality and health of the soil through biological recycling. The practice of composting and mulching also reduces the pests in crops due to presence of increase predators in the mulch according to some recent studies (Brown and Tworkoski, 2004).

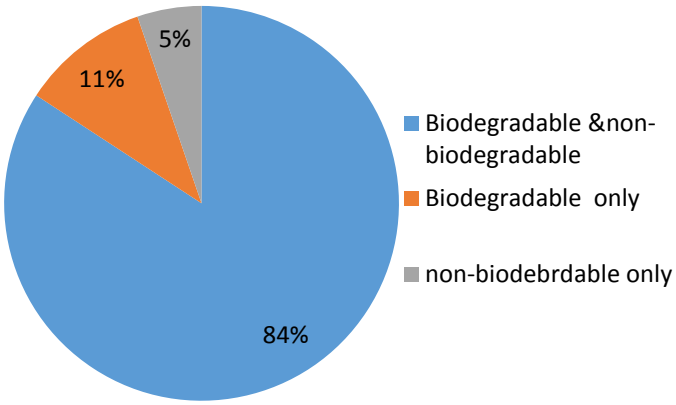
4.6.5.2 Reusing domestic solid waste as a means of resource recovery

The reusing of domestic solid waste also contributes to the recovery of important resources that could otherwise be lost through the disposal process. When resources are recovered through the reuse of items, it reduces the demand on extractions of more natural resource used by humans. The solid waste is reused by people globally in different departments, organizations and companies as the need arises. The building, architecture and furniture designers are now reusing

old materials to find the cheapest way of building accommodation (Best 2004). The reuse of domestic solid waste to recover useful resources is also important with the Wamonagu households. This resource recovery activity by households is discussed here.

All households reuse some of the domestic solid waste that they generate and so recover the resources through this practice. The materials that are reused by the households at Wamonagu are both of biodegradable and non-biodegradable solid waste (Figure 4.3). The domestic solid waste is either reused by the household that generates it or is given away to another household to be reused. This reuse of domestic solid waste by two types of households mentioned is discussed further here.

Figure 4.3: Households Reusing Biodegradable and Non-Biodegradable SW



Source: Fieldwork, 2011

The way the resources are reused by the households is important as reusing and sharing in the indigenous communities have enabled them to manage their resources sustainably through the principle of limited harvest to conserve resources for the future generations (Gadgil et al., 1993). This concept of limited harvest and conservation of resources though applied to biodegradable

material in the past is now applied to both biodegradable and non-biodegradable as the type of products consumed change from agricultural produce to manufactured goods.

There are different purposes for reusing different categories of biodegradable and non-biodegradable solid waste. The biodegradable solid wastes that is categorised as vegetable products consists of vegetable peelings and left over of cooked vegetables are fed to domestic pets and live stocks. Domestic pets include dogs and livestock is mainly goats but also pigs. The leftovers of cooked vegetables are fed to both domestic pets and the live stocks while the peelings are fed to livestock. The other biodegradable solid waste that is classified as plant products is made up of used bamboos, leaves that are used to cover the mumu and old string bags made from organic fibres. The bamboos are reused to cook food after being used to carry and store water or reused to make knives and to make fire to retrieve energy. The retrieval of energy is discussed further in the section where burning of solid waste is discussed. The leaves from the mumu are reused mainly to feed livestock while the old string bags are reused to store and carry the solid waste such as peelings and other vegetable waste to be mulched or composted. The final type of biodegradable solid waste is the waste from animal products. These types of biodegradables consist of animal bones, furs, feathers and fat. The large and long animal bones are used to make knives and the small bones are used to make traditional attire with furs and feathers for traditional dances. The animal fat is used for cooking and sometimes used as body oil during traditional dances.

The non-biodegradable solid wastes that are reused are from plastic products. These plastic products consist of shopping bags; stock feed bags, empty rice bags and plastic bottles. The plastic shopping bags are used by the households to carry and store crop seedlings while stock

feed bags and empty rice bags are used by the households to carry the peelings from the house to gardens or under tree crops to be composted or mulched. Plastics bottles are reused to fetch and store water or to store crop seedling.

Reuse of both biodegradable and non-biodegradable solid waste by households may have a short term reduction and resource recovery benefits, however when it is broken or worn out it is disposed into the pit, burnt or mulched and composted depending on whether it is biodegradable or non-biodegradable in nature. The biodegradable solid waste from mainly plants can easily be composted or burnt as the households have those resource recovery processes in place in their waste management system. These processes improve soil formation and fertility from ashes and composts and therefore do not pose any direct threat to the environment and the people, even though burning releases carbon into the atmosphere. The reuse of plastic non-biodegradables by households cannot be used as compost or mulch or recycled in the case of plastic bottles. Therefore when plastic products are broken or torn, they can only be disposed of or burnt.

Giving away of items that are not needed by one household to another is a common practice in the world. Through these actions resources are recovered by other households who are not the producer of the solid waste. This process of giving and receiving solid waste as a resource is a practice that allows households to access some crucial resources that they need.

The households that give away or receive solid waste in Wamonagu for this research are a minority, however a very important one. Giving away of peelings and leftovers reinforce the shared responsibility that households have in raising livestock whose meat is later shared within the community when it is ready for consumption. The giveaway of materials by one household to another to be reused or to be feed to their domesticated animals highlights the indigenous

principle of mutual support and reciprocity (Anderson, 2015) that is embedded in the indigenous societies. The principle of mutual support and reciprocity embedded in the indigenous societies in PNG enables the members of the community to respect and care for the properties of others. This leads to establishment of safe and stable community for members of the community to live in and recovery of resources that would otherwise be lost in the disposal sites.

Furthermore, this practice of giving away what one person does not need but another person does, emphasises the concept of someone's trash being another person's treasure in solid waste management. The solid waste that is either given or received is not restricted to households within Wamonagu village. There were a few households that received mainly non-biodegradable plastic products such as empty stock feed bags. These non-biodegradables were given to households by relatives in Goroka town to store the coffee beans. This gesture of giving and receiving, results in sharing of resources. Moreover the recovery of resources through sharing is important for rural subsistence communities as it reduces the need for the household to clear more land and grow crops to feed their animals. Therefore it reduces the total amount of land cleared for agriculture and gives enough time for the land to fallow and regain nutrients to retain soil fertility (Gilley et al., 2001).The sharing by giving away or receiving by households helps to build and encourage the reciprocation relationship of sharing between households to maintain close social relationship where people care and respect others' property that is crucial for a stable indigenous community. The sharing is common with people in the rural indigenous communities where households share almost all resources they have, hence reducing the need for other households to extract more resources. This in turn reduces the over exploitation of natural resources and encourages conservation. The practice of sharing though important for sustainable resource management and solid waste management only a few households interviewed practices

it. With few households continuing this practice of sharing vegetable wastes by giving away to other households to feed their animals, it may impact on the traditional practice of animal rearing for protein hence increasing the consumption of processed tinned protein. This will lead to an increased production of non-biodegradable SW in future. Therefore there is need to encourage this crucial indigenous practice.

4.6.5.3 Burning of solid waste

The burning or incineration of solid waste to remove or retrieve energy is a common resource recovery method. Even though there are advantages of burning which include removal of solid waste from households and recovering energy needed for the households to use, it also presents environmental and public health threats. The Wamonagu households' responses are discussed here regarding the practice of burning solid waste.

All the households' burn biodegradable SW with some households also burning non-biodegradable SW. Burning of solid waste by Wamonagu households reduces the volume of waste produced. All households burn some of the solid waste they generate. The composition of the SW burnt depends on the quantity of each type of SW generated by the households. The biodegradable solid waste burnt is generated both from inside the house and outside from the yard and the gardens. Almost all the households burn solid waste from plant materials. Only a few households burnt the other two types of biodegradable solid waste that derive from animal materials and other unspecified organic waste. The majority of the households' burn biodegradable solid waste from the gardens and yards such as leaves, grass, branches and roots as they are all subsistence farmers whose activities are centred on growing crops for their own

consumption. The subsistence farmers clear land and burn organic solid waste before the land is dug up to plant crops.

The burning of biodegradable (organic) solid waste was practiced by the ancestors of the Wamonagu people in the past and this IK has been transferred from generation to generation. This transfer of knowledge will be discussed later in the chapter. However with the introduction of the cash economy and the change in the type of goods consumed, the households now have plastic solid waste. These plastics can burn easily therefore the households burn them to remove the plastics when they are not reusing them. The households that burnt non-biodegradable solid waste mainly burnt plastic packages.

The Wamonagu households burnt the domestic solid waste for various reasons. The majority of households gave reasons for burning different solid waste with the minority of them not giving any reasons. The purposes for the burning of solid waste were mainly (a) to retrieve energy for cooking food and warmth; (b) to remove solid waste; (c) to be used for gardening and; (d) to be used as torches in the night. The households that gave reasons for burning the solid waste had half of the households giving only one reason, while the other half gave a combination of two to three reasons for burning solid waste.

4.7. Benefits, Challenges and transfer of knowledge of Indigenous solid waste management practices (ISWMP)

There are many benefits of Indigenous Solid Waste management (ISWMP). All the households in Wamonagu village responded positively to the benefits of ISWMP.

4.7.1. Benefits of indigenous solid waste disposal practices (ISWDP)

The values of indigenous disposal practices were reinforced by the village leaders to keep the community clean and safe. There is an understanding amongst the households that ISWDP is beneficial for the health of the environment where they directly source the resources for their survival. The resource that the households observed to be crucial for their survival is water. Therefore the households' understanding and awareness of having a clean water source is demonstrated in the practice where the disposal sites such as the pits and other disposal sites are located away from rivers. This is clearly indicated through the quote from a respondent: *'Water is our life and so we have to protect that from being polluted by disposing rubbish away from the river'.*

4.7.2. Benefits of Indigenous Resource Recovery Practices (IRRP)

The Indigenous Resource Recovery Practices (IRRP) or Solid Waste Reduction Practices (SWRP) that are used to manage the solid waste at Wamonagu also has benefits that were identified by almost all the households interviewed. One of the main benefits was having a safe living environment for households and the village community which were the same as the benefits of Indigenous Solid Waste Disposal Practices (ISWDP). However there are four specific benefits identified in this research with the use of IRRP: (i) agricultural (ii) financial (iii) safe and healthy homes (iv) and clean village environment.

The two common benefits of using the IRRP that all households gave were (i) benefits for agricultural activities that supply food for the people and (ii) sustained safe and healthy living for households in the village community.

4.7.2.1 Agricultural and financial benefits for the household

The IRRP of composting and mulching of biodegradable solid waste directly in the flower and vegetables gardens, under tree crops and pit as well as ashes from burnt biodegradable solid waste improve soil fertility, structure and reduce the occurrence of pests so growth of vegetables and tree crops in the gardens are enhanced with good yields of crops to maintain households' food supply. When compost and mulch are applied under coffee trees the yield is good so the houses harvest and sell the coffee beans for cash therefore the households benefit financially.

The reusing of stockfeed that is given to the households by their relatives in Goroka town reduces their cost of buying new bags to carry and store their agricultural produce.

4.7.2.2 Safe, healthy living environment and natural environment

The health of the natural environment is important for the health and wellbeing of the households, however only a minority of them actually mentioned the benefits to environmental health when they were first asked. When the households were asked specifically about the benefits of IRRP for the natural environment, all responded that the IRRP reduce and prevent solid waste from entering the river, land, air and forest hence preventing pollution.

Composting is beneficial for the land as the practice enriches the soil fertility and structure. The composting under coffee trees allows for organic farming preventing the use of chemical fertilizers that would negatively impact the soil and the environment that the indigenous community in Wamonagu depends on.

The reusing of biodegradable solid waste like peelings and food leftovers by the households to feed their pets and livestock and storage of solid waste or coffee in old bags reduces the need to grow more crops for food to feed the animals and extract new resources to make bags for storage purposes. This practice is important and encourages the conservation of the resources as well as recovering resources.

4.7.3. Challenges of Indigenous Solid Waste Disposal Practices (ISWDP)

The ISWDP like any system has not only benefits but also the challenges. The major challenge that the household has is their lack of understanding of the chemical makeup of the non-biodegradable solid waste, especially the empty tin cans and plastic products that are disposed of. This lack of understanding leads to the households not taking precautions to design the disposal sites well in a suitable location for disposal of non-biodegradables even though it is produced in small quantity.

The disposal of empty tin cans and plastics in open pits, under bamboo trees or tall grasses and rivers during flooding by individual households with no plastic linings to collect leachate leads to leaking of the toxic chemicals into the soil and the underground water contaminating them. The contamination of the soil means that the crops grown on or near the contaminated soil will absorb the contaminants hence ending up in food sources of the households negatively impacting their health. The toxic chemicals from the leachates that make their way in the underground water will end up in the rivers thus contaminating waterways and creeks impacting on the water quality and health of the people. This contamination of the land and the water is highly possible as the households have individual disposal sites all around the village.

4.7.4. Challenges related to Resource Recovery Practices (IRRP)

The IRRP have many benefits but also challenges that are a threat to the people and the environment. The IRRP are composting, burning and reusing with no practice of recycling non-biodegradables. With no recycling of non-biodegradables, this type of solid waste which comprises of mainly plastics and empty tin cans are disposed, burnt or reused. The non-biodegradable solid wastes that are reused are plastic bottles and bags for a short time until they are broken or torn before being burnt or disposed. Therefore the reuse of plastics and bottles recovers the resources for a short time. The practice of burning both biodegradables and non-biodegradables though remove the solid waste, poses threats to the environment and the health of the people.

Burning of organic solid waste from the yards and gardens instead of composting or mulching them, leads to the release of carbon dioxide into the atmosphere. The burning, even though done on a small scale by households, can contribute to the significant emission of carbon dioxide into the atmosphere when population increases contributing to the enhancement of carbon in the atmosphere that contributes to the issue of global warming **(**Fearnside, 2000).

The non-biodegradable solid waste mainly from plastic products that are burnt releases the toxic pollutants into the air and soil that are harmful for the health of the household members and the other villagers. However, with the lack of knowledge of the chemical composition of the non-biodegradables, the households are not aware of the chemical contamination brought about through the burning of plastics on their land, water and the other resources that their livelihoods depend upon. The lack of knowledge of these characteristics of the products of manufactured goods is due to non-biodegradables being a new type of solid waste that was recently introduced

to their society in the 1930s by the Europeans. They lack the education to understand these facts as there were no non-biodegradables in the past. Therefore there is no transfer of knowledge regarding this type of solid waste down from one generation to another. This is a major challenge for management of non-biodegradable solid waste by the households.

4.8. Transferring indigenous solid waste management knowledge from one generation to another at Wamonagu

The transfer of the skills and knowledge is important for the survival of the human race. All societies whether primitive or modern transfer skills and knowledge to the young generation and innovate, develop and adopt new ones as they encounter challenges and changes. The common mode of knowledge and skills transfer may differ from one society to another. In modern urban societies the mode of knowledge and skill transfer is predominantly through formal education while in the indigenous societies the mode of knowledge and skills transfer through informal education.

Wamonagu is a rural village in PNG with the population being indigenous and their livelihood is focused around subsistence agriculture. For generations, the Wamonagu villagers have transferred the skills and knowledge needed for their survival from parents to children through oral history, observation and practical hands on activities. The formal education system where classes are held in schools is a recent concept for the villagers after the first European contact into Eastern Highland Province (EHP) in the 1930s (Finney, 1990). Therefore the transfer of skills and knowledge on ISWMP are discussed here with the reference to formal and informal education.

The formal education though new for the villagers is also important and was emphasised by the colonial government as well as the parents for their children. This form of education presents an opportunity for the young generation to be employed in the formal economy in Papua New Guinea. However not all the people who had formal education are employed in the urban centres in PNG. The majority of people have some formal education but end up in the village as subsistence farmers.

In order for the knowledge and skills of any kind to be transferred within a society there must be a process in place to do that. At Wamonagu all the respondents remarked that the ISWMP are transferred by the adults, mainly parents, relatives and other members of the village, to both male and female children. However the responsibility of transferring this knowledge and skills lies with the parents. Relatives and other villagers' role in the transfer of knowledge and skills of ISWMP is emphasizing the it.. Furthermore there is a cultural emphasis for these skills and knowledge to be transferred to the girls when they have their first menstrual period and are kept in a separate hut for the village women especially her relatives to teach her norms of the society about being a woman and her role in society. This is a significant practice in the culture as it marks an important change in the life of the child and prepares her to take up responsibilities at home by helping her parents and so learn the life skills needed to survive in a difficult environment that lacks the luxury of modern society such as water supply, gas, and electricity. The verbal emphasis and transfer of skills and knowledge is an important part of rural indigenous communities.

The transfer of knowledge and skills on ISWMP informally from parents to children is important as the whole process for domestic solid waste management occurs at the household level. The

children are taught the skills and knowledge of ISWMP at a very early age. All households commented that they understand that ISWMP is important for their society. Therefore they teach their children at home where the children actually practice the ISWMP by assisting them in the households' activities that involves solid waste management. However in a rural indigenous community the job of raising children also involves the community as the households have close relationships with the extended family. This is important as the development of a child who knows the values and norms of the community allows the community to function in a peaceful and respectful environment. In this case at Wamonagu even though the parents are responsible for teaching the ISWMP knowledge and skills, the community at large is responsible as well. When the community becomes involved in the raising of children, they grow up with the feeling of belonging to the community so it nurtures the feeling of love and respect for the members of the community and their property as well as public property. The people involved in the transfer of knowledge and skills of ISWMP apply their different techniques to educate the children as discussed below.

4.8.1. Method of transferring knowledge and skills on ISWM at Wamonagu

There are three main modes of communication used to transfer knowledge and skills from one generation to another at Wamonagu and they are: (i) verbal teaching of the children and young people; (ii) through demonstration and observation - namely, the people responsible for knowledge transfer demonstrate or perform the activity while the children and young people observe and imitate the process performed or demonstrated; and (iii) through practical participation whereby the children and young people help their parents and relatives to perform

chores and learn through them. Table 5.1 below shows the distribution of modes of communication used in transfer of knowledge at household level.

Table 4.7.: Methods Used To Transfer Knowledge on ISWMP

Combination of methods use	Number of households
1 method used	3
2 methods used	6
All 3 methods used	10
Total	19

Source: Fieldwork, 2011

The majority of households use all three methods of communication to transfer the knowledge to the next generation with over half of them using two methods of communication to transfer knowledge and skills on ISWMP.

4.9. Existence of other ISWM practices used in the past

The ISWMP at Wamonagu have been used over thousands of years and have developed and evolved over time. However it has changed over time and some practices tend to die out when not practiced constantly. Here is a quote that illustrates the participants' responses

'In the past our ancestors used the bamboos and gourds to fetch water but we no longer use these items often to store water as we now use plastic bottles'.

The majority of the households responded positively to knowing some other ISWMP used in Wamonagu in the past by their ancestors that are not practiced at present. However a few

respondents were either not sure or did not know. The uncertainty in their answers show that the practices are changing as society goes through the transitions of consuming totally goods that produce biodegradable SW to the consumption of goods that produces both biodegradable and non-biodegradable SW.

All the households' responded that the ISWMP that exists in Wamomagu also exist in the neighbouring villages that have population of indigenous people living in tribal communities. Therefore the research findings are applicable to the neighbouring village communities.

4.10. Management of solid waste in the public space or common area at Wamonagu

The public space in Wamonagu is limited to only a few common locations where the villagers conduct meetings, festivals, ceremonies and other significant community activities. These public spaces in the past were (i) common designated areas in the village for the whole community to use for gatherings and (ii) ceremonial locations in the village or outside the village that were open to both genders or restricted to one gender. A good example of this is a *"hausman"* (men's house) where important issues about the tribe or clan were discussed. The current public space at Wamonagu had changed with western influence and the public spaces now include primary schools, church areas and clinics. The management of solid waste in this public space is the responsibility of all the members of the community. The responses of the households regarding the management of solid waste in the public space are discussed here.

All the households commented that the solid waste generated in public areas is produced by the community; therefore it is the responsibility of all individual members to manage the solid waste. This involves collection and disposal or resource recovery or waste reduction activities of

composting, burning and reusing. This feeling of social responsibility is reflected in the following statements made by respondents:

'All the people in the village are responsible for cleaning the public areas, collection and disposal of the solid waste. Sometimes the person in charge of our clinic asks us to clean the clinic so the villagers go to clean. In the church our elders make announcements for the church members to do the cleaning around the church so we organise ourselves and clean the church building. For the school we the parents clean the school when the teachers ask us to clean the school yards'.

'When we have a gathering our leaders tell the villagers to go and clean the area where the gathering is going to be held so we all go and clean the area and collect the rubbish and dispose it and later after the gathering. We do not let only one person to do the job'.

The two responses show that the community cleans, collects and disposes of solid waste in public areas when the village and church leaders, education officers and health workers request the assistance of the village community to clean the meeting places, schools, churches and clinics. The responsibility is shared and not left to one person. The solid waste that is generated in the public areas and properties is disposed of at sites located in the area. These are common disposal sites used by the villagers' community during this cleaning period as well as during the use of the facilities such as schools, churches and clinics. In addition, all the respondents expressed that they are involved in the cleaning of public areas as they are members of the community and had to participate to keep the village and the service facilities clean for the good health of the village community.

The members of the community take ownership of keeping the public areas clean for the health and wellbeing of the community. The households provide their own tools to participate in these community activities as a volunteer understanding that their involvement would benefit the

whole community including themselves. However the collection and disposal of solid waste in public areas by the village community is not done on a daily basis.

4.1.1. Conclusion

The information on ISWMP was gathered from interview questions asked to selected adults, usually the mother or father, in the Wamonagu households. The household heads originate from four clans and who are mainly subsistence farmers growing vegetables for their own consumption and only selling them when there is surplus. This population demographic of Wamonagu shows a typical age structure of a society with young population (PNG National Statistical Office, 2006)

The ISWMP that is used by Wamonagu households begins with separation of the domestic solid waste at the source of generation into different categories. In the past before European contact, the domestic solid waste generated was only biodegradable SW, therefore any biodegradable solid waste disposed of decomposed easily and maintained soil structure and fertility. The biodegradables were segregated and classified into, compostable, burnable, and reusable solid waste. The biodegradable solid waste from these categories were managed using the IRRP of composting, burning, and reusing which recovered vital resources and reduced the quantity of solid waste produce. The management of predominantly biodegradable domestic solid waste in the past was not a challenge. However with introduction of non-biodegradable solid waste, using the ISWMP presents a challenge for domestic solid waste.

To conclude, the knowledge and skills of ISWMP of the people of Wamonagu are passed on from generation to generation emphasising the principle of integrated solid waste management

(ISWM). This practice was effective in the past as the solid waste was predominately biodegradable. However, the current solid waste disposal would be a challenge with consumption of more manufactured goods and generation of more non-biodegradables. The absence of recycling activities of non-biodegradable in Wamonagu means that unless this issue is addressed it will have harmful impact on the health of the people and the environment as the population increases over time.

The ISWMP like many other cultural practices in the indigenous PNG community have gone through changes since the introduction of the western cash economy where there is consumption of manufactured good as well as the traditional products. The introduction and consumption of manufactured goods resulted in an introduction of a new by product which did not exist previously in the indigenous society. However as the indigenous communities in PNG have the adaptive characteristics to change (Anderson, 2015) the people especially in Wamonagu are able to adapt to and manage the new type of solid waste, the non-biodegradable solid waste by using the ISWMP in their society.

CHAPTER 5:

SOCIO-ECONOMIC CHARACTERISTICS OF THE PARTICIPANTS IN GOROKA

WASTE COMPOSITION AND EQUIPMENT USED BY THE PARTICIPANTS INTERVIEWED

5.1 Introduction

There are major problems with the management of solid waste in Papua New Guinea's (PNG) urban settlements. The term urban settlement refers to the towns and cities where the

population's livelihood is predominantly centred on the modern cash economy. Goroka Town, where this study was undertaken, has significant issues concerning the management of SW in the areas of households, public space and institutions or organisations. The factors contributing to the improper management of solid waste (SW) range from lack of council resources to a lack of community participation and ownership. This chapter will cover the following discussion points focusing on the participants in this research in order to gain a better understanding of the issues related to solid waste management in Goroka:

a. Population, housing and age distribution of Goroka Town

b. Education level and employment of participants

c. SW Composition generated by households

d. Quantity of SW generated by each household

e. SW management at household level by members

5.2. The population of Goroka Town

The population of Goroka Town consists of people who migrated from different regions of Papua New Guinea as well as local people from other parts of the Eastern Highlands Province (EHP), in which Goroka Town is located. A significant number of the population working and living in Goroka town are from overseas countries. Some of these residents are from Solomon Islands, India, USA, Australia, Japan and Germany. Goroka district is divided into Goroka Urban LLG (Local Level Government) and Goroka Rural LLG. According to the National Census of 2000 the total population of Goroka district was71, 870 and Goroka Town has a population of

19,523 (EHP Government, 2003). The last census in 2011 indicated that Goroka District Population has increased to 103,396 people with Goroka Urban LLGs population at 23 277 people (NSO 2013)

5.2.1 Age Distribution of household participant in Goroka Town

The age distribution for household respondents and focus group participants in Goroka Town were categorised into five age ranges starting with the 18-30 year old age group to the 61-70 age group as shown in Table 5.0.

Table 5.1: Age distribution of participants in Goroka Town

Age range	No. of household respondents in each age group	No. of focus group members in each age group
18-30	9	14
31-40	23	4
41-50	26	2
51-60	16	1
61-70	3	1
Unknown	3	0
total	80	22

Source: Field work, 2011

The majority of the respondents were aged between 18 and 50 with a few respondents who did not know their ages. There is a relationship between the responses of the individuals with unknown age and education status. It was established that the respondents who did not know their age had minimal or no formal education. The difference in the level of education means that policies on the education and awareness to promote appropriate effective solid waste management must be tailored to meet the needs of the different target audience and this crucial issue is discussed in Chapter 6

5.2.2 Where do the interviews respondents originate from, and do they use ISWMP from their society to manage solid waste in Goroka too?

The majority of the household respondents and focus group members in Goroka Town are Papua New Guineans with only two hailing from the Solomon Islands. The respondents come from 20 out of the 22 provinces of PNG with most having parents from only one province while a few who are of mixed parentage have parents from two different provinces. There was no majority from any of the 20 provinces, but the Eastern Highlands Province (EHP) had the highest respondents as the fieldwork was done there.

Having a representation of people from different cultural groups would give some understanding of similarity and difference in the type of ISWM techniques, practices, values and knowledge that exists traditionally in the society from which they come. This will then be used to establish whether or not the households use ISWM to address the challenges that they encounter in managing their Domestic Solid Waste (DSW). This diversity of people from different ethnic and cultural groups can contribute to the understanding of people's attitude, behaviour and responsibility regarding solid waste management in Goroka. This behaviour and attitude is discussed later in Chapter 7 under the education and awareness section and the use of ISWMP is discussed in chapter 6.

5.2.3 Duration of residence in Goroka and existence of current solid waste management

Establishing the duration of residency for the residents in a given location is important as information regarding the changes, development and effectiveness of the services provided in the past and at present in an area can be gathered through this. The population of the study had different duration of residency in Goroka Town. The information on the duration of their

residency was classified into eight groups beginning with residency of less than 6months to over 25 years of residency (see Table 5.2).

Table 5.2: Duration of household residency in Goroka Town

Duration of residence in Goroka	No. of participants household participants	Percentage	Focus group members
less than 6 months	4	5	1
6 to 12 months	1	1	2
1 to 5 years	12	15	10
6 to 10 years	8	10	3
11 to 15years	14	18	2
16 to 20	9	11	2
21 to 25	8	10	-
0ver 25	24	30	2
Total	80	100	

55 participants

Source: Field work 2011

The table 5.2 above shows that the majority of respondents (55) have duration of residency at least 11 years and over.

All the household respondents commented that the council collected a mixture of both biodegradables and non-biodegradables and transported that for disposal. In addition, when the respondents were asked about how long it had taken for the council to use the current collection and disposal system, there were three responses. The responses were:

a. A long time

b. Since the establishment of Goroka Town

c. Not sure.

The majority of the household respondents stated that this system of collection and disposal had been in existence for a long time since the establishment of Goroka Town. When comparing the responses of the respondents regarding the existence of the current collection and disposal

practices during their residency, there was no difference in the responses. The responses of both recent-arrival and long-term residents in Goroka were the same. That is, the current mixed collection and disposal of all solid waste have existed since the establishment of Goroka Town. However, the majority of the long term residents (10 over 25 years' residence), commented that, in the past, the collection and disposal of DSW was carried out regularly twice a week. Nonetheless, this regular collection and disposal according to these long term residents were effective and Goroka residents did not store their DSW at home for a long time. This view was supported by the responses of the council staff who stated that the collection and disposal practices of mixed solid waste had existed since the town's establishment. The DSW was supposed to be collected twice a week on Tuesdays and Thursdays. However, the council does not collect it regularly as scheduled due to lack of resources (trucks and finance).

This irregular collection was evident in the observations made by the researcher during collection where, for two weeks, the collection team did not collect solid waste from the residential areas. This was because they had one truck which was collecting the bulk of solid waste generated in public areas daily, and they could not collect DSW. On the other hand, the majority of the focus group members had been living in Goroka for five years or less. Through the focus group discussion it was also established that the council did not collect the solid waste from the households in the squatters' settlement, so those households managed their own solid waste. Consequently, the current collection and disposal of mixed solid waste has existed since the establishment of Goroka Town. The DSW retrieval is scheduled for collection twice a week on Tuesdays and Thursdays. This collection schedule was followed closely by the council staff in the past but not at present making collection and disposal of domestic waste ineffective and

problematic for residents living in formal housing. The residents living in informal housing are not provided with any collection and disposal services.

5.2.4. The type of housing occupied by residents of Goroka Town

The housing in Goroka can be classified into two categories: (i) formal and (ii) informal housing. Formal housing is located on allotments and sections and is given corresponding numbers to identify them. This form of housing is planned and has official records for the council to use for billings purposes. The bills are for services such as water, sanitation and garbage and are provided by the Goroka Town council. However, the plan and map of formal housing in Goroka is out-dated and not readily available which makes it difficult for the council to plan and deliver services effectively. The population interviewed for this research in Goroka occupied formal housing as the council services are only delivered to those in formal housing. Generally, the households who are living in these areas had the following employment status:

a. Both husband and wife, or at least one, are employed in an institution in the formal economy

b. One other member of the family is employed in the formal economy

c. Both husband and wife, or at least one, were once employed in the formal economy but are now involved in the informal economy

The formal economy in PNG is where registered organisations or businesses pay direct tax to the government for their operations with employees having regular fortnightly income. The informal economy is a market economy where individuals produce and sell their products without paying tax directly and do not have a regular fortnightly income.

Informal housing refers to the houses built on unused government land on steep slopes of gullies and on waterlogged land that is termed not suitable for development in Goroka Town. All houses built in this way are clustered into settlements forming unplanned communities also known as the squatters' settlements. As the housing in the squatters settlements were not planned with houses on numbered allotments and sections, these households are not provided with basic services of water, garbage and sanitation by the council.

The majority of people living in informal housing in Goroka migrated from rural areas in EHP as well as from other provinces in the hope of finding employment and a better standard of living. Most live in tribal and provincial groups and are self-employed in the informal economic sector. However having said that, a significant population of people living in squatters' settlements are employed in the formal economic sector in both private and government organisations or institutions as housing is a major problem in Goroka and PNG.

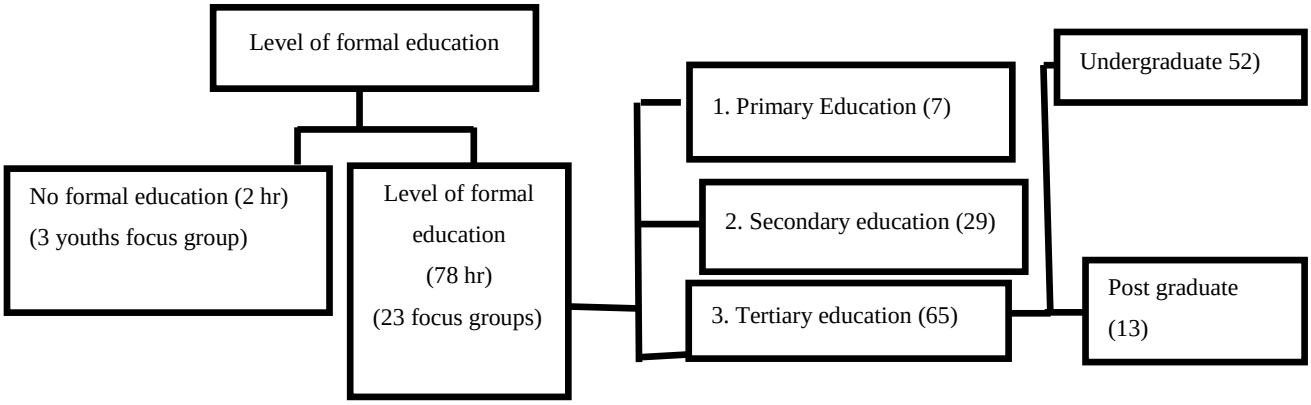
In addition, there are some people who have migrated to Goroka district and established themselves in the villages in Goroka Rural Council Area (GRCA) by buying blocks of land from customary landowners. This group of people are also involved in both the formal and informal economy in Goroka town thus generating solid waste and are using the town bins to dispose their domestic solid waste (DSW). However, the council collection and disposal service does not include this group as indicated by the in the focus group participants. This is because the GRCA is governed by a different council administration. Almost all rural council area(RCA) in PNG that consist of villages do not provide collection and disposal services to its residents as the people live on their customary land and are responsible for their DSW. The villages in GRCA are no different as individual households are responsible for the management the SW they

generate. Therefore when people buy blocks of land in villages near the town they sometimes use have limited land space so they tend to transport and dispose SW in the bins in town as discussed some participants of the focus groups. The Goroka rural local level government comprises of villages on customary land surrounding Goroka town making the town landlocked by these villages. This fact makes land acquisition for development purposes difficult including land for town dump.

5.3 Educational qualifications of the respondents and their employment status

The educational qualification of a person is vital for formal employment in the modern cash economy in urban settlements in the world. Having no or minimal educational qualifications could restrict a person's opportunity for employment in the formal economy. The household participants and focus group members in Goroka Town in this study had different levels of education and were grouped into two main categories as shown in the Figure 5.1.

Figure 5.1: Level of education for households and focus group members in Goroka



Furthermore formal education is also very important for the public in understanding written information provided through education and awareness on solid waste management systems in Goroka Town. Therefore, in order to choose the appropriate mode of communication for the public in Goroka the educational status of the population is vital.

Interestingly majority of the participants (75%) in this research in Goroka town had at least primary education. Among these participants around 85% had tertiary education. Similarly the majority of the participants had some form of employment. It was revealed in the focus group discussions that to be employed in the formal economy with a regular income, residents of Goroka have to have a tertiary qualification at least at an undergraduate level. The employment status of the respondents can determine the type of solid waste that is generated depending on their consumption due to their income. According to McCullough (2001), the quantity of DSW generated by the households' increase as their income increases showing the relationship between increased income and increased production of SW. The increase in income signifies increase in the households buying power. However the method the household use to manage the SW depends on the SWM knowledge and information available to them. Table 5.3 show the different institutions were the participants are employed in.

Table 5.3: The participants' employed by each Department or Institution in Goroka Town

Departments or institutions	No. of employees	employees for focus groups
Government Departments		
-Educational institution	27	1
-EHP Administration/ Government	2	
-Hospital	2	1
-Other Government departments	9	
Non-Government Organisation (NGO)		
Non profit organisation		
-Church organisation	9	

- Research and Education Institutions ***Private company*** - Educational institution -Financial institution -Hospitality &Travel company others	3 5 1 2	 1
Self-employed	2	24 (2 youths & 20 women)
Grand Total	62	27

Source: Fieldwork, 2011

This indicates that the bulk of the household respondents' are employed by government departments with the highest number employed by educational institutions. The educational institution with highest number of employees is the University of Goroka. This is important as there can be partnership between the Goroka Town council and these institutions to utilise human resources there to provide education and awareness on the positive and negative impacts of different solid waste management practices.

On the other hand, the bulk of the women and youths in the focus group interviews were self-employed. Most women lived in either squatters' settlements or blocks of land bought by their family from the customary land owners in the villages surrounding Goroka Town. The youths lived with their parents or other relatives in either the formal housing in town or in the informal housing in the squatters' settlement and blocks of land bought in the village near town. The people who are self-employed in this case are involved in selling their products in the markets as individual sales people or as a household. The self-employed people provide some of the important goods and services that Goroka Town residents depend upon that the formal economy cannot provide. For instance, a participant in the women's focus group that lives in a block of land her family bought from customary land owners, commented that her household composts all organic waste and grows vegetables. These vegetables are either sold at the vegetable market or

are consumed by the household. From the observations of the researcher, the fruits and vegetables are mostly sold in the market by individual producers who come from the town and villages in the different Districts in EHP.

Having self-employed residents grow vegetables to generate income and for their own consumption provides the opportunity for the biodegradable solid waste to be used by this group of people through composting and mulching. The vegetables that are produced and supplied to town markets are also contributed by some of these self-employed residents of Goroka. Therefore their empowerment through improved composting and mulching for their farming is vital to keep the town's food supply as well as providing the income that they need. The type of economy that these self -employed people are involved in is the informal economy. This informal economy does not provide regular income for the people as it depends on their individual production and how much is sold. The different composition of solid waste generated in Goroka is discussed in the section 5.4 below.

5.4 Solid Waste composition in Goroka

There are two main categories of solid waste produced by the households in Goroka Town, like any urban settlement. These categories of SW are biodegradable and non-biodegradable solid waste. All subjects responded to the production of both type of solid waste. The respondents gave specific names of both biodegradable and non-biodegradable solid waste generated in their households with a few stating that their households generate all different kinds of solid waste.

These types of biodegradable and non-biodegradable solid waste were categorised according to the kind of materials which they are made of and/or the source from where the solid wastes were generated. The biodegradable solid waste had nine categories while non-biodegradable waste consisted of ten. The categories of non-biodegradable and biodegradable solid waste are discussed further below is Sections 5.4.1 and 5.4.2.

5.4.1. Generation of Biodegradable Solid Waste

There were nine different types of biodegradable solid waste generated by the household respondents as indicated in Table 5.4. The most common type of solid waste that all households generated was fruit and vegetable peelings. Apart from the generation of these peelings, a significant number of households also generated papers, yard and garden waste and food leftovers. The households ‘generation of paper and paper products as solid waste indicates that almost half of the household buy goods sold with paper products

Table 5.4: Type of Biodegradable SW generated by the households in Goroka Town

Biodegradable SW produced by households	Number of Households
Vegetable and fruit peelings	80 (ALL)
Papers and paper products	37
Yard and garden waste	31
Food waste (leftovers)	27
Other organic waste	15
Betelnut waste	11
Fabrics	8
Bones and fat	1
Wood	1

Source: Field work, 2011

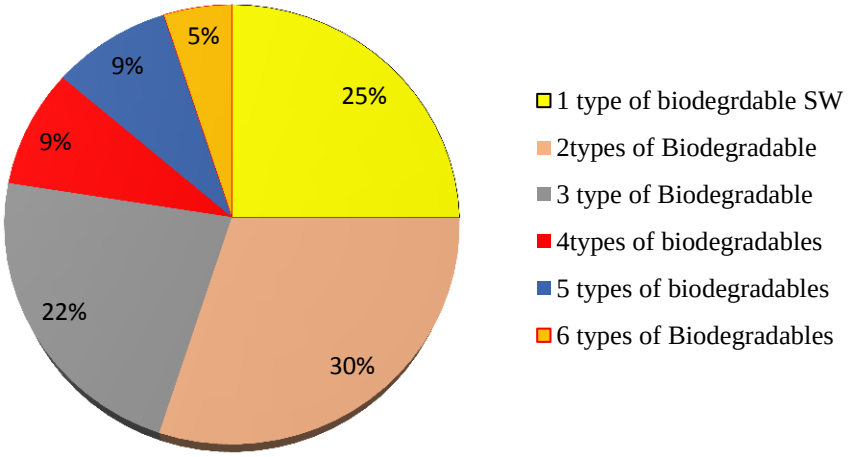
The households consume fruits and vegetables on a regular basis, often daily, thereby generating solid waste on a daily basis as well. The generation of fruit and vegetable peelings reflects two factors. These are readily available fruits and vegetables sold in the markets in Goroka Town. The fruits and vegetables are cheaper than the manufactured goods sold in the shop. The response from one respondent below gives one of the reasons for the generation of vegetable peelings on a daily basis:

'We produce more peelings and other organic waste because we eat more vegetables due to the expensive cost of the manufactured store goods. We basically tried to live off the garden vegetables sold at the market and from our backyard gardens.'

This response indicates that the households prefer to buy and consume more vegetables that individuals bring from their gardens and sell at the market as they are cheaper. In addition to the consumption of fruits and vegetables from the backyard gardens, this has benefits for the households in terms of providing a healthy diet and saving money. Through this action the amount of non-biodegradable solid waste is avoided and reduced by the household. The production of non-biodegradable solid waste is discussed in the next section 5.4.2.

Furthermore, these households generated a combination of more than one type of biodegradable solid waste as shown in Figure 5.2. The majority of the households generate a combination of one to three different types of biodegradable solid wastes when combined together. However there were no single dominate combination of biodegradables generated.

Figure 5.2: Combination of biodegradable solid waste generated by households in Goroka



Source: Field work, 2011

5.4.2. Generation of non-biodegradable waste

The non-biodegradable solid waste generated by the households is from manufactured goods bought from the shops and the markets in Goroka Town are presented in table 5.5 below.

Table 5.5: Type of non-biodegradable SW generated by households in Goroka Town

	Type of non-biodegradable SW	No. of households generating SW
1	Empty fish tins and meat cans	77
2	Plastics packaging and shopping bags	74
3	Bottles	39
4	Metals	12
5	Diapers and sanitary pads	5
6	Smoke waste	4
7	Automobiles	3
8	Glass	2
9	Broken utensils	1
10	Building materials	1

Source: Fieldwork 2011

These non-biodegradable solid wastes were classified according to its material contents and use. These non-biodegradables were then classified into ten categories as shown in Table 5.6. The households generated a combination of two or more non-biodegradables with the two most common types of non-biodegradable solid waste generated being empty tin cans and plastic from packages or bags used to pack manufactured goods. The plastic packaging was mainly from food items. A quote from a household respondent given below reflects the common responses of majority of the respondents in Goroka.

'*We have empty fish, corned beef tins, plastic packages from rice and noodles, and paper from the goods we buy from the shop.*'

Table 5.6 and the response above indicate that the households consume a lot of tinned protein and goods with primary plastic packaging. The other types of non-biodegradable solid waste were not common as they were produced from non-food items. The large production of plastics and tins by households requires a careful and effective solid waste management system to recover resources and prevent chemicals from these solid wastes negatively impacting the environment and health of the people.

The households produced both biodegradable and non-biodegradable solid waste. However, the quantity of each solid waste varies from one household to the other making one form of SW more common than the other. In addition the SW generated by the households were predominately from the by- products of the food products that they consumed. As the quantity of the biodegradables and non-biodegradables differ from one household to another, so was the responses of the households regarding the common type of SW their households generated. Some households generated more biodegradable solid waste while others generated more non-biodegradables. Still a few household commented that they produced equal amounts of both waste streams as indicated in table

Table 5.6: The most common type of SW stream generated by households in Goroka Town

	Employment					Percentage distribution
Common type of SW generated by households	Yes	No (self-employed but spouse employed)	Self – employed but used to	No. Students	No. households	
1. Biodegradable	28	2	3	2	35	44%
2. Non-biodegradable	25	9	2	0	36	45%
3. Both	9	0	0	0	9	11%

Sources: Field work, 2011

There is no significant difference in the number of households who commonly generate biodegradables as opposed to the ones who generate non-biodegradables. However it can be stated that a majority of the house respondents were working or either their spouses where working. Therefore they had a choice to buy goods that generated either biodegradable or non-

biodegradable solid waste. The choices that the people made in buying the goods depended on two factors. Firstly their financial capacity to buy food products that generated one or the other type of SW. Secondly the availability of the goods for the consumers in the shops and markets. These two factors are shown in the quotes of two household respondents below:

'The rubbish that we produced the most are tins and plastics that are from the manufactured goods as we are in town and there are more manufactured goods sold.'

***'**We produced more organic solid waste because we eat more foods from the garden due to the cost of the store goods that is expensive for us to afford, we basically tried to live from the garden produce'.*

The first respondent generated mostly non- biodegradable SW as that was readily available and the household could afford to by the goods that generated the non-biodegradables. However the second respondents opted to buy vegetables from the market or grow own vegetables and consume it leading to SW that comprised of biodegradables as the household did not have the financial capacity and the vegetables from the market are cheaper than the goods manufactured goods from the shops.

This finding is clearly supported by the discussions of the focus groups whose members were self-employed and produced mainly biodegradable solid wastes. Therefore households generated more non-biodegradable solid waste when there is regular income through formal employment but also depended on whether the income was enough for them to buy manufactured goods from shop or vegetables from the markets. The vegetable markets in Goroka are part of the informal economy as sellers pay minimal to amount of money as fees for their activities to sell vegetables and other products that are mostly produced locally at a cheaper price. On the other hand the shops are part of the formal economy and must have license to operate and the operations

involved importing goods outside of the province and the country therefore is expensive as the freight costing are taken into account.

5.5 Quantity of solid waste generated and the equipment used to store them

The amount of solid waste generated by each household varies depending on the rate of consumption and the size of each household member. This quantity of solid waste generated can be measured daily and weekly to calculate the quantity generated in a month or in a year. The quantity of the solid waste can be quantified by its weight or the number of bags generated in volume. In this study the quantity of solid waste generated was measured using quantity of bags that were concerned about the volume of SW produced. The quantity of SW produced by the households varies from day to day and from week to week as established by the responses of the household discussed in sections 5.5.1 and 5.5.2.

5.5.1 Quantity of solid waste bags generated

The number of garbage bags generated by each household ranges between less than a quarter of a bag to 5 bags each day. The responses were classified into five main categories as indicated in Table 5.7.

Table 5.7: Quantity of garbage bags produced in Goroka by households daily

No. bags	No. households	%
Less than 1 bag to 1	43	54
1 to 2 bags	22	28
2 to 3 bags	11	14
3 to 4 bags	3	4
4 to 5 bags	1	1
Total	**80**	**100**

Source: Field work, 2011

Table 5.7 shows that the common number of bags produced by the households is one bag or less of solid waste per day. The reason for generation of the different quantity of solid waste bags depended on each household's solid waste management technique, rate of consumption, and the family circumstances and size. These three factors are discussed further here. Some households generated more bags of solid waste per day for the three reasons below:

a) Large household size
b) Households none separation of SW into biodegradables and non-biodegradables by mixing all the SW together in a bag
c) Rate of consumption

For instance, a participant commented that his household generated 3-4 bags of SW as he had a large family. Having a large family meant the family's consumption was high daily so the number of solid waste bags generated reflected the household's family size. In addition, some households generated more as they had visitors who visited and were accommodated in their house thus increasing their consumption rate. Furthermore, some households have more bags of solid waste daily due to the non-separation of solid waste into biodegradables and non-biodegradables and the storage of all solid waste together in a bag.

The small family size means there is lower consumption rates leading to fewer solid waste bags. Some households had fewer solid waste bags daily as there was less consumption of food at their household due to rationing and the fact that the household's members were either at work or school for the day. The separation of solid waste into biodegradable and non-biodegradable effectively reduced the number of solid waste bags kept in the house for disposal as the biodegradables were composted. Finally, there were inconsistencies in the production of solid

waste bags daily as the activities and consumption of the households changed during the weekdays and weekends.

In summary the quantity of solid waste bags generated by the households per day depended on various factors from the size of households, rate of consumption, the activities of the household members during work days and the weekend, and whether or not the households segregated the different categories of solid wastes. The two major factors that determined the quantity of solid waste bags generated were the household size and the consumption rate during the day.

The results also indicated that the households generate more garbage when they have visitors. A visitor in this case is someone who is visiting for a short period from one day to a week or two. In Papua New Guinea, there is a high movement of people between rural and urban or urban and urban settlements to visit relatives and friends for a short time before returning to their place of residence. This movement of people who resides with friends and families for a short time are called visitors. It is culturally acceptable for people to visit without prior knowledge and communication with people they are visiting therefore generation of solid waste can be inconsistent in a given household day to day or week to week. Religious restrictions too have an impact on solid waste generation. For instance, a few respondents commented that during the weekend their household generated very little solid waste as they are Seven Day Adventists (SDA) who worship on Saturdays and so do not prepare meals.

5.5.2 The equipment used for the storage of solid waste by households in Goroka Town

The equipment and facilities used to manage solid wastes are very important as the lack of the equipment and facilities or its availability can impact positively or negatively on the overall

management of SW in a given area. All the households responded positively to having some form of equipment provided for the storage of the DSW that they generated. The households in Goroka town used several pieces of equipment for the management of SW at the household level especially for storage as listed below:

a. Bags - Plastic bags (garbage and shopping bags); Empty rice bags: String bag and Market bags (bags made from stock feed bags)

b. Bins (baskets, buckets and drums)

c. Boxes (empty cartons);

d. Bowls or dishes

e. Others

The households use whatever storage equipment is available to them or is affordable. The majority of the households use a combination of two types of storage equipment as shown in Table 5.8 below. The two common types of equipment that most households used to store their DSW are bags and bins with plastic bags being the more common SW storage item. The plastics bags are either the plastic shopping or garbage bags. The bulk of the households use plastic shopping bags to store DSW. The shopping plastic bags were used as it was given to the households to pack their groceries. The bins that the households used were small trash bins and big bins, normally 44 gallon size drums were kept outside for the solid waste to be transferred to for storage and later collected for disposal (detail in the next section).

Table 5.8: Combination of Equipment used by households in Goroka for SW

Combination of SW equipment used	**Households**	**Types of Equipment used**	**No. households**
Only plastic bags	18	only 1 type	18
Plastic, boxes and bin	2	two types of equipment	53
Plastic and boxes	8	three types of equipment	7
Plastic and bowl	1	four types of equipment	2
Plastic, boxes and others	1		80
Plastic and bins	33		
Plastic, bins, boxes and rice bag	1		
Plastic and bag of rice	1		
Plastic and stockfeed bag	7		
Plastic, bin, stock feedbag d others	1		
Plastic bag, bowl and bin	1		
Bin and stockfeed bag	2		
Stockfeed bag and bag of rice	1		
Bin, rice bags and string bags	1		
Plastic, bins and stockfeed bags	2		
Total	80		

Source Field Work, 2011

Out of the four types of equipment used for storage and transportation of SW, most were made from non-biodegradable materials. Therefore, the bulk of this equipment would end up being disposed as there is limited recycling of non-biodegradables in PNG, especially in Goroka town. There was only one household that mentioned the use of bilums or string bags to store the DSW, even though the art of making bilums were important traditionally and were made from local biodegradable fibres by women for storage and transportation of household possessions and food stuff which were later reused as storage equipment for SW. However, today the women use the manufactured yarns to make the bilums mainly as carry bags for women in urban centres to store and carry their personal items. This traditional art of billum-making by women for the carrying and storing of household items from biodegradable materials needs to be encouraged to reduce generation of non-biodegradable storage equipment. The non-biodegradable storage equipment poses challenges for its disposal after the wear and tear from its usage.

Finally, the bulk of the equipment used as storage equipment are items that the households reused with only a few households actually buying the garbage bags and bins purposely made for storage of DSW. Therefore, the size of the equipment used is difficult to establish and is discussed here in the section.

The types of storage equipment used by the households in Goroka were by products of manufactured goods that were reused showing inclusion and adaptation of a new type of SW using the ISWMP in an urban society in PNG. Inclusion and adaptation is an important part of PNG indigenous society (Anderson, 2015) that addresses change in the society

5.5.2.1 Size of the equipment used to store the solid waste

The size of equipment used by the households in Goroka varied according to what was available for them to use. The sizes of bags, bins, cartons and bowls used for the storage and transportation of the household solid waste varied tremendously. This is because the equipment used for storage of garbage was not standard garbage bags and bins sold in shops. Most equipment for storage of solid waste inside the house were provided by the households and therefore most reuses plastic shopping bags and other old items such as garbage bags and bins. The equipment used for storage outside the house was mainly empty 44 gallon drums that were reused as garbage bins. To establish the sizes of equipment used, the bags were compared with the bags of rice bag ranging from five kilogram to over twenty five kilogram bags that are sold in PNG. Size did not necessarily refer to the weight but the volume of the bags. Bins, cartons and bowls were classified into three sizes: small, medium and large.

(i) Sizes of garbage bins use by households in Goroka

The garbage bins used by households to store their DSW were classified into three categories as listed below.

a. Small trash bins

b. Medium trash bins

c. Large bins (empty 44 gallon fuel drums and wheelie bins)

Small and medium bins were used by the household to store DSW mainly in the house that was to be later transferred to the large bins outside which were mainly empty 44 gallon fuel drums with a few households using the wheelie bins. The SW was stored outside in the large bins until the council collected it for disposal. From the households that used bins for solid waste storage some households use a combination of two different sizes of bins as shown in Table 5.10.

Table 5.9: Households use of the different sizes of bins

Combined use of different sizes of bins	**No. households**
only small	3
only medium	7
only large	12
large and small	15
large and medium	6
Total	**43**

Source: Field work, 2011

The table shows that the most common types of bin used by the households were large 44 gallon fuel drums. There were almost an equal number of households that used only one size of bin and a combination of two different sizes of bins to store solid waste both indoors and outdoors. The large bins that were used by households were provided by the landlords, councils and mostly the

organisations that employed the participants or their spouses. Most of the empty 44 gallon fuel drums used by households where shared amongst a number of households in the vicinity of the drum. The responsible organisation providing the bins for the households will be discussed later in section 5.5.5. However, the bins used in the houses were lined with plastic shopping bags or garbage bags by the households for easy transportation to the large bin for collection and disposal. The use of bags for storage and transportation of the solid waste by the households are discussed in the section below.

(ii) Type and size of bag used to store and transport household solid waste in Goroka

The bags used for storing during transfers of the solid waste were mainly empty rice bags, string bags, and bags made from empty stockfeed and plastic bags. All households used bags and combinations of other equipment discussed earlier to store DSW. The most common type of bags used for storage of solid waste was the plastic bags. There were two types of plastic bags the households used for storage of DSW in their households. These were plastic shopping bags and plastic garbage bags. Almost all households used plastic bags to store their DSW of which the majority used plastic shopping bag to store the solid waste inside the house. This indicates that the most common DSW storage equipment in Goroka is the plastic shopping bag. The sizes of the shopping bag and garbage vary with sizes difficult to establish. Garbage bags were mainly small, medium and large. The bag sizes are discussed in the next paragraph. The bags used by households for storage of solid waste were different sizes and were compared to the kilogram sized bags of rice. The bag sizes were classified into eight groups ranging from less than 5kg to over 25kg bags of rice as shown in Table 5.10:

Table 5.10: Size of bags used to store DSW in Goroka

Size of bags less than or equivalent	No. households	combination of bag sizes	households
Less than 5kg	8	Only one type	70
5kg	40	2 types	8
More than 5kg less than 10kg	1	3 types	2
10kg	16	total	80
20kg	3		
25kg	1		
Over 25 kg	1		
It depends	10		
Total	**80**		

Source: Field work 2011

The most common size of bag that households use to store their DSW is a bag equivalent to a 5kg bag of rice. In addition, the majority of households used only one size of bag to store DSW. While most households gave the sizes of the bags that their households use, some households commented that the sizes of bags they used were inconsistent and depended on the quantity of goods consumed and the number of people in their household at a time as they had visitors. The size of bags used depended on the production of solid waste by each household and is determined by the household's population and the availability of the different sized shopping bags for the household to store solid waste sourced from the shops. The common size of shopping bags used by households was equivalent of a 5 kilogram bag of rice as mentioned earlier, which is a small size bag. The provisions of equipment for the storage of SW were done by both the households and the other organisation as discussed in section 5.5.4.

5.5.2.2. Who is responsible for providing solid waste storage equipment for the households' DSW in Goroka?

The provision of equipment for the storage of DSW inside the house was viewed to be the responsibility of the individual households. All household respondents responded to providing

the equipment for the storage of the DSW inside their houses. However a few households also commented that the institutions that employed them provided small and medium bins for use in their houses.

Apart from the equipment provided for storage of DSW inside homes, about a third of the households were provided with the large empty 44 gallon fuel drums as garbage bins by the town council, landlords and institutions for which the respondents or their spouses were employed. A few households that had the wheelie bins commented that the bins were provided by their employer. The majority of the households had large bins provided for their households to store DSW outside for collection and disposal by the institutions that employed them or their spouse.

This shows that households in Goroka are responsible for providing the equipment for storage of the DSW inside their households. The common storage equipment used for storage inside the house was plastic shopping bags with all households using these. Bins are the next common equipment used both inside and outside for storage of DSW. Most households use large bins for storage of DSW outside the house. The large bins are mainly empty 44 gallon fuel drums provided by the organisations that employed the heads of the households. The households that had bins provided by their employers, indicated that the bins were either for couple of households in the institutions, all households in a compound of an institution or for the whole institution.

The provision of the large bins for storage of DSW outside the house is vital for effective storage and collection. Therefore, provision of bins for households by the different organisations is discussed further below.

(i) Institutional provision of large bins for DSW storage

The households that shared the large bins with couple of other households were all employees of the University of Goroka who resided in university housing on campus. The households that shared the bins within the whole institution, shared with the rest of the households as well as the offices. These institutions were mainly lower educational (colleges and secondary schools) and church institutions. The bins for secondary schools and church institutions were placed in one common location for all members of the institution to use while the college bins were placed in couple of locations for both staff and students to use. Church institutions that provided large bins for its members included various places of worship and institutions involved in providing social and educational services to the community. The third group of households shared two large bins with a number of other households in their compound. The number of households using two large common bins for DSW storage depends on the number of units or houses in that compound or block. Generally the number of households in a compound ranges from 4 to 12 households using two common bins. The large bins provided by the institutions were empty 44 gallon fuel drums. The minority households that had individual large bins provided by their employer were either empty 44 gallon fuel drums or wheelie bins for DSW storage. It is clear from this discussion that households are provided with large common bins to store DSW by their employers or their spouse's employers when they reside in institutional housing. The decision to use empty 44 gallon drums instead of wheelie bins for solid waste storage is due to the cost of providing the bins. Each wheelie bin costs K700, while empty 44 gallon drums cost K50.00. This huge difference in cost largely contributes to the common use of empty 44 gallon drums. The

other group that provided large bins for household use was the landlord group as discussed in the next section.

(ii) Landlords and councils' provision of large bins for DSW storage

Landlords were another group that provided large bins for DSW storage for households that rented their properties with the exception of one household respondent who was a landlord sharing with other tenants. The households provided with bins by the landlords had both shared and individual bins. Some households shared two large bins with others in their block of units or with other houses in the compound. The exception was one household that had one large bin for the storage of its DSW. The large bins were either wheelie bins or empty 44 gallon drums with the bulk being the empty 44 gallon drums.

The final organisation that provided the large bins for the storage of DSW before collection and disposal was the Goroka town council and it is recognised as the official collection and disposal service provider. However, the few households that responded that the council provided the bins were referring to the bins that the council placed in certain locations along the main streets for public use. The households that used the bins provided for public use along main streets are located along the main streets in Town-Seigu section of Goroka town, just at the edge of the central business district of Goroka town (CBD) and, therefore, are able to use these main bins that the council provides for public use. From the researcher's observation, the collection and disposal of solid waste are conducted frequently, sometimes daily, in the CBD of Goroka Town.

To conclude, all individual households provide their own equipment for DSW storage inside the home. However, only a minority of households have large bins, mainly large 44 gallon drums and few wheelie bins provided for storage of SW outside the houses while ,over half of the

households have no large bins to store DSW outside the house before collection. The majority of the households stored their rubbish mainly in bags for collection and disposal. The bins are provided for the minority of the households by landlords and institutions where they are employed. The households that use public bins proved by the council did so as they were in close proximity to the bins. Landlords and institutions mainly provide common bins for a number of households near each other.

Furthermore, the use of wheelie bins by a few households indicates that there may be the possibility of other households being provided wheelie bins instead of the empty 44 gallon drums. This type of drum gets rusty and breaks as a result of the weather and heavy usage. They also do not have lids and the solid waste is exposed making it unhygienic as the solid waste overflows when the council fails to collect it. This factor was very obvious through the observations made by the researcher. The cost of providing appropriate and suitable equipment for DSW storage determines the type of equipment that is provided for households' use. The cost of the equipment for the household use is discussed in the next section.

5.5.2.3 The cost of equipment used for storage and management of DSW by households in Goroka town

The cost of equipment used for the storage of DSW inside the house such as string bags, cartons, bins, stock feed bags and plastic bags varied and depending on the size and the type of equipment. This equipment either had no or little cost for the households. The responses of the participants were classified into two main categories: (i) households having no cost for the equipment provided; and (ii) households having some cost for the equipment provided.

The majority of households do not pay for certain storage equipment such as plastic shopping bags, empty cartons, empty rice bags and old bins for use inside the house. Most of the participants responded that the plastic shopping bags they reuse as garbage bags were given to them by the shops at no cost to pack and carry home their groceries. The cartons used for storage of solid waste were given free by the shops when asked for or were obtained from schools and offices where the participant worked. The old bins were found by the households to be discarded on the streets and they were reused for garbage storage. One respondent's comment illustrates how empty cartons are attained to be reused as storage equipment:

'The empty cartons that my household uses to store our domestic garbage is from the empty students' exercise books cartons from my office that are reused'.

This statement indicates that this person's household is able to reuse packaging of exercise books not needed for any immediate school activity. These can be used for household waste storage without payment as cartons are available in that person's work place. However, as the majority of the households also used a combination of equipment to store the solid waste, they paid for some of the equipment as listed here.

a. Shopping plastics from the market

b. Market bags made from stock feed bags

c. Cartons from shops

d. Garbage plastic bags from shops

e. Garbage bins from the shops

The shopping plastic bags that some of the households used to store domestic garbage were bought from the market to carry vegetables and other goods and were later reused. The market bags made from empty stockfeed bags and sold at the market were also bought to carry vegetables and goods for the households, and later reused when they were worn-out as garbage bags. Empty cartons used for packaging of goods from shops were also sold to several households who reused them to store garbage. Garbage bags and bins were bought to use for their intended purpose of garbage storage.

The cost of the different equipment for the storage of DSW differs according to the size and the quality ranging from K1.00 to K25.00. The households gave a combination of different costing ranges for the equipment bought for DSW storage. The household respondents that paid for storage equipment either knew its cost or were not sure as the equipment was provided by organisations other than the households such as the institutions that employed the respondents or their spouses or by the landlords and the town council. A quote from a respondent illustrates this common response from the households who were provided with large bins:

'The large 44 gallon drums that are provided for the households were bought some years before I joined the University even though my department is responsible for the collection of solid waste on campus I do not know the costing.'

This particular respondent was the head of the department which was responsible for the management of the solid waste in the institution, especially the collection and disposal. He was, therefore, in a position to give the costing of the bins, but could not do so as the bins were bought well before he joined the institution.

The data collected in this research indicate that the households that pay for storage equipment preferred to pay for smaller and less quality storage equipment as these are cheaper and easily accessible compared to the larger quality storage equipment that are expensive. Large equipment like 44 gallon bins or quality and expensive equipment such as wheelie bins are bought for households' use by landlords and employers of participants or their spouses. The landlords and institutions pay for the large expensive bins as most households cannot afford this kind of cost due to the low standard of living in Goroka and rest of PNG (Kin, 2010 and UNICEF, 2014). In addition the council regulation requires the households to provide the SW storage equipment themselves as indicated by the council staff and few of the household participants. However the requirement of the quality and size of the SW storage equipment for households are not established by the council hence leaving it up to the households own interpretations.

5.6 Conclusion

The population of Goroka that are living in the formal housing are predominately employed with majority of them having an age range between 31 to 51years. The bulk of them living in the formal housing are employed by the government institutions with 33% of the households interviewed employed by government educational institutions. However households employed by private and public educational institutions are combined education institution that along employees 40% of the households interviewed in Goroka.

The bulk of the households are long time residence of Goroka with most living in Goroka for over 10 years with 40% of the households residing there for 21 years to 37years. As these households are employed most of them including the focus group participant had formal

education. The bulk of the households had tertiary education while the focus group participants had mostly secondary education.

The composition of SW generated by the households was both biodegradable and non-biodegradable by nature. There was a slight difference in the commonality of the two types of SW with slightly more biodegradables being produced by the households. However the common type of biodegradables generated by all households were vegetable solid waste and the two common non-biodegradables produced were plastic products from food packages and empty tin cans from food products.

Moreover the households provided their own storage equipment with most storing the SW in plastic bags. For most households that used shopping plastic bags to store solid waste it cost nothing. However the generally the households paid up to K25.00 ($9.00 AUD) to get storage equipment.

The households in Goroka are able to provide their own storage equipment mainly small to medium shopping bags that are reused where the town council is not able to provide the storage bins for each household. Therefore households adapt to this need by reusing varies items as substitute storage equipment. This indicates that the households, landlords and institutions are active participants in the provision of SW Storage equipment's. This participation shows the indirect partnership relationship in SWM that exist in Goroka that is not fully recognised and utilized by the parties involved in DSW management and therefore needs to be trapped into.

CHAPTER 6:

HOUSEHOLD SOLID WASTE SEGREGATION, RESOURCE RECOVERY, COLLECTION & DISPOSAL

BENEFITS & CHALLENGES OF SOLID WASTE MANAGEMENT TECHNIQUES IN GOROKA

6.1. The knowledge of Indigenous solid waste management practices (ISWMP) in Goroka

There is high migration of people from the rural to urban settlement in Eastern Highlands Province (UN-Habitat 2010; Rogers et al undated) like rest of PNG in search of better life due to lack of services and development in rural areas (Kolo 2007). Through this movement of people the knowledge and use of Indigenous Solid Waste Management Practices (ISWMP) is being transferred to the urban population. The majority of the respondents indicated that they have knowledge of ISWMP. The ISWMP identified by the participants were both indigenous resource recovery practices (IRRP) and SW disposal practices. Interestingly there was an indication in the result that the resource recovery or solid waste reduction practices are very similar to the practices of the Wamonagu village that was discussed in chapter 4. The ISWMP used by households in Goroka are discussed in the next two sections: (6.1.1) and (6.1.2).

6.1.1 Indigenous Resource Recovery Practices (IRRP)

The concept of IRRP is the same in indigenous societies. For example research done in Nigeria by Ajibade (2007) noted similar IRRP by Nigerians to that of households in Goroka. However the types of SW used, location, and reasons for IRRP and types of IRRP for each society differs. For instance, the respondents in Goroka who commented that they use solid waste to reclaim the land come from villages where the terrain is hilly and steep or where the land is waterlogged due

to swamps and wetlands. Furthermore, the coastal communities compost under coconut trees and in coconut plantations while the highlands communities' compost under coffee trees and panda nut trees. The reclaiming of unsuitable land indicates that the suitable land is scare in communities that have hills, gullies and wet lands. The table 6.1 below shows that the IRRP used by traditional societies involved predominantly biodegradables. However, currently the IRR practices have changed adapting and including both biodegradables and non-biodegradable solid waste.

Table 6.1: IRRP in the societies in PNG

IRRP	Type of solid waste	Reason for the use of each IRR
Burning	Yard and garden waste, Other organic waste and Coconut shells	-To get ashes and use as pesticides and fertilizer through composting -To retrieve energy for cooking -Coconut shells were burnt and ashes used to cook meat and leafy vegetabl
Composting	The peelings of fruits and vegetables Yard and garden waste	To give nutrient to the soil as the biodegradables are composted -In the vegetable gardens -On the soil that is later used for planting -In a pit that is used to plant tree crops such as banana -In a horizontally dug drain that is cover with soil and vegetables especially sweet potatoes -Under tree crop such as banana, coffee, coconuts, panda nut and sugar can
Reusing	Bones of animals Plastic containers and tin cans bought from stores	-The bones of large animals were reused by sharpening them and we spoons and knives for scraping and cutting vegetables and cutting panda nu Reused as storage containers
Avoidance of solid waste	Vegetables	The vegetables were cooked without peeling or removing the hard stalks ones
Reclaiming of land	The larger logs	Disposed in the gullies or the hillsides and waterlogged areas to reclaim human use.

Source: Field work 2011

6.1.2. *Type of solid waste disposal sites in indigenous community in PNG*

The types of disposal site used by the indigenous societies in PNG as identified by the household and focus group participants are open dumps. All the disposal sites are in the environment in landscapes where the SW can be easily hidden from the people as given in the list below. In the past only biodegradable SW was disposed of into these disposal sites. However, today both biodegradables and non-biodegradables are disposed of into these sites identified by the household and focus group participants.

a. Dug up pits

b. In a body of water (seas and rivers)
c. In the bush
d. Under bamboo tree
e. In mangroves
f. In gullies and hill slopes

The type of disposal sites people used in their indigenous societies depended on the environment in which they lived. For instance, the household respondents who lived in the coastal community near the sea disposed of SW in the sea and mangroves. The communities near the rivers disposed the solid waste in rivers while the villages on hilltops disposed solid waste into gullies, hill slopes and under bamboo trees. However, the common disposal sites that are used by coastal and highland communities are dug up pits and bushes.

From the majority of the respondents who had knowledge of ISWM practices, over half of the total household respondents mentioned using ISWMP of both the IRRP and the SW disposal practices as discussed in Section 6.2 of this chapter. The focus group discussions also indicated that due to lack of collection and disposal services provided for the households in the informal housing area in the blocks and in the squatters' settlements, the households used the IRRP and SW disposal practices to manage domestic solid waste (DSW). These IRRP and SW disposal practices are the ones they had knowledge of as discussed earlier. As the squatters' settlements in Goroka are located in the gullies and slopes, some residents dispose of the non-biodegradable solid waste there to reclaim land to build their houses.

The households that did not use the ISWM practices even when they had knowledge of the practices gave various reasons for not doing so as listed here:

a. There was no space in their yard

b. The practices they knew were applicable only in the village with certain geographical features
c. The accommodation is rented so there is restriction on the use of land
d. There is collection and disposal service provided so they do not use the ISWM practices.

These responses show that households would have used the ISWMP if they had the opportunity to do so.

6.2. Indigenous Resource Recovery Practices /Solid Waste Reduction by Households in Goroka

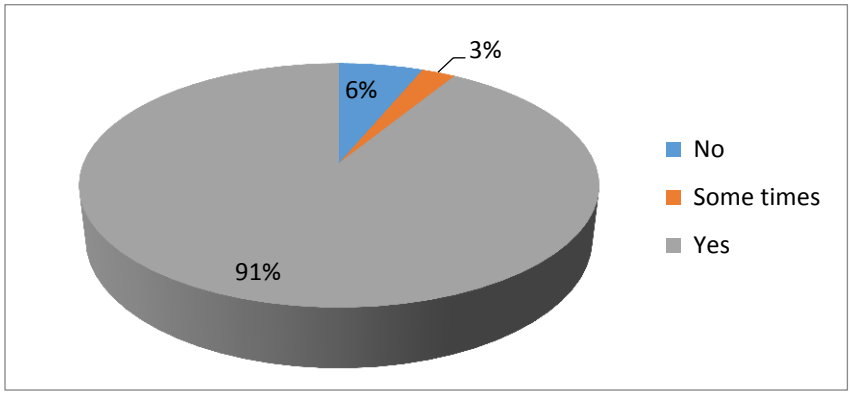
To recover resources at the domestic level the segregation and storage of DSW occurs simultaneously when solid waste is generated. The categories into which DSW is segregated and stored depend on the storage equipment provided, solid waste minimisation, and resource recovery activities. The effectiveness of solid waste segregation and storage depends on the availability and suitability of the storage equipment and solid waste management system in place. The domestic segregation activities and storage of solid waste are discussed in this section is mainly adapted by the households from the IRRP that the households acquired from their indigenous society which have been transferred from parents to children through practical activities. This IRRP is used by the majority of households in Goroka to manage their domestic waste where there is lack of collection and segregation done by the town council.

6.2.1. Segregation of solid waste by households in Goroka

The segregation of solid waste at the source enables the recovery of vital resources that would otherwise be lost through the process of disposal. In order for the effective management of solid waste, segregation must be done at all levels of production. An overwhelming majority of the

households responded positively to segregating their DSW at the source of generation. This is shown in Figure 6.1.

Figure 6.1: Segregation by households in Goroka Town



Source: Field work, 2011

The segregation of solid waste by the households is the first activity in the process of resource recovery. Much of the knowledge on segregation of different types of solid waste into categories of SW of the households are based on the ISWMP as there is no SW segregation system in place for the Goroka town council. As there is no initial segregation system in place for Goroka town most households segregate their domestic SW using their own resources and initiative while a minority do not involve in the segregation activity. The reasons for household segregation or non-segregation of DSW by households are vital. Therefore, the reasons for the non-segregation or segregation by the households as discussed here.

(i) Reason for non-segregation of solid waste by households in Goroka

Some households do not segregate their DSW for various reasons in Goroka Town, for the following reasons:

a. The households perceive that all solid waste generated is waste and so stored all in one storage equipment for disposal,
b. The segregation of solid waste generated is time consuming and so they opted not to segregate at the source,
c. The households did not segregate at the source of solid waste generation as they were simply ignorant.

The reasons for non-segregation of solid waste at the source indicated firstly the households' lack of knowledge and understanding of the different types of solid waste and the importance of resource recovery and waste reduction through segregation. Secondly, they indicate that the households were ignorant and not willing to segregate even if they understood the importance of segregation and resource recovery from the different types of solid wastes. Therefore awareness regarding the production of the different types of solid wastes, the importance of avoiding SW and segregation at source to reduce solid waste and recover resources is vital. Furthermore, the households that are purposely not segregating at the sources need to be encouraged by emphasising the benefits of segregation into different types of solid waste for their households.

(ii) Reason for segregation of solid waste by households in Goroka into different categories

The reasons for the segregation of DSW by the households in Goroka town were for reduction or remove of solid waste for a healthy living environment and to recover the resources. However, the main focus of the bulk of Goroka households was on the former rather than the latter as they try to keep their homes healthy in the process reducing solid waste and recovering resources. The reasons for segregation of DSW into various categories are vital to understand why segregation of DSW is done at the source to encourage the practice. The DSW was segregated into these five

categories and later managed according to the needs and circumstances of each household. The different categories of DSW after segregation are: (a) burnable; (b) compostable; (c) reusable; (d) recyclable; and (e) disposable. The purposes of segregation are shown in Table 6.2.

Table 6.2: Reasons for household segregation of DSW in Goroka

Purpose for segregation	No. households
Dispose permanently	80
Composing	73
Burning	70
Reuse	63
Recycling	53

Source: Field work, 2011

It is clear that the main purpose of segregation is to recover resources and reduce solid waste due to lack of service provided by the Goroka town council. The majority of households had a combination of reasons for the segregation of DSW. The bulk of the households gave all five reasons for segregation. Some households gave away solid waste that they generated as the primary producer to the other households to be reused and recycled. Therefore, all resource recovery activities are common amongst the households in Goroka. The focus group discussions also establish these five reasons for segregation of DSW. Segregation is common amongst the occupants of both formal and informal households but at varying degrees. These reasons for segregation are discussed individually to establish the challenges and benefits of the SW disposal and resource recovery or SW reduction activities.

There are four categories SWM mainly, composting, burning, reusing and recycling that target resource recovery and waste reduction indicating that the households are aware of the three "R" principles of reusing, recycling and reducing solid waste. The solid waste generators and managers around the world are developing different techniques to recover as many resources,

thus reducing solid waste before final disposal. Some of these techniques are simple and need less input to recover the resources, while other techniques require large resource input in terms of machinery, technology and technical knowledge. This is a challenge for developing nations that lack the resources mentioned, resulting in some useful resources ending up in the disposal sites. Goroka Town in PNG shares this challenge with the towns and cities in other developing nations. Disposal of solid waste and resource recovery techniques are discussed further in this section.

6.2.2. What Domestic Solid Wastes (DSW) is categorized as disposable SW by household in Goroka?

Disposal of particular items are done when the SW are seen to have no more use. The DSW that were disposed of by households were predominantly non-biodegradable. The household disposed a combination of different non-biodegradable and biodegradable DSW. These non-biodegradable and biodegradable DSW that were disposed of by the households in Goroka town are given in table 6.3.

The two main types of non-biodegradable DSW that were commonly disposed of by households were empty tin cans from canned food products, and plastic products mainly bags, containers, bottles and packages as shown in Table 6.3. On the other hand the biodegradable DSW for disposal were mainly papers, vegetable waste and yard cuttings.

Table 6.3: Combination of solid waste disposed by household in Goroka

Non-biodegradable DSW	No of Households	Biodegradable DSW	No of Households
Tin cans	75	Papers	12
Plastic bags, bottles, containers and packages	72	Vegetable waste and yard cuttings	8
Glass bottles	19	Bones	1
Other unspecified inorganic	7	Other unspecified organic waste	1
Sanitary pads and nappies	5		
Fabrics	3		
Cigarette buts	1		

Source: fieldwork 2011

The bulk of the households dispose DSW that are made of metals and plastics indicating that there is very minimal to no recycling of these products. This is evident in the responses of the households segregating DSW into different categories with the lowest number of households recycling out of the four resource recovery categories. The bulk of non-biodegradable solid generated by the households is disposed in the dumpsites as the resource recovery for these SW was not available for the households. Moreover, there are low recycling activities and a high disposal of non-biodegradable DSW in Goroka even though there is significant reuse of DSW resulting in the bulk of non-biodegradables that eventually end up being disposed in the dumpsites. The recycling and reuse of non-biodegradable DSW and its challenges are discussed further later in the chapter. Furthermore the non-biodegradable DSW was disposed of as some households had minimal recovery and reduction activities even when they were presented with opportunities to reuse and burn DSW. However they opted to dispose the SW as there were collection and disposal services provided. The other households were aware of the negative impact that burning has on the environment and public health when pollutants are released into the environment so disposed the SW instead of burning. This was evident in the response of this participant.

'In my house we do not burn the domestic solid waste as it would pollute the air and affect the health of the people as well as emitting greenhouse gasses contributing to the impact of global warming. Therefore we dispose them in the bins for the council's collection.'

The households that disposed the biodegradable DSW gave three main reasons for their actions which are listed below.

a. Lack of land space for composting or mulching

b. Over production of vegetable and yard cuttings

c. Households lack of time to separate and use the resource recovery methods

From the three reasons given, it is evident that households were aware of the resource recovery methods of composting but were unable to practice it due to the challenges presented above. A quote from a respondent given below illustrates the households' desire to compost but could not due to factor of space limitation:

'I would like to compost the peelings, but I cannot as we are on the top floor of the building. We do not have a backyard but I still separate the solid waste into different categories and dispose them.'

It is evident that this household could not change the practice of disposing biodegradables unless they move to an accommodation that has enough land space. However for the other two reasons there is room for the households to reorganise their consumption rate and time to address it. The resource recovery activities by the households would improve and increase when an overall resource recovery system is developed as part of Goroka town's SWM system which is currently lacking. The resource recovery and solid waste reduction activities are discussed below.

6.2.3. *Resource recovery or solid waste reduction activities*

The resource recovery activities by the households in Goroka town were mostly from knowledge of ISWMP with an exception of only one which was not. The one resource recovery activity that was not an ISWMP is recycling of non-biodegradables. These practices are discussed below.

6.2.3.1 Burnable DSW by households in Goroka

The type of DSW that the households classify as burnable waste and burn them are of both biodegradables and non-biodegradables that were mostly dry and could easily burn as shown in table 6.4

Table 6.4: Type of domestic solid waste burnt by household in Goroka

Non-biodegradable DSW	**Biodegradable DSW**
Plastic products	Papers and cardboards
Old sanitary pads	Yard cuttings like grass, dry leaves and branches
Rubber products	Coconut shells and husks
Old clothes	Used dry bamboos

Source: fieldwork, 2011

This DSW were burnt for three reasons as given below. The households gave a combination of reasons for burning the DSW. However, most households gave only one reason:

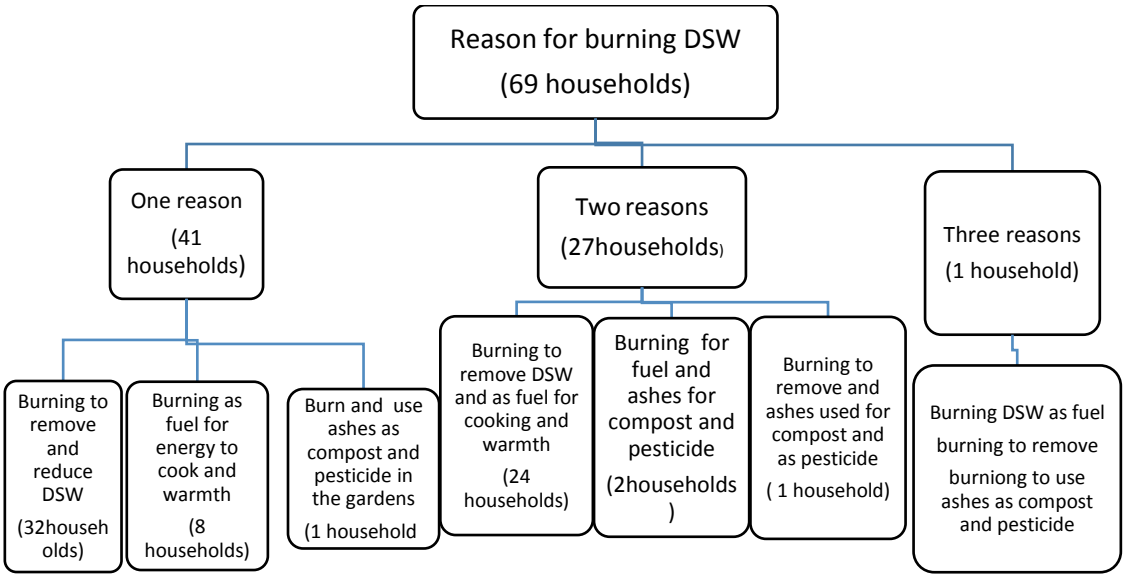
a. To remove and reduce the SW

b. Burn to retrieve energy for cooking and warmth

c. Burn to collect ashes that were used as compost and pesticide

The two most common reasons for burning DSW were (a) and (b) with the bulk of the households burning to remove and reduce the solid waste as the council were not collecting the DSW regularly. The two types of DSW commonly burnt were plastic products and papers with plastic having a slightly higher number of households burning them. In addition to that, the common DSW burnt to retrieve energy was coconut shells and husks. The type of DSW burnt for energy was predominantly biodegradable while mostly non-biodegradable solid waste was burnt for reduction and removal of SW. Figure 6.2 illustrates further the reasons for households burning of DSW

Figure 6.2: Reasons for burning of DSW by households in Goroka



Source: Field work 2011

It is important to establish the types of solid waste burnt for removal, to reduce solid waste, to retrieve energy, and to be used as pesticides. This will give an insight into the benefits and impacts of burning the different types of DSW. These reasons are discussed further in sections (i), (ii) and (iii) below:

(i) Type of solid waste burnt to be used as compost and pesticides

The type of solid waste burnt is mainly dry organic waste such as grass and flower cuttings, branches, leaves and papers with some non-biodegradable components consisting of plastic products. All these SW are burnt together and the ashes are collected and put under the fruit trees and vegetables in the gardens as mulch or compost. They are also sprinkled on vegetables and fruits in the garden as pesticides. The burning of biodegradables and use of ash as compost in the vegetable and flower gardens are important practices as the ash enriches the soil for plant growth. Households are aware of this fact and are able to burn solid waste for composting purposes. However during households' burning of plastics with biodegradables, there is a risk that the toxic chemicals from the plastic can be released into the soil when used as compost, thus polluting the land. When soil is polluted with the toxic chemicals, vegetables would absorb these toxins and when consumed there is a potential impact on peoples' health.

Apart from using ashes as compost, they are was also used as pesticides being sprinkled over crops to allow for good yield by preventing pests from destroying the vegetables and fruits grown in the garden. The use of ashes as a pesticide is beneficial for the household and environment as it cuts the cost of buying manufactured pesticides for use in gardens and prevents harmful chemicals contaminating the soil and the environment at large. However the question on the residue of contaminants that might be present in the ashes from burning of organic solid waste with non-biodegradable especially plastics remains a concern

(ii)Type of SW burnt to remove and reduce DSW

The burning of DSW to remove or reduce it consisted of both biodegradables and non-biodegradables. The biodegradable solid waste burnt for this purpose was less in volume and

comprised the two categories of garden waste such as leaves, branches, grass cuttings, weeds, flower cuttings and paper products. The bulk of the solid waste burnt for removal was non-biodegradable and comprised the four categories given here. They were plastic products, sanitary pads, fabrics (old clothes), and rubber products (car tyres). The two most common types of DSW burnt for removal and reduction were plastics and papers products from food packaging and broken shopping bags.

The plastic and paper packages were burnt as these materials disintegrate easily when burnt and most packaging is made of these two materials. Burning was the easier option when the council was inconsistent in its collection of DSW from residential areas. A quote from a respondent given here shows the household's justification for burning of DSW:

'*We burn the papers and plastic packages to remove the rubbish. I know it is not good to burn rubbish but we have no way of disposing them so that is what we do.'*

This indicated that the respondent is aware of the implications of burning plastics and papers, but had no other option of disposal and therefore burnt the waste to reduce and remove it. This also indicates that the households are doing everything possible to manage and reduce their DSW with the limited collection and disposal services provided.

(iii)Types of solid waste burnt for energy to cook and warmth for the household

While a majority of households burn DSW to remove and reduce it, a significant number of households also burn DSW as fuel to generate energy for cooking and warmth. The DSW burnt for this purpose were both biodegradable and non-biodegradable in nature. The biodegradable DSW burnt for energy consisted of (i) coconut shells and husks, (ii) paper products, (iii) branches and twigs from yard cuttings and (iv) used bamboo. The non-biodegradable DSW burnt

for energy were mainly plastic products. The most common type of solid waste burnt for energy was coconut shells and husks. The coconut shell and husk made good firewood for coastal and island communities in PNG as established from the focus group discussions. The burning of the shells and husk from the coconut indicates that a product that households in Goroka consume is coconut which is brought from the coast and sold in the market. The burning of used biodegradable solid waste to retrieve energy in open fires is an indigenous practice that households are using in Goroka with a need for adequate and affordable supply of fuel. In addition, households are now using plastic products as an energy source to prepare their meals. The focus group discussion also established that many of the informal households in the squatters' settlements are now using plastics to cook their meals due to financial constraints and lack of access to firewood.

The burning of SW for energy indicates that most households use the open fire to prepare meals and need firewood for energy. Therefore, when there is no wood households use the SW they generate as a substitute. Burning this SW may benefit the household to reduce their costs of buying wood, but as energy is retrieved from open fire it creates health risks for household members from smoke and toxins released.

Burning plastic products to cook food releases toxic chemicals into the air and contaminates the food impacting the health of the family. It also releases greenhouse gases into the air. This can impact negatively on peoples' health and the environment, and also contribute to the global environmental impact in terms of greenhouse gas emissions. As the burning of DSW is done at an individual household level around Goroka Town, the toxic chemicals are released into the different sections of the town environment. When the chemicals seep into the soil through

burning, this pollutes the soil but can also contaminate the ground and surface water that the town's people and peri-urban settlers depend on.

6.2.3.2 Compostable Domestic Solid Waste

The composting and mulching of biodegradables is important as through these processes biodegradables are biologically recycled enriching the soil. The majority of households segregate the DSW to compost the organic wastes. Composting is the single most common reason for segregation efforts by the households in Goroka Town. The households either composted only one category of biodegradable DSW or combination of two and three categories as shown in Table 6.3: The types of biodegradable DSW that are composted are: (a) Fruit and vegetables peelings (b) Dry leaves and yard cuttings(c) Food leftovers (d)Papers (e) Chicken manure (f) and Ashes from burnt DSW

Majority of the households composted only one type of biodegradable solid waste with the bulk of biodegradables composted being peelings and left over vegetable waste. The households composting of fruit and vegetable waste reflects the high daily consumption of these product. The consumption of vegetables daily is good for their health as it provides the vital nutrients for human health and at the same time households are able to organically recycle them back into the environment without release of toxins. Location of compost and reason for composting is import as it gives insight into household's values and the impact of this practice.

(i)) Location of Compost

The location of compost and mulch is important as it gives information on the reasons behind composting or mulching activities. Composting is done in three locations: vegetable or flower

gardens; under tree crops such as bananas planted in yards; and in pits purposely dug up in which to compost biodegradables. A quote from a respondent illustrates how the households composted in dug up pits:

'We dug up holes and disposed of the peelings and leave there as compost and later covered the hole and planted yams over the compost. The compost gave nutrients to the soil enhancing the growth of the yam'.

It was also established in the focus group discussions that household members (mainly women) dig pits and drains to compost organic solid waste. Theses pits and drains are later covered and larger root crops and fruit trees are planted. The common crops planted in the horizontally constructed drain compost are a new variety of yam that is known to the growers as the African yam introduced to the community by the Department of Primary Industry (DPI) in Goroka. The compost in the pit, also called hole, by the households was used to plant bananas and sugarcane.

This discussion indicates that the residents of Goroka have knowledge about the importance of composting for agriculture. This value is part of the indigenous solid waste management practice where composting is done for agricultural purposes. The focus group discussion and household interviews established that the majority of households use the ISWMP that includes composting. With knowledge of the value of composting when new composting techniques are introduced to grow either a new or old variety of crops, it is easily adopted. One of the new composting techniques that was introduced to the households was the linear composting. In this composting style households dug horizontal drains and filled it up with organic matters before planting yams that were originally from Africa.

(ii) Reasons for composting of biodegradable DSW

The way households manage their solid waste focuses on the benefits it brings. There were two reasons for composting according to households and focus group discussion findings. The first reason was that the biodegradables gave nutrients and improved the soil structure for the growth of their vegetables and fruit trees and provided rich soil for their crop seedlings that was planted later. The residents' understood the benefits of compost on soil fertility and on crop growth and yield. This understanding was mainly gained from their indigenous knowledge from their societies.

6.2.3.3: Reusable DSW

The reuse of DSW is another common method that households use to manage their SW in Goroka town. Household responses and focus group discussions established that the majority of the households reused both biodegradable and non-biodegradable DSW. Non-biodegradables that were reused were plastic, glass and metal products while the biodegradables were paper and vegetables products and food leftovers as shown in Table 6.5:

Most households reused non-biodegradable SW made from plastic materials. There is more reuse of non-biodegradables as most cannot be recycled due to limited recycling in Goroka. The biodegradable food wastes are reused to feed animals. The focus group discussions also established that non-biodegradables are the common DSW reused by the households for various purposes which are discussed in section (i) below.

Table 6.5: DSW reused by households in Goroka Town

Material type	Type of product	Specific solid waste	Main SW
plastic products	plastic drink bottle	soft drink and cordial bottles	
	plastic bags and packages	plastic shopping bags and packages	non-biodegradables
	plastic cup	plastic drinking cups	
	plastic jars and containers	jars from food stuff such as jam and peanut butter	non-biodegradables
	plastic jars and containers	containers from ice cream and butter	non-biodegradables
glass products	glass jars/bottles from food stuff	glass jars or bottles from jams, peanut butter and coffee	non-biodegradables
metals products	empty tin cans	tin fish and meat plus milo tins	non-biodegradables
paper product	papers and paper products	sheet of papers and paper packages	biodegradables
vegetable waste	vegetable peelings & fruit peelings and left-overs vegetable	sweet potatoes and stock of leafy greens	biodegradables
food left overs	leftover cooked food	sweet potatoes, rice and leafy greens	biodegradable

Source: Field work, 2011

(i) Purposes for reusing of DSW

The DSW are reused for various purposes. Some of these households gave more than one purpose for reusing DSW while others gave only one. These purposes were classified and are listed below from the most common to the least common. The three first reasons are discussed individually as the majority of both individual interviews and focus group discussion established three reasons

-To reuse as carry bags, garbage bags and poly bags
-To be reused as storage containers

-To be reused for making home made products
-To be used as classroom resources
-To be fed to the domestic animals
-To be used as utensils

The reuse of fruit and vegetable waste and food leftovers to feed domestic animals and livestock are ISWM practices that households learnt. Through this practice the households are able to reduce the cost of buying food for animals. This is because there is limited animal feed for domestic animals and livestock sold in shops and are also expensive for households.

(ii) DSW reused as carry bags, garbage bag and poly bags

The high cost of living in PNG means that the income earned by residents is not enough to meet all the needs of the households. Plastic bags were reused by households for three reasons. They are carry bags to carry vegetables and fruits from market as well as sometimes storing household items as well as using them as garbage bags, to store DSW, and are used as poly bags for nursery seedlings of vegetables, fruits and flowers. The two common purposes for reusing the plastic bags were for use as garbage bags to store garbage, and as carry bags for carrying household goods especially vegetables from the market. The reuse of plastic bags as garbage bags is the single biggest purpose for plastic bag reuse. The type of plastic bags reused for these two purposes were plastic shopping bags. The plastic bags used as poly bags were plastic packages of good for nursery seedlings of crops and flowers. The common seedlings for nursery using plastics are coffee seedlings. A quote from a respondent regarding the use of plastic package is give below.

'The plastic rice packets we reuse as poly bags to nursery coffee and orange seedlings Apart from coffee being the main cash crop, oranges are now a main fruit crop grown and sold at the market. The oranges

were introduced to the EHP by the DPI and are a popular tree crop grown by villages as well as residence of Goroka Town.'

The reuse of plastic shopping bags has reduced the cost of buying garbage bags that are expensive and limited in supply. Plastic packaging from store goods are reused as substitutes for poly bags that would have also cost the households to purchase them. The plastic packaging reused as polybags enables households to nursery crops to sell or grow as well as households consuming the crops themselves. The plastic is also reuse to nursery coffee seedlings and later replant, generating good income for the coffee growers. Coffee is the main cash crop grown on plantations as well as in small holdings in family units.

(iii) Domestic solid waste reused as storage containers

The types of products reused for storage equipment were from plastic and glass materials. These products were plastic bottles and bags, plastic jars and containers and glass jars as storage containers for storing household items and cold water. Again the main SW reused by majority of the households for storage was from plastic products.

The households that lived in informal housing in the squatters' settlements and in the blocks of land bought from the villages in the periphery of Goroka Town also reused many of the plastic bottles and containers to store items as well as water and kerosene for lamps. This is because they did not have water and electricity supplied to their households as most are unemployed or self-employed with no regular income. In addition the squatters' settlements are often excluded from town planning for basic service delivery. The practice of reusing is useful as the households reduced their costs by substituting bottles and jars for the ones sold in the shops for storage purposes.

(iv) DSW reused to produce home made products

The DSW that is reused by the some residents of Goroka is purposely to store homemade products. Again the main domestic waste reused is from plastic and glass materials and few households are now reusing tin cans. Plastic products such as bags, bottles and containers plus glass jars and containers are the main items reused to make home made products. In addition, few residents in both formal and informal housing reused empty cans mainly from tinned fish and tinned meat to store home made products for sales or for their own consumption The home made products and the solid waste reused are discussed below:

The reuse of 500ml plastic soft drinks bottles by households: Empty bottles were reused to store homemade soft drink through refilling of the empty bottles with juices made from tang powder and cordials. Tang is a powdery product that is mixed with water to create tang juice. The cordials sold in the shops were also bought and mixed to make soft drink. These two types of homemade soft drink are sold to the public in informal and formal markets for K1.00 which is cheaper and popular than the drinks in the shops. From the researcher's observation, the soft drinks and water in the 500ml bottles cost about K4,00 and the drinks in the aluminium cans were selling at K2.50 or K2.60 which is about two to three times expensive than the home made soft drinks. The household members who made the soft drinks for sale were females according to the household responses and the focus group discussions.

Reuse of plastic and glass jars: The second type of solid waste reused for home made products are the plastic and glass jars from products such as peanut butter, jam and coffee. These items were reused by some households to store the homemade jams and oil. The homemade jams were made from fruits while the body and cooking oil were the products of animal fat and plant oil.

These jam and oil were mainly consumed by the households with few households selling the jam from pineapple, pawpaw and citrus fruits. The body oil was made from animal fat and used as a medicine for treating fever. Below are typical responses the households gave regarding the production of homemade jams and oil:

'We reused the bottles to store the pork fat and later heated it to get the oil and used by rubbing it on children's' bodies before they went to sleep when they have fever. When the oil is rubbed on a child's body and the child is put to sleep, the fever subsides when he or she wakes up.'

Reuse of plastic containers: The third type of solid waste reused is plastic containers such as ice cream and butter containers used by some households to make ice blocks and store-cooked rice. These ice blocks and cooked rice were sold to the public. The ice blocks were mainly sold to sellers in the market to keep drink products cool in the coolers while some households use the ice blocks during celebrations. The rice cooked and packed in plastic containers was sold main in schools. The two quotes below gives evidence of the households' reuse of plastic containers:

'I wash the butter containers and keep them to be reused as containers for rice that I cook and sell to the school children at our church school for 50t a container.'

Reuse of tin cans: The final solid waste items reused to make homemade products are cans such as tinned fish and tinned meat cans. The types of cans are the self-open tins with key on the lid that can be easily pulled open without the use of the can opener. These tin cans are collected and reused by some residents in both informal and formal housing for baking of muffins using steam. The respondents who reuse the tin cans for this purpose were females from the households and the focus group discussions who were self-employed or employed but earn a low income due to their skill level. The women learnt about the reuse of tin cans for baking at church from their women's ministry activities. A quote from two of the respondents illustrates this activity:

'*The small tinned fish and tinned meat cans I wash and reuse to bake steamed muffins. They can be sold for K1.20. I have taught the women in my church and in the squatters' settlements how to bake steamed muffins using these tin cans. The aim of this practice is to help the mothers to earn income through baking and selling as most are unemployed or self-employed'*

This discussion indicates that the residents of Goroka, especially women whose households have a low income or are in financial difficulty, are engaged in self-sufficient activities by reusing tin cans as baking trays to produce home-made food products. These products are consumed by the households to reduce the costing and the products can also be sold at a cheaper price for the household to generate income. When the practice was seen to be beneficial for households, the woman who started the practice taught others to encourage them to apply the new skills and knowledge for the financial benefit of their individual household. In addition, a few households reused DSW as utensils. Large animal bones were used as knives for cutting and peeling vegetables and nuts. This practice of reusing bones as knives is a traditional practice that some societies still use to cut wild plants that they harvest for food. The plastic containers such as ice cream and butter containers were sometimes reused as plates to serve meals.

(v) DSW reused as classroom resources, fed to domestic animals

The DSW that was reused as feed for domestic pets and livestock was biodegradable solid waste such as vegetable and fruit peelings, uncooked vegetables, leftovers, and cooked food leftovers. This food and vegetable wastes were fed to domestic livestock such as pigs, sheep and goats and pets were fed only cooked food leftovers.

Apart from feeding animals, a few respondents who are employed as education officers reuse solid waste as resource materials for their lessons. These types of solid wastes were from plastic, glass and paper products from food and drink packages.

Reusing the DSW helped households to recover both biodegradable and non-biodegradable solid waste as resources that would otherwise have ended up in the landfill. However these non-biodegradable DSW when damaged ends up being burnt or disposed. This is because there are no recycling of plastics and the bulk of the glasses apart from the glass beer bottles that are recycled by the beverage company. There is no recycling of plastics and glasses in Goroka and the rest of PNG. This means that recovery of non-biodegradable resources through reuse was short term. However, the challenge is that the plastic and tin cans that are reused have chemicals in them. Therefore, reusing the plastics in the presence of heat, releases chemicals thus contaminating the homemade products. When consumed, this may allow the chemicals to enter the human body impacting their health both in the short and long term.

6.2.3.4 Recyclable DSW

The recycling of solid waste to make new products is an important resource recovery method and is emphasized by SW managers all over the world. The recycling and recovering of the resources leads to conservation of the natural resources and mitigate destruction of the natural environment from extraction of new resources. The SW recycled in PNG is limited to only few items. This is clearly reflected in the recycling of non-biodegradable in Goroka. The recycling of SW in Goroka is conducted through household collection and storage before selling to the trading companies who then sell it overseas for recycling.

The recycling of non-biodegradable DSW, unlike other methods of resource recovery, is done by companies with the exception of one household that recycled the foam from food packages into glue. The items collected for recycling are scrape metals, aluminium drink cans and glass beer bottles by few companies. There were only two companies that were identified to be collecting metals and glass bottles and they were Kalapi Scrape Metal and South Pacific (SP) Brewery. SP bought glass beer bottles and aluminium cans while Kalapi collected all beverage aluminium cans, glass beer bottles and other metals Out of the SW that were traded for recycling, aluminium soft drink cans were the popular solid waste items collected and sold for recycling by households. Over half of the households collected and stored materials to be sold for recycling but it is not popular due to limitations of the items collected for recycling, as the drinks in cans and bottles are not consumed on a daily basis and there is lack of awareness by the company trading recyclables. The storage and sale of the aluminium cans and glass beer bottles are not done regularly. Common concern amongst the residents was that there is limited type of solid waste recycled therefore most non-biodegradables are stored for disposal resulting in overflowing solid waste with ineffective collection services provided by the council. Consequently, the recycling actions by the residents are predominantly focussed on generation of income from the sales of the recyclable SW and solid wastes reduction is an unconscious outcome achieved by the households.

6.2.3.5 DSW to give away to other households.

Giving away of SW to other households is an ISWMP whereby households give away SW mainly peelings of fruits and vegetables plus food leftovers to be reused as feed for domestic animals knowing that this gesture will benefit the household in its social relationship with the

other household. This practice is used by some residents in Goroka town with the households giving away non-biodegradable SW to others for reused or sold for recycling by the receiving household. The types of DSW that were given away were reusable and recyclable SW such as fabric, glass, plastic, and metals products. These items were the same as the items that the households reused and recycled themselves discussed earlier.

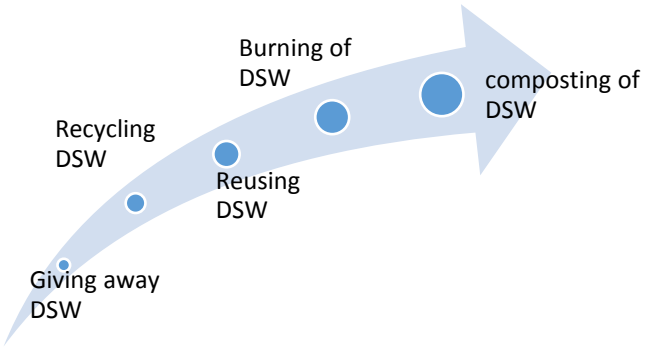
The reasons for the households giving away their solid waste to others were that the (a) households did not need the items and gave them to other households that needed the items, (b) the households produced more of a particular SW and needed to get rid of them and (c) the households saw the needs of other people and helped by collecting items and giving it away. The households were either giving away for their own benefit or for the benefit of others. Through this solid waste management technique, the solid waste that was trash for one household became a resource for another.

The giving away or sharing of DSW with other people actually builds social relationships with people within the town community and between town residents and villages. It also reduced the cost of buying new items for receiving household and generates income when the SW is recyclable. Even though this gesture comes with good intentions, the difficulties of managing non-biodegradable DSW would be passed on to the next household in the town and villages when SW is given away for reusing. This is because reusable solid waste is a short term resource recovery activity as the items are disposed of when there is wear and tear.

From the five reductions and resource recovery methods, four methods dealt with reduction and recovery of both non-biodegradables and biodegradables while composting involves only biodegradables. There was a combination of different resource recovery and waste reduction

techniques by households to manage their solid waste. Figure 6.2 gives a clear indication of the resource recovery techniques that are most common to the least common amongst the households in Goroka:

Figure 6.3: The least common to the most common IRRP used by household in Goroka



Source: Field work, 2011

The Resource Recovery activities based on IRRP enables the households in Goroka to recover vital resources and reduces the amount of SW that is collected and disposed in the open dumpsites. The households' participation in the segregation of solid waste and resource recovery activities based on the IRRP indicates the adaptability of the ISWMP in a changing society. It further illustrates the concept of individual household's ownership and responsibility to the management of SW at the domestic level that exists in the indigenous community similar to the Wamonagu villagers discussed in chapter 4 showing the household's moral obligation to the safety and wellbeing of the community. The household's initiative in applying IRRP in the management of SW is motivated by the benefits of the IRRP for their households and their community which is an important value for the indigenous communities in PNG (Anderson, 2015).

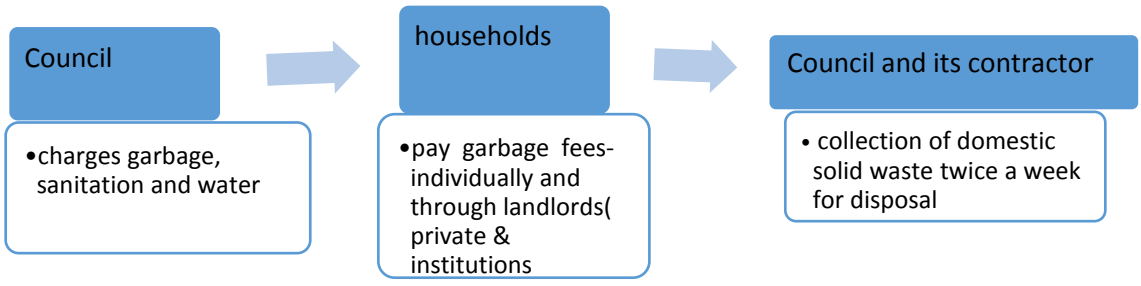
6.3 Collections of DSW in Goroka

Effective and sustainable methods of collection and disposal of solid wastes in a settlement whether urban or rural, is vital to minimize the negative impact of toxic materials from the solid waste polluting the environment and posing threats to the health of the people. The collection and disposal of SW in Goroka town is problematic leading to inconsistency in collections that result in huge amount of SW that is not collected. The collection and disposal of DSW of households in Goroka town is discussed in this section.

6.3.1 Collection of solid waste in Goroka Town

The collection of DSW involves several processes. In this section, DSW collection will be discussed in relation to these factors: (i) authorities responsible for DSW collection and collection fees; (ii) collection times and frequency of collection; and (iii) effectiveness of collection. The processes of DSW collection according to the responses of the households is illustrated in Figures 6.4a and 6.4b:

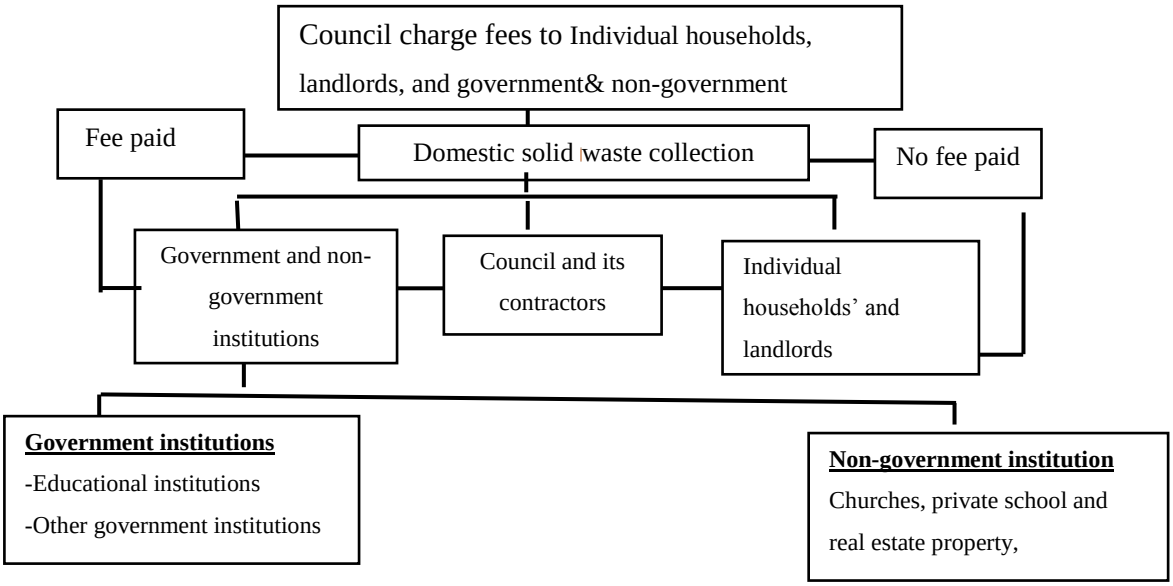
Figure 6.4a: Established process of collection by town council



Source: Fieldwork, 2011

Through this process of service delivery, the households are required to pay a monthly fee to the council for the council to deliver services for garbage, sanitation and water. However this process is not followed for the services to be delivered due to the lack of payment by the households and lack of garbage collection by the council and the contractors.

Figure 6.4b: Current domestic solid waste collection in Goroka Town



Source: Field work, 2011

The normal established DSW system according to majority of the households interviewed used by council is shown in Figure 6.4a. The council and its contractors are responsible for the collection and disposal service. However currently, the system works differently as shown in Figure 6.4b according to the households' responses. To better understand these processes the three factors: (i) authorities responsible for DSW collection (ii) collection fees charged; (iii) collection times and frequency of collection; and (iv) effectiveness of collection are discussed in detail.

6.3.1.2 Authorities responsible for DSW collection

Almost all the households interviewed stated that the authority responsible for providing the collection and disposal of DSW was the Goroka urban town council. However when asked about the authority that actually collects and disposes the DSW; the responses were mixed with the following institutions being stated as responsible for the DSW collection:

a. Goroka Town council and its contractors
b. Individual households and individual landlord
c. Government institutions
d. Non-government organisations

The role that each of the organisation play to provide the collection and disposal services for the households is important for the removal of the DSW in Goroka. Therefore each of the organisation and its involvement in the DSW collection and disposal is discussed further in this section. The households sometimes have more than one organisation collecting and disposing their DSW as collection by council is not done.

Council doing collection for disposal: Half of the households indicated that Goroka town council and its contractors were the main bodies that collected and disposed of the DSW. However a good number of households also responded that other organisations provided collections and disposal services as listed in points (b) to (c) and (d) above. A quote given below from a respondent shows this type of combination:

'The town authority (council) is responsible for collection of the rubbish in the Goroka town but they don't come around to our residence often. Therefore our rubbish is always lying around and , sometimes when we have a lot of rubbish and the rubbish area is overflowing, we dig a hole

along the fence or at the back yard and dump the hard stuff in there. Most times, we burn the plastic bags'.

This response indicates that council collection and disposal system is inconsistent leading to households doing collection and disposal themselves. Some of the households collect and dispose DSW in public bins in the main streets at night when council and contractors fail to collect from their residents.

All respondents that responded to having individuals and other institutions providing the collection and disposal service for their household also commented that town council did not collect their DSW or that it was inconsistent in its collections. Therefore, they had to do the collection and disposal themselves or landlords provided that service, and /or the government and non-government institutions that employed them or their spouses

. Some household were concerned that their solid waste might be dumped illegally along the roads and rivers and was polluting the problem. The individual households collected and disposed their DSW in the night as they were aware that their actions are illegal. These illegal dumps where the households dispose their DSW were unoccupied or attended piece of land in town. Some households and organisations paid a small about of money to the council staff to do the collection and disposal for them and other times they hire private vehicles to do the collection as collection was not only inconsistent but non-existent for some of them. It is clear that individual households and landlords disposed in unused land such as gullies illegally.

Where the institutions provide the collection and disposal services, the institution either collected the SW using their own vehicles and transported it for disposal, or paid the council employees to collect or hired a private vehicle owner to provide the collection and disposal

services. The participation of the households, landlords and institutions in the collection and disposal of the SW again illustrates the indigenous society's values and concept of individual and community ownership of problems in this case it is the problem related to council's lack of SW collection and disposal. The involvement of the three groups shows that there is an established public-private partnership in place that is not being utilized and coordinated by the council with written policy documents to drive the SWM activities in Town. When it is shown that council collection and disposal services for the households are inconsistent or non-existent the question of why the council is failing to provide the service effectively as a lead agency is SWM in Goroka town cannot be avoided. Hence there is a need to examine the resources of the Goroka town council and the management system that exist. One of the resources is their finance especially where the funds come from. One important source of their fund is the revenue generated from service fees. This source of funding is discussed below.

6.3.1.3 Service fees for collection of DSW in Goroka Town

The Goroka town council charges fees for services that they provide and uses the funds generated from the fees for their operations. From the households that were interviewed, the majority of them paid for the collection and disposal services that were provided. The households that responded to paying the service fees for the garbage were classified into four groups. The first group was the individual households that paid the service fees to the council. The second group of households were households that rented their accommodation and paid the solid waste collection fees to the landlords as part of their rent. The third group of households paid the solid waste collection fees through salary deductions to the government and non-government organisations that employed them or their spouses. The final group of households

did not pay as a household but the government and non-government organisations that employed them or their spouses paid the fees to the council for the services.

The amount of money charged as fees by the council to deliver the SW collection and disposal services vary from one household to another depending on the classification of the houses. That is whether it was termed as low or high covenant houses. The low covenant paid less than the high covenant house. Secondly the amount of money paid for service delivery to an organisation depended on the size of the organisation. The smaller organisations paid less and the larger organisation paid more. The frequency of payments made to Goroka Town council, landlords, government and non-government institutions by households were different. There were three time periods that the majority of the households gave regarding the payments of the fees for the solid waste collections. These three time periods were: (i) fortnightly payment through salary deductions; (ii) monthly payments' and (iii) annual payments. Most households made monthly payments, followed by fortnightly, and then annual payments. In addition households also responded that apart from paying the solid waste collections fees, the household and institution sometimes pay for the truck load of solid waste that individuals and institutions collected and disposed. Table 6.6 shows the people who made the payment for the collection of DSW and the body to which the payment was made including the time period for the payment:

Table 6.6: Payment of collection service in Goroka Town

Payment period	Types of respondent making payment	Type of body payment is made to	No. households
Fortnightly	Employees of the institutions	Government and non-government education institution	13
	Individual households	Council	2
Monthly	Individual households	Council	20
	Government and non-government institution employees	Council	8
Annually	Individual household	Council	1
	Landlord	Council	1
	Government institution's employees spouse	Council	1
Do not know	The respondents did not know the pay period as either theirs or their spouses organisations paid and or through one spouse's salary deduction		10

Source: Field work, 2011

The households that paid fortnightly fees for collection of their DSW, made payments to the educational institutions that provided the SW collection service for their households. The households that paid monthly fees for collection services were mostly individual households who owned their houses, individual households who lived in rented accommodation rented by their organisations, and households that were accommodated in institutional accommodation. The bulk of the households paid collection fees to the council monthly payment duration indicated that the town council charges monthly fees for the services provided to the households and annual fees for businesses and organisations that are not business organisation. The majority of the households that paid fees for collection of DSW gave the actual amount of money paid in

kina (PNG's currency) fortnightly, monthly and annually. The money was all supposed to be paid to the council but sometimes that did not eventuate.

The amount paid for collection of SW ranges from K5 a fortnight for an individual household to about K25, 000 for the whole institution that included the households. The payment information is given in table 6.7.

Table 6.7: Actual payment for the collection and disposal service and the duration covered (Source: Field work, 2011)

Amount of money paid	**Households**
K10 to K35 (monthly for individual households)	32
Do not know	17
K50 - K100 monthly (individual houses and non-government institutions-church institutions)	4
over K100 - K300 monthly (individual household and non-government institutions-private schools	3
K1000 - K25000 annually(from government institutions and landlords)	3
Total	59
In addition, one institution pays K900 for 5 truckloads at K180 per load	1

Over half of the households that responded to paying for the solid waste collection service paid between K10 to K35 that was provided to the council and a government educational institution who were the service providers. Apart from the households that knew the actual amount of fees paid for the collection services, significant respondents did not know the actual amount of money paid for these services. This was because the fees were either paid by their employers or their spouses' employer and or deducted from their spouses' salary which they had no idea about. Most respondents in this group were female.

Some households also mentioned that in the past they used to pay individually for their household's solid waste collection or their employer, especially a government institution, paid for the collection of solid waste in their compound but have stopped the payments as Goroka Town council is no longer providing the collection service.

The willingness of the households to pay for the DSW collection and disposal is vital. Where households are not willing to pay for collection services that were provided, the service providers' financial capacity to provide the service is reduced. The households in Goroka had different views on their preparedness to pay for the DSW collection and disposal. The responses of the households were classified into six categories: (i) willingness to pay K10 to K50 ($5 to $25) monthly; (ii) will pay when the council provides the collection service; (iii) not willing to pay; and (v) not sure. The majority of the households responded that their households were willing to pay collection fees and commented that they were willing to pay between K10 to K50 monthly. Most opted for payment ranging between K10to K20 ($5-$10).

The group of households were willing to pay the collection fee when the council provided the collection service. This group either had no collection service provided for them or did not pay as no charge was made to the household. Therefore, the households were willing to pay when the collection service was provided with the appropriate charge given to them. The third group of households were not willing to pay the collection and disposal fee as they thought the payment should be made by the institution they were with. Furthermore a few households were satisfied with the payments that their employers made to the council therefore were not willing to pay as an individual household. The last category of households was not sure about the amount of money that was appropriate for the provision of the collection and disposal service. Almost all

households in this category responded that they were not sure as their households never paid any service fee for collection and disposal of their DSW.

The different responses of the households showing their willingness to pay for the DSW collection indicates that the households are not aware of the actual operation cost of collection and disposal of DSW. The amount that council charge for providing the collection and disposal service is very low and has been used for a long time. It has not changed much to reflect the rate of generation by the households and the economic condition such as inflation.

6.3.1.4 Frequency of solid waste Collection in Goroka Town

The responses of the households regarding the frequency of DSW collections were mixed and were classified into seven different categories. From these categories, six time periods were found within which the DSW was collected, while the households in the last category were not sure about the number of times DSW was collected from their residence. The responses depended on the people that collected and disposed the DSW. The six categories of time periods given for collections of DSW are given here with number of households in each category:

a. Daily (6)
b. Twice a week (7)
c. Once a week (16)
d. Once a fortnight (4)
e. Once a month (4)
f. Inconsistent times (44)

The responses indicate that for bulk of the households there is inconsistently in the collection service provided by the service providers. For most of them the DSW is collected once every two weeks to once every six months. A few of the households also commented that the DSW from their households used to be collected but the service providers have since stopped collecting

altogether. It is clear from the responses that there is an established system for DSW collection that households are aware of as it was used in the past. However this schedule for collection twice a week is not followed by the council to collect and dispose the DSW. This had led to households disposing their DSW in public bins or keeping their garbage hanging on the fence for long time as the households are not being informed of the collection day for the section of town they live in due to the inconsistency in the collection. This made it difficult for the household to put out their bag of solid waste for collection at the appropriate time. The households that had knowledge of the scheduled collection system were long- time residents who lived in Goroka for over 10 years up to 37 years. The collection days were Tuesday and Thursday.

The other households that had their DSW collected and disposed daily did the collection and disposal themselves. The rest of the households that responded to having their DSW collected twice a week, once a fortnight or monthly, did the collection and disposal either individually, or was done by the landlords and the institutions. Therefore landlord collected from their tenants' houses and institutions collected from their employees houses. Few households also had their DSW collected once a week and once a fortnight by the Goroka town council. These few households were located in the North Goroka and Town Seigu areas that were close to businesses and the centre of Goroka Town. From the researcher's observations Goroka town council did regular collection of SW in the CBD and for businesses that paid them. Therefore any households in the vicinity of the CBD and business houses had their DSW collected during the council's or the contractor's collection period in or at this area.

From all that has been discussed, it is evident that collection time for DSW was inconsistent in regards to the days and how often the solid waste was collected by the Goroka town council.

However when the DSW was collected by individual households, landlords and other organisations mentioned above, apart from town council, there were regular collections and disposals with varying time frames. These collections and disposals time frames were within two weeks duration with only few monthly collections.

There is also the indication that the amount of fee charged for the services to be provided for the households is low as the rate is out-dated and cannot meet current SWM demand. In addition there is sometimes non-payment of fees to generate adequate funding to meet the SWM demand of the current population in Goroka. Hence the main hindrance to the effective operations of Goroka towns SWM activities is lack of adequate resources and policy documents to drive the SWM activities.

It is evident that the solid waste management of Goroka town in terms of domestic waste is currently reduced and not causing major problems for the council due to three major factors;

i) The households use of IRRP to recover resources and reduce SW

ii) The concept of ownership of one's own solid waste by households which is an indigenous society's expectation place on an individual responsibility in managing domestic waste. Hence the households in Goroka manage the disposable SW using the Indigenous Solid Waste Disposal Practices (ISWDP)

iii) The participatory approaches by other stakeholders (households, institutions and landlords) in the collection and disposal of SW.

6.4 Disposal of domestic solid waste after collection by service providers

The DSW that was disposed of was collected by different service providers according to discussions earlier. The group that collected the DSW also disposed of it. The disposal of the solid waste generated in an appropriate disposal site is important for proper management and control of the solid waste disposed of. Disposing the SW well reduces the risk to the environment and the public health. Therefore in the next section the disposal sites and its proximity to the residence and the water sources are discussed.

6.4.1 The disposal site and the distance from the respondent's residence

The responses of the households in Goroka regarding the final disposal sites reflected whether the households disposed of the DSW themselves or the landlords, institutions and council disposed the SW. Table 6.8 below shows the main dumpsite were the town's solid waste was disposed of and the locations of the dumpsites where individual households disposed of their DSW when it was not collected and disposed by the Goroka Town council and its contractors.

Table 6.8: Main town dumpsites and dumpsites created by the households

Household dumps	Type of land	Main dumps	Type of area land
In a gully and hillsides	Government	A location at Bena	Customary
In a pit near the house	Individual or institutional	Faniufa	Customary
In bins in town and at Rotary park	Government	Fimito	Customary
On the roadside	Government	Kamaliki	Customary
School dump in school	Government	Lopi	Government
Zokozoi River	Government	Near CIC	Customary
		Slope near YWCA	Customary

Source: Field work, 2011

Some households disposed of their own DSW in the public areas, and in unused land owned by the government on natural features such as rivers, gullies and hillsides, while other households

disposed of the DSW on land near or on man-made features such as parks, roadsides and schools. The majority of the households that disposed of their own DSW dug up pits in their residential areas for disposal of domestic waste. These households were able to do that as they lived on their own properties or on institutional properties with enough land space for them to dig pits for the disposal of their DSW. These were evident in the responses of two of the respondents quoted below:

'We have a big pit for the South Pacific Brewery here where all the households collect their solid waste and dispose it there and it is burnt later as the council do not collect the rubbish from our house and that goes for all the houses in this compound as SP has enough land to dig the disposal pit.'

This household lives in an accommodation compound owned by the institution that had dug pits in its land space for the households in the compound to share and dispose of their DSW due to lack of service from the council..

'The DSW is finally disposed of in the pit near our house. My family lives in a house that belongs to Goroka technical college and we have our gardens around our house and in fact we have dug seven different pits since residing in this house for the 14 years. The council has never collected any DSW from my house even when we put it out when we see them collecting solid waste.'

This respondent's household had several dug up pit near the institutional house that her family is residing in. For the duration of her household's residence the household has managed the DSW itself without Goroka town council's assistance. Hence the council collection and disposal service is non-existent for this household.

When analysing the responses above, it is evident from their previous responses regarding the payment of collection and disposal fees charged by the council, that when the respondent

collected and disposed of their DSW in pits as the council did not provide the collection service for them they did not pay.

The disposal of DSW by individual households in pits and other natural or manmade features may seem to solve the households' need for solid waste removal but it poses a great environmental and public health threat for the town community. Most of the DSW disposed of was non-biodegradable and was disposed of in an open dump in close proximity to respondents' residences and other residences in town as household disposal sites were in town in or near both natural and manmade features. These disposal sites outside the respondents' residents were all illegal. Most of these disposal sites were within a distance of one to two hundred metres from the respondents' houses. The distance of the disposal site to the town and the respondents' residences will be discussed later in this section.

6.4.1.1. The Common dump sites

The common or main disposal sites that the population of Goroka Town used were on the land that belongs either to the state or the customary land owners (table 6.8). Almost all the land where the town's population disposed of DSW belonged to the customary land owners with the exception of only one that was located on state land within the town. Most of the dumpsites on customary land were outside or at the edge of the town with only one that was located at the YWCA found within the town boundary. The rest of the disposal sites on customary land were in an area near villages where the houses were located. This was evident through two observation visits done with the Goroka town council's solid waste collection and disposal department to two disposal sites that the council use. These two sites were Fimito dumpsite at Kafana, and Kamaliki dumpsite near Asaro or Kamaliki River.

From the seven disposal sites where the DSW was disposed of, the majority of respondents knew of three common disposal sites which were Fimito, Kamaliki and Faniufa in order from the first to third. Most households responded that Fimito was the main dumpsite with Faniufa being another one and the Kamaliki disposal site was a new site for town disposal. However not all households are aware of the change in the dumpsites.

Having dumpsite on Customary land would means that the traditional land owners sometimes complained and charged the council therefore the dumpsite closes. Therefore acquiring suitable land for disposal of solid waste in PNG is a main problem the councils faced as urban centres are surrounded by customary land.

Some households also mentioned four other common disposal sites as shown in Table 6.7. The households' mention of these common dumpsites reflected that the disposal sites were in close proximity to the section of the town the respondents lived in. The respondents who lived in North Goroka had their domestic waste disposed of at the disposal site near the YWCA. The disposal site at CIC and Lopi were used by households in West Goroka while the disposal site at Bena was used by households in Town-Seigu section of Goroka Town especially those at Seigu. Six of the seven disposal sites were on customary land. Out of that two were located within the town vicinity, two away from town and two at the edge of the town just couple of distance out of town. These distances are discussed below in relation to their impact on the town community. The disposal sites were acquired through rental arrangements with the landowners or were an illegal dump in the case of the one that is located in town:

6.4.1.2 *Distance of disposal site to the respondent's residents*

The distances of the dumpsite where the DSW was disposed of depended on whether the dumpsites were household dumpsites or main town dumpsites. The household dumpsites were located between 3 metres to 200 metres depending on whether the households disposed the DSW in pits in their residences or away from their residences on and near natural or man-made features.

The DSW disposal pits were a few metres away, between 3 metres to 5metres from the respondents' houses and were controlled and managed by the households. Therefore, the majority of the households that used this method to dispose of DSW responded that their disposal method was successful with few problems. The households that disposed of the DSW away from their residences on or near natural or man-made features had disposal sites at a distance between 6 metres to 200 metres. The households who responded that their domestic solid waste was disposed of in the main disposal sites gave the distance of the dumpsite to their residence in kilometres. Most dumpsites were located outside or at the end of Goroka town with only two sites, Lopi and YWCA, located in the vicinity of Goroka town. The distances from the dumpsites to the respondents' residences ranged from half to about ten kilometres depending on the section of the town where the residences were located and the locations of the dumpsites.

The households that were located in North Goroka responded that the dumpsite at YWCA was about half to one kilometre from their residence while the dumpsites at Kamaliki and Fimito where estimated to be five to ten kilometres away from their residences. The respondents who lived in Town-Seigu section of Goroka town gave distances from their household to the Faniufa and Fimito dumpsites. The distance from Faniufa dumpsite to the respondents' residences was

estimated at two to five kilometres while the Fimito dumpsites' distance ranged from five to seven kilometres. The respondents living in West Goroka gave the distance from their residence to five of the seven main dumpsites in Table6.7. The dumpsites are listed below with their approximate distances from the respondents' residence.

(i) Lopi and CIC dumpsite - distance ranged from one to two kilometres. Lopi dumpsite is located just inside the town and CIC is at the edge of town

(ii) Faniufa dumpsite - distance ranged from two to four kilometres

(iii) Fimito and Kamaliki dumpsite - distance from dumpsite- three to six kilometres

The section of Goroka Town that was closer to the main dumpsites of Kamaliki, Fimito and Faniufa is West Goroka. The residents in North Goroka disposed of DSW at YWCA as it was closer to them, while the respondents who resided at West Goroka used Lopi and CIC. The Town-Seigu residents' main dumpsites were at Faniufa, Bena and Fimito. Therefore, the dumpsites were about one to ten kilometres away from the respondents' residences with Lopi and YWCA in the town and the rest at the edge of town or a few kilometres away from the edge of town. The results indicate the majority of the households, landlords and institutions knew the location of the main dumpsites but opted to take the easier and cheapest option. In addition a majority of the households knew the locations and distance of the main dumpsites in relation to their residence, a minority but significant number of respondents could not give the distance as they generally did not know the location and name of the dumpsites.

6.4.1.3 The location of the disposal sites in relation to town community and natural environment

The location of the disposal site and its proximity to urban and rural communities and the natural environment should be carefully planned and designed to minimise negative impact. The disposal sites used by the Goroka town population for disposal of DSW are open dumps. The responses of the respondents regarding location of the dumpsite in relation to the health of the people within the vicinity of the disposal sites are discussed in two sections. Firstly, the location of the disposal site in relation to the town community and, secondly, the sites' location in relation to any water source in the area will be discussed.

(i) Location of the disposal sites and its impact on the people

The negative impact of the open and uncontrolled dumpsite can be huge for the environment and the communities located in close proximity of the dumps. The dumpsites for Goroka town like all dumpsites for urban centres in PNG are open dump. This was evident from some respondents' responses and the field observations made from trips to the two main disposal sites, Fimito and Kamaliki. When the solid waste disposal sites are not constructed properly into land fields to collect the leachate, the sites become a threat to the health of the public and the natural environment in and around it. The households view on the dumpsites and their impacts in relation to the public and environmental health was divided with some responding that the location was appropriate and safe, while others said it was not safe for the town community. A significant number could not comment as they did not know the location of the disposal sites. From the three responses, over 50% of the respondents viewed the locations of disposal sites to be unsafe for the communities and the environment. These respondents' major concerns were

that the dumpsites were a threat to the public health with a minority concerned about the pollution to the environment. These groups of respondents' views depended on the type of disposal sites they were referring to, that is, whether the dumpsites were household dumpsites that were mostly located in town or common/main town dumpsites that were located either in Goroka town or outside as discussed earlier.

The respondents who used the household dumpsites to dispose of DSW in pits, gullies, hillsides, and rivers responded that the practice pollutes the environments and is unhygienic for the residents near the dump who may contract diseases. The respondents who identified the location of the main dumpsite within the town vicinity, especially the Lopi and YWCA dumpsites, also commented that the dumpsites were a health hazard for the two communities. The threat was greater for the residents who were living next to the dumps because of the smell and disease-carrying insects such as flies that they attracted. For the YWCA dump, some respondents commented that it was on a slope above a few informal houses that were there with a creek below the dump. Therefore the rubbish ends up in the river polluting it. In addition, all the respondents who referred to Lopi and the YWCA as inappropriate commented so due to health and environmental threats posed by the dumpsite as viewed by the households. Hence it was important that the dumpsites were moved away from the town. The final respondents who indicated that the current disposal sites were not safe for the people and the environment referred to Faniufa, Fimito and Kamaliki dumpsites. The respondent who referred to the location of Faniufa dumpsite as inappropriate was concerned that it was close to town and had the potential to impact the health of the people negatively. Therefore some respondents commented that the Faniufa dump should be relocated somewhere else away from town. The rest of the respondents who answered that current locations of dumpsites were not safe for the people and the

environment considered Kamaliki and Fimito's proximity to Goroka Town, with most considering these two dumpsites to be at a safe distance from the town community but considered it to be health hazard for the villages that are located in its vicinity and the environment on which these dumps are located. From the field observation that was conducted, in both Kamaliki and Fimito had houses near the dump with the Kamaliki dumpsite located about ten metres in front of the landlord's front yard. Therefore, these concerns raised were important for health and safety of the people and the environment on which they were located.

(ii) Proximity of the dumpsites to any water resource and its impacts

Water resources are extremely important resources in the world; therefore, reserving and conserving the quality of water is vital for human communities. The solid waste generated by people needs to be carefully disposed of to maintain the quality of water saved for human use. In this research, the respondents were asked about their views regarding the location of the disposal sites in regards to any water resource near it. Their responses are discussed here.

The respondents were asked about their knowledge of any waterway that was located near the household disposal sites and the main town disposal sites. The majority (62%) of the respondents answered affirmatively (yes) while a minority responded negatively (no). A significant number responded that they could not comment as they did not know the location of the disposal sites.

Table 6.9: Location of disposal sites and its relation to the water resources near the sites

Responses	**Households**	**View on the disposal sites impact**	**Households**
Yes	50	Pollute the water and impact people health	45
No	11	Does not impact the water way or people	5
No comments	19	No comments	30
Total	**80**	**Total**	**80**

Source: Field work, 2011

The households that commented that there were no waterways near the disposal sites, and those who responded with no comments as they did not know the location of the disposal site, made no further comments on the sites' impacts. However, from the respondents who responded positively to having waterways near the disposal sites, the majority viewed that the disposal sites would pollute the waterway and impact the health of the people. The majority of the respondents that expressed their views that the dumpsites polluted the waterways and affected the health of the people gave reference to both the household disposal sites and the main town disposal shown in Table 6.7. Most of the disposal sites especially the ones used by the whole town were located near the rivers or waterways with Zokozoi River being used as a dumpsite. The disposal sites close to the waterways or in the river are listed below:

a. Gullies in town (household disposal site)
b. River Zokozoi (household disposal site)
c. Lopi (common disposal site in town)
d. Fimito (main town disposal site)
e. Faniufa (main town disposal site)
f. Kamaliki (new main town disposal site)
g. YWCA (common disposal site in town)

All the respondents were concerned about solid waste and toxic chemicals in the decomposing SW disposed contaminating the open disposal sites reaching the water in the rivers, creeks and

gullies and their impact on people using the contaminated water. A good number of the households were concerned that the quality of water in the water ways near the disposal sites were degraded especially the river located near Fimito, Kamaliki and YWCA. They mentioned that the people were actually using the water in the water ways for their daily household use and only one participant took some action in stopping the disposal of solid waste from the University of Goroka being disposed of at YWCA even when the cost of disposal was cheaper there. One participant was also concerned that the toxic waste from the solid waste would seeps into the soil and contaminates the underground water that eventually ends up in the creeks and rivers contaminating the surface water. This is an important observation as many people in Papua New Guinea do not easily make the link between contaminated underground water and health problems.

6.5 Benefits and challenges of household DSW management techniques

The segregation of solid waste at the source brings about many benefits for those who generate it. The DSW when segregated well at it source results in the recovery of resources and minimises the solid waste that ends up in the land fields. The responses of the household interviews regarding the success of the DSW management using the solid waste reduction and resource recovery methods and the benefits for the households are discussed here.

The majority (64) of the households responded that the management of their DSW using the reduction and resource recovery methods before disposal and after segregation in their households were a success.

This majority claimed that their solid waste minimisation was successful and all shared the common view that it reduced the total solid waste that was disposed of at the disposal site.

The households' successful reduction of DSW through resource recover activities is an important factor that led to council reduction in DSW for collection. Therefore the council does less collection from the households.

6.5.1 Benefits of Indigenous Resource Recovery and Reduction Techniques for Household in Solid Waste Management

The solid waste reduction and resource recovery methods reduce solid waste but also recover resources. These two factors are beneficial for the people involved in solid waste management. The households at Goroka gave various benefits of using the IRRP with 98% of the households commenting that there are benefits to the IRRP they used.

Table 6.10: Benefits of reduction and resource recovery activities

Benefits of waste reduction activities	**Reduction activities**
Finance(61)	Reusing, recycling, burning, composting and reducing consumption
Food Production (56)	composting / mulching of biodegradable
Clean healthy environment (40)	All reduction activities especially composting and burning
Beautification (15)	composting /mulching of biodegradables
Education for households (3)	All reduction activities
Saves time (3)	Reusing, recycling, burning, composting and reducing consumption
Personal satisfaction (1)	All reduction activities especially composting

Source: Field work, 2011

The responses of the households were grouped into different categories as shown in Table 6.10. The benefits are listed from the most common to the least common according to the number of respondents who mentioned that benefit. The financial benefits for households were through generation of income and reduction in spending.

6.5.1.1 Financial benefits, Food production and Healthy environment

The management of DSW in Goroka for majority of the households are focussed in the benefits that the households receive from it. Financial benefit is a major motivating factor for households involved in the IRRP There are two major financial benefits for the households from the resource recovery activities. The benefits are income generation and cost reduction.

The incomes were generated from reusing plastic products (bottles and containers) to making homemade products such as soft drinks, ice cubes, jam and cooked rice for sale. The reusable plastic products (bottles) were also sold to other residents to be reused. The plastics were also re-used to nursery crops and flower seedling and sold to the public. The second activity that brought income to the households was the selling of soft drink aluminium cans and glass beer bottles to companies for recycling purposes. The glass jars are also being reused to store jam and some are reused to make homemade lamps. The third activity that generated income for the households was composting. When the households composted the biodegradables in their gardens they were able to grow vegetables and flowers that they sold to the public. The households reduced their costs firstly through reusing plastic and glass products as storage containers, carry bags and poly bags to nursery seedlings. Secondly, the households burnt papers and dry branches from yard cuttings as firewood for cooking. They also burnt plastic package and bags to start fires. Thirdly, through composting the households are able to produce their own vegetables and fruits thereby reducing their cost of buying food from the market and shops. Finally, some households plan by choice their daily meals and reduce the consumption of food and other goods thus reducing their costs.

The financial benefits for households through resource recovery is important for the households as some households had incomes that is not enough to sustain them due to high cost of living. The financial benefits are important for households in urban centres therefore SW management efforts in Goroka should promote activities that give such benefits to generate interest and active participation from the public in management of solid waste in Goroka town.

6.5.1.2 Food production and healthy living environment

The composting of biodegradables to grow vegetables and fruits to maintain the households' food supply was the second most important benefit that households had. The production of food through composting is linked to the households' cost reduction that is mentioned earlier. Through composting the residents are able to grow crops for their own consumption or for sales to the public in town. This enables them to reduce their cost of buying vegetables from the market and maximises their opportunity to generate income. The income that is generated from composting is through sales of vegetables and flowers harvested from their garden, plus the seedlings of crops and flower nurseries using the compost. The residents who are commonly involved in this agricultural activity are the self-employed population of Goroka town. However with high cost of living the employed residents are also involved in the agricultural activities mainly vegetable growing in their yard for consumption. For most residents who live in informal housing, composting is important as through composting activities households are able to grow their crops and harvest the vegetables to sustain their livelihoods since most are self-employed. To conclude, composting is a resource recovery activity through which there is food production, cost reduction and income generation. The practice is also important as it is an environmentally safe practice as through composting carbon is retained and not emitted into the atmosphere.

However, the disadvantage of composting is that when it is not managed well, it generates methane gas which is a dangerous greenhouse gas that can impact on people's health. Furthermore, when the compost is contaminated by inorganic substances it can lead to contamination of the food supply and impact on people's health.

The other main benefit for the households was having a clean living environment when they used all the different reduction and resource recovery activities to manage their DSW. However, the activity that was the most commonly used was burning solid waste to reduce the quantity and removing the SW completely. The quote from a respondent given below reflects this benefit:

'The compost from peelings and grass cuttings plus the ashes from burnt leaves improve the quality of the soil for our vegetables to grow well. We harvest the vegetables for our consumption so sometimes we do not go to the market to buy vegetables.'

This respondent knew that composting the biodegradables improved the soil quality and allowed vegetables to grow well and the household was able to produce and maintain their own food supply which reduced their cost of buying vegetable at the market. The households also remove the solid waste through burning to prevent the breeding of flies that would bring diseases to their household and make them sick. These activities thus keep the members of the household healthy. It is evident that the main focus of the households in engaging in the solid waste reduction and resource recovery activities was for their households' benefits. These benefits were to reduce cost and increase income generation, produce their own food supply for their daily needs and keep a clean and healthy environment for the members of the household to maintain their health.

The benefits of using ISWMP (IRRP and ISWDP) are a motivation in itself to get the households to participate in the management of SW at the domestic level. Hence Goroka town council the organisation responsible to provide the SW collection and disposal services have to

capitalize on the this factor and strategically develop a system that encompasses the ISWMP used by the households that is beneficial for the town's domestic SWM.

6.5.2 Problems associated with solid waste reduction and recovery techniques

When the solid waste reduction and resource recovery techniques are not executed well, problems arise. The majority of the respondents that use reduction and recovery methods that their households use to manage the DSW, do not have any negative impact for their households. Whilst the majority stated that there were no problems, a minority of them responded that there were some problems with the techniques used. The minority that responded that there were problems with their current waste reduction and resource recovery activities were concerned with the issues listed here in order from the most common to the least common:

a. Burning of solid waste pollutes the air and sometimes does not burn completely
b. The compost gives off smell when it is not managed well
c. The recycling of metals and glass products was ineffective
d. Improper segregation by household members
e. The reuse of plastic bottles could be a health risk

Most of these households were concerned about the toxic fumes that were given off when plastics were burnt and how that affected the members of the household as well as the other residents. This concern is a significant one as burning releases toxic chemicals into the soil and greenhouse gases and other toxic pollutants into the atmosphere which are harmful for humans and the environment. Therefore, burning though removes the solid waste- releases pollutants and gasses into the environment.

6.6 Conclusion on solid waste management by households in Goroka town

The households in Goroka generated both biodegradable and non-biodegradable solid waste. There were almost equal amounts of biodegradable and non-biodegradable solid waste produced by houses with biodegradable solid waste being slightly greater. The equipment for managing the DSW was provided mainly by the households themselves, with only a few provided by the council, landlords, government and non-government organisations. The equipment that was provided by the institutions was commonly large bins. However the most common household equipment for storage of DSW was plastic shopping bags. The management of solid waste by the households interviewed for this research in Goroka comes in two parts: i) the disposal of DSW; and ii) solid waste minimisation and resource recovery. The majority of the households segregated the DSW at the source of generation into different categories while the remaining households disposed of all the domestic waste together. The households that segregated the domestic waste had six categories- with one being for permanent disposal and the other five categories involving waste reduction and resource recovery. These five categories were: composting, burning, reusing, recycling and giving away. The households used the reduction and resource recovery methods to manage their DSW as it was beneficial for them. The major benefit that the households got from these activities was financial as it generated income and at the same time reduced spending. The domestic solid waste that was disposed of was either collected or disposed of by the individual households in disposal sites created by the households or in the main town's disposal sites. There were six different types of domestic disposal site used by the households and seven main disposal sites. The common disposal

sites that individuals used were dug up pits and the main town's disposal sites were open dumps of Kamaliki, Fimito, Faniufa and the YWCA slope. The entire disposal site posed threats to the people and the environment as they were not controlled or well-managed and thus caused pollution and public health problems.

It is indicated clearly that the ISWMP with regards to IRRP is beneficial for the SW producers who are applying the techniques as well as the wider community in Goroka and the town council who is mandated to deliver the SWM services. The ISWDP used by the households to dispose both biodegradable and non-biodegradables have some challenges as the ISWMP is not design to properly address the disposals of the non-biodegradables that poses threat to the environment especially the leachate and toxin chemicals that can pollute the ground and surface water and soil. In this instance a proper sanitary landfill that is design to prevent environmental pollution needs to be considered.

Furthermore there is an urgent need to develop SWM policies and strategies in Goroka to drive the activities that promote sustainable SW management system that is aimed at mitigating the negative impact of the environmental and public health. This policies and strategies should also aim at maximising the productive in the town's SWM whilst minimizing the cost.

CHAPTER 7:

SOLID WASTE MANAGEMENT IN GOROKA TOWN: BENEFITS AND CHALLENGES OF CURRENT SOLID WASTE MANAGEMENT

7.1 Introduction

The management of solid wastes in towns and cities are based on different solid waste generators originating from those in public places as well as in the households. The types of areas which are accessible and used by the public include parks, shopping centres, markets, streets and ovals among others. The type of solid waste in the households is called household (domestic) solid waste. The solid waste from the public spaces is known as non-household (non-domestic) solid waste (Damanhuri et al., 2009). The solid waste which is generated in public spaces in the towns and cities of developing countries is highly problematic to manage, as the authorities responsible for their disposal lack the resources to manage the daily solid waste produced by the public. Apart from this factor, the public's attitude toward littering and their lack of ownership of the solid waste in the public places for which they are responsible for contribute to the challenge that solid waste managers encounter (Makwara and Magudu, 2013). In Papua New Guinea these challenges are evident in the uncollected piles of rotting rubbish that is left in public areas and drains. Goroka town, with its growing population, demonstrates the need for improved solid waste management service as the current service capacity, established in the 1940s to cater for its then small population, is out dated. In this chapter the different type of solid wastes that are generated in the public area such as streets, roads, parks, and markets shopping centres will be discussed. This discussion will include the organisation that is responsible for providing the

services and the income earning opportunities that are available for the solid waste managers and generators through recycling. In addition, the following aspects will also be reviewed:

i. The effectiveness of the current municipal solid management in public areas with reference to benefits and challenges and with suggestions of possible actions that can be taken to address the issues that exist.
ii. The organisational operations of the Goroka town council and its partners in providing the collection and disposal services for the community
iii. Community participation of municipal SWM
iv. The importance of community awareness and education about improper or effective SWM and their impact on the health of the environment and people.

7.2 Composition of Solid waste generated in the public areas

The type of solid waste that is generated in the public areas and discarded in Goroka town as litter is from both biodegradable and non-biodegradable solid waste. The majority of the households interviewed in this study responded that the bulk of the solid waste that they see in public areas in the town was non-biodegradable with a minority of the households responding that both types of SW were common. The households that commented that both types of SW were commonly found in the public areas further stated that the type of SW depends on the location in which it was found. The common type of SW at the vegetable market was mainly biodegradable while at the shopping centres it was commonly non-biodegradable. All the households commented that the people who generated the solid wastes and littered the public areas were the general public. However, the fieldwork observation for this study found that there were four broad groups of generators of solid waste in the town. They are:

(i) The residents of Goroka

(ii) Businesses and institutions operating in the town

(iii) Sellers at the town markets and street vendors

(i) Villagers and visitors commuting to Goroka town for a visit and for business activities

The quotes from respondents as mentioned below show their observations and opinions on the groups of people responsible for littering the public areas in Goroka town:

'The residents and people from the villages that come to town buy goods and consume them and dispose of the rubbish anyway they want. The town residents bring their rubbish from their houses and dispose them in the rubbish piles in town for the council to collect.'

'The main producers of the rubbish that is littering the town are the business houses who are disposing of cartons and plastics nearby. The other group is the people who come from outside to sell their vegetables at the market and who dispose the vegetable rubbish and plastics from the food they consume.'

'The people who are roaming around the town without a purpose or to shop litter the town with the rubbish they produce.'

Overall it was observed that most of the public, through their daily activities and operations use the public spaces to generate rubbish and litter areas such as shopping centres, markets, streets, parks and outside of offices with solid waste. The households also commented that from their observation the people or the public do not have any sense of responsibility of proper storage of solid waste. The following quote from one of the respondents reflect the grievance about public behaviour related to generation of solid waste in public areas and littering.

'It is our town as we reside in it but we are not looking after our town. Our town is very filthy. Betel nut sellers are everywhere so people who buy the betel nuts from sellers' dispose of the husks everywhere. There is plastic everywhere in town with few workers to collect and dispose of the rubbish littering the

town while more people generate it. When there is more rubbish the collection and disposal job becomes too much for the council workers to complete in one day.'

The above quote portrays lack of ownership and initiative of the public to actively participate in the management of solid waste generated in the public areas. This behaviour contributes to the build-up of litter around town with no proper storage of solid waste adding to the workload of the organisation managing solid waste in town. The behaviour of the public reflects the concept of 'public goods for private use' (Tyler Cowen 2013), where people use public areas for individual or group activities without taking ownership of the public area thus leading to overuse and abuse of the public space. Littering by individuals is related to people's mindset (Makwara and Magudu, 2013). The change of the individual's mindset regarding solid waste will alter their attitude and behaviour related to littering as well. The types of solid waste that is generated and the littering of public places in town are discussed in Sections 7.2.1 and 7.2.2.

7.2.1 Biodegradable solid wastes littering the public areas

The biodegradable solid waste that is generated and the littering of public space or areas as observed by the respondents can be classified into four categories according to the type of solid waste as shown in Table 7.1.

Table 7.1: Biodegradable solid waste littering the public areas in Goroka Town

Biodegradable SW littering the public area	**type of biodegradable**
Food products waste	Fruit & vegetable waste, leftover food and coconut husk
Betel nut waste	Betel nut husk and spittle
Paper products waste	Sheets of paper empty cartons and cardboards and paper packages and bags
Parks and garden cuttings	Tree, grass and flower cuttings and weeds

Source: Fieldwork, 2011

The biodegradable solid waste that is found littering the public space is similar to that which individual households generate. However, the amount of each type of biodegradable solid waste from households and the public areas depends on the population of the respective areas. The quantity of solid waste generated in the public area is greater compared to that of the households, because the public spaces are frequented by a mobile population which is larger in totality and more mobile than that of households.

According to the household respondents interviewed in this research, the two most common biodegradables that litter the public areas are food and betelnut waste (mostly fruit and vegetable waste), followed by waste from paper products. Parks and garden cuttings appeared to contribute negligible amounts to biodegradable waste. More specifically, fruit and vegetable waste appeared to constitute the single most common biodegradable solid waste littering the public areas. This is so because it appears that people consume more fruits and vegetables than other products, because fruits and vegetables are probably cheaper and more readily available.

From the observation of the researcher during the collection of solid waste in the public areas by the council, it was noted that there were two established fenced vegetable and fruit markets. These markets sold fruits and cooked and uncooked vegetables in Goroka town. There are several other informal markets in front of shops and along the streets in the town where vendors sell different varieties of goods. The cost of each fruit or vegetable differs slightly from market to market. However, in the market where the researcher bought fruits and vegetables, the cost ranged from 20t (10cent) for a single or small fruit to K4.00 ($2) for a large fruit such a pawpaw/pineapple or a bunch of ripe bananas. Cooked vegetables that the public in Goroka bought and consumed from the same market ranged from 20t (10cent) to K2.00 ($1.00) and

almost all the vegetables were cooked without peeling. This means that the consumers had to peel them in order to eat them thus discarding the outer covering and, as a result, littering the public areas.

Betelnut husk is another common biodegradable solid waste discarded in public areas by the consumers. The researcher observed that betelnut is sold in bulk in designated markets. It is bought by individuals and re-sold at a price of 30t (15cents) to 80t (40cents), again depending on the size of the nut, in informal markets along the streets and in front of shops in the town. The betelnut is a nut that grows on the coast of PNG which was initially used as a commodity for social gatherings where people chewed betel nut and mingled with each other. Betelnut was given to people especially visitors as an icebreaker before any discussions and negotiations were done. However, with modernisation betelnut has been commercialised and sold throughout PNG moving from the coastal provinces to the highland provinces such as the Eastern Highlands where Goroka town is located. The betelnut is chewed with mustard and lime made from sea shells and corals to produce a bright red mixture that is later spit out. The large proportion of betelnut husk observed by the households littering the public space reflects the high public consumption of betel nut in Goroka town.

7.2.2 Non-biodegradable solid wastes littering the public areas

The production and management of non-biodegradable solid waste in public areas in Goroka town is problematic due to lack of storage equipment and infrequent collection which results in an overflow of solid waste and littering in public areas. The solid waste that is generated or litters the public areas are both household and non-household waste. Household solid waste is discarded on public streets or areas seen as common garbage areas. The different types of non-

biodegradable solid waste that are found discarded or littering the public areas are given in Table 7.2. According to the responses of the households interviewed in this study, the bulk of the non-biodegradables discarded in public areas are plastic waste, consisting mainly of packages and bags, but empty tin cans and glass bottles are also reported to be very common non-biodegradable wastes in Goroka town.

Table 7.2: Types of non-biodegradable SW littering the public space in Goroka town

Kinds of non-biodegradable waste littering the public space	**Number of households mentioning each kind***
Plastic products	79
Empty tin cans	39
Glass bottles	32
Used diapers	6
Cigarette butts	5
Met al	5
Building materials	1
Old clothes	1
Drink cans	1

*The total in the second column exceeds the actual number of households
Interviewed because a household had mentioned more than one kind of biodegradable solid waste

Source: Field work, 2011

With plastic products being the main items of litter in public space in Goroka town, the reduction of packaging and use of alternative materials that can degrade easily may minimise the issue of pollution from non-biodegradable products. Partnerships between the businesses and the government with legislation targeting improved and less packaging with a focus on recycling would reduce the solid waste. Furthermore the adoption of no-plastic bags and reusable bags could mitigate the problem. The reusable bags adoption can include and encourage the use of bilum (string bag) made from tradition fibres that are biodegradable.

In addition, both the non-biodegradables and biodegradables litter the public areas. These solid wastes are either generated by the public during their daily business and are also discarded by households in the public areas for council to collect. This is evident in the quotes from two respondents, which is a common view shared by others.

'In the public areas especially on the streets I see used diapers, plastic packages of food, fruits and vegetable peelings, sheet of papers, empty tin cans and plastic and glass bottles discarded. The town council is ineffective in collecting rubbish so households dispose the rubbish along streets where the council can collect it.'

'*Plastics shopping bags, cans, betel nut husks and food rubbish from especially the market area when mothers come to sell their garden products are discarded everywhere. Also rubbish such as the pineapple peelings and plastic packages are discarded everywhere as there are no bins.'*

This indicates that people's behaviour of littering is tied with the lack of resources and storage equipment such as bins in public areas and the households. Moreover, the ineffective collection and disposal system by the council and its partners, the contractors have left the solid waste overflowing. This leads to a bad smell and breeding of vectors leading to diseases. The pollution to the environment from the garbage that is discarded everywhere leads to waterborne diseases such as diarrhoea and typhoid that are prevalent in Goroka.

7.3. Responsibility for collection and disposal of the solid waste in public areas in Goroka town

The individuals or organisations responsible for the handling, transferring, transportation and disposal of the solid waste in the public areas are vital for the effective and sustainable solid waste management systems in a given settlement. In Goroka town it is the responsibility of the Town council to collect and dispose of the domestic and non-domestic solid waste. This includes the commercial and industrial waste. The council sometimes contracts individuals with open

back trucks to collect and dispose of solid waste. However, from the household interviews and focus group discussions due to the ineffective collection and disposal services there are other individuals who also provide the service in public areas. This is shown in Table 7.3:

Table 7.3 Collection of SW by organisations other in public areas in Goroka town

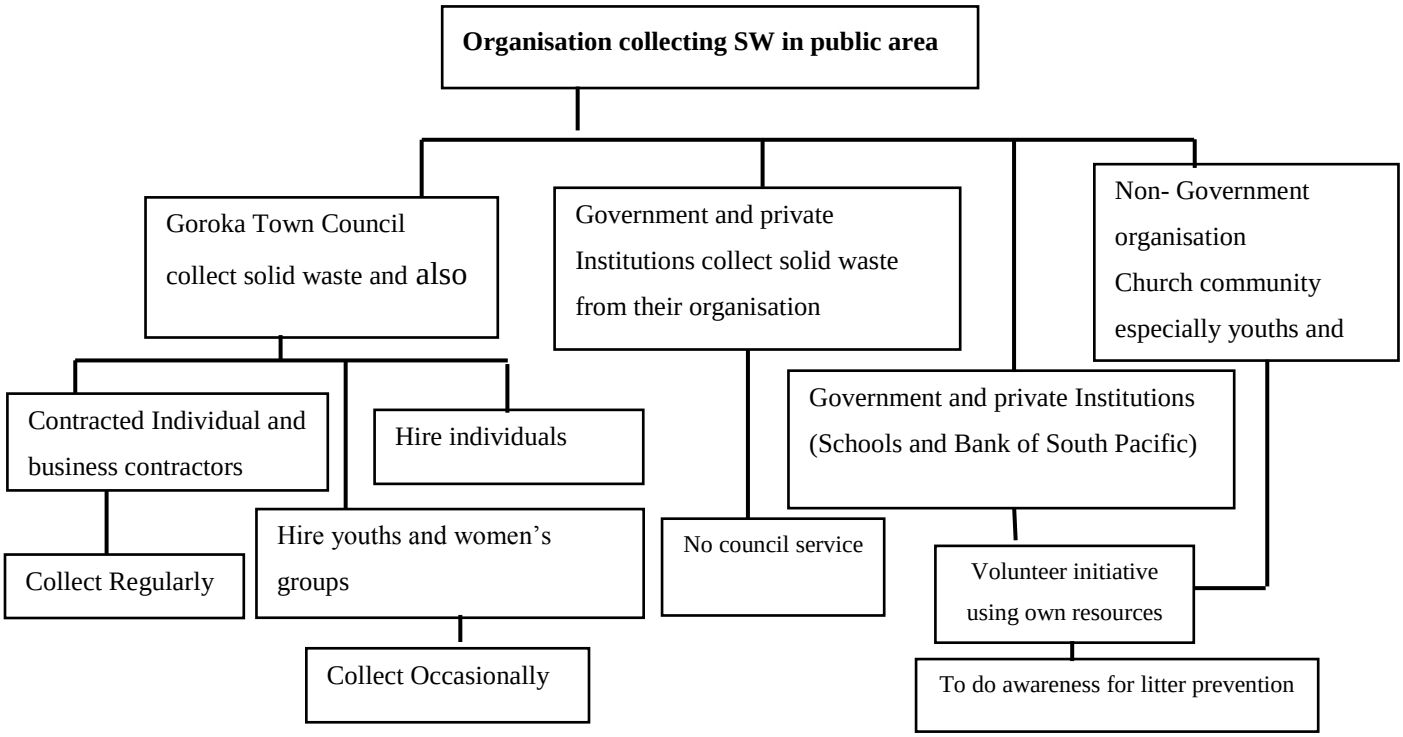
Organisations other than the (GTC)	**Specific organisations**
Contractors contracted by the (GTC)	Individuals with trucks & businesses
Non-government organisations	Churches (youth, women and overall church community
Government and private Institutions	Government institutions such as schools, universities, colleges, hospitals and sports institutes
	Private institutions such as shops, private schools, guest houses and banks (Bank of South Pacific)
Individuals	Individuals who sometimes do collections and are paid by the council

Source: Field Work, 2011

The solid waste that is collected and disposed of is a mixture of both the biodegradable and non-biodegradable solid wastes. There are common bins for all waste streams in public areas where mixed garbage is stored. Therefore, mixed garbage is collected from the bins and disposed without separation. The groups that collect and dispose of the solid waste from the public areas apart from the council are doing so for three basic reasons: (i) the council pays them to perform the duty (ii) failure of the council to provide the service (iii) groups such as churches, schools and Banks of South Pacific collected and disposed of all the different kinds of solid waste that litter the public areas occasionally. This collection and disposal activities by other stakeholders apart from the council was simply for the education and awareness of the public to prevent littering in public using their own resources on a volunteer basis.

Based on the information collected through the fieldwork, the organisations and individuals involved in the collection of solid waste and the reasons for their involvement can be explained as shown in Figure 7.1.

Figure 7.1: Organisations and individuals collecting, disposing and involved in litter prevention awareness in Goroka Town



Source: Field work, 20011

The initiatives of the groups in the collection and disposal of solid waste generated by their organisation and by others reflect three ways of improving solid waste management, as indicated below:

(i) Gaining ownership and management of the solid waste that is generated by the individuals

(ii) Claiming ownership of the public space and the solid waste found in these areas as willing members of the community by volunteering to maintain a safe and clean public space.

(iii) Claiming ownership of the issue of littering in public space and educating the public to actively participate in the litter prevention in public space.

The values displayed in the actions of the different groups indicate that some residents of Goroka town are aware of the problem of littering in public spaces in Goroka town and are trying to address the issue at an organisational level. However, these initiatives and efforts need to be encouraged at a broader level for the whole town community for an active participation in litter prevention and effective solid waste management that is sustainable and eco-friendly. The way to start this should be with the groups that are already involved.

7.4 Equipment provided for storage, collection and transportation of solid waste in public space and public behaviour towards public property (Storage equipment)

The management of solid waste in the public space begins with generation, storage, collection, transportation and finally disposal. The coordination and management of these processes in an effective and sustainable way to promote good health of the environment and the public is vital. However in a town like Goroka located in a developing nation this is a major challenge and is discussed in this next section.

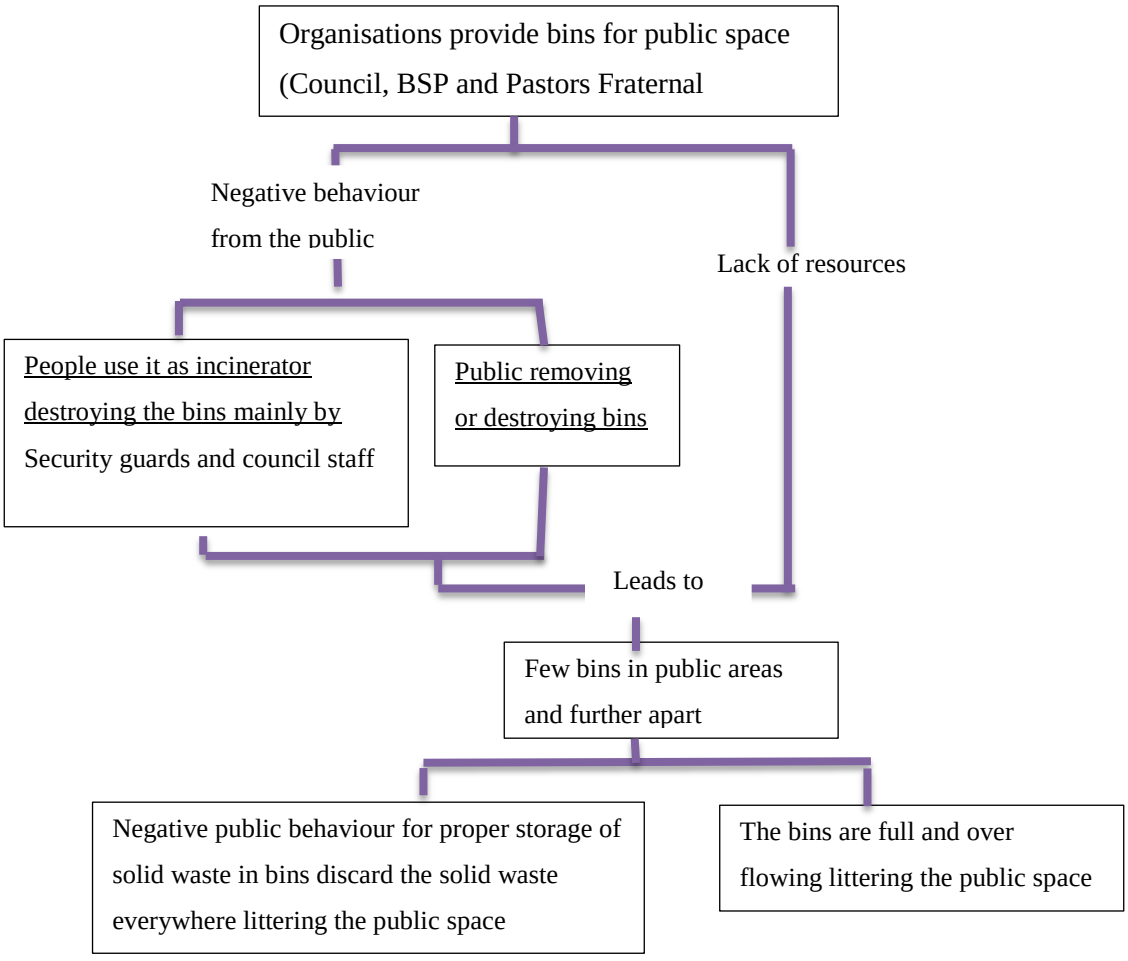
7.4.1. Storage facilities in public space in Goroka town

The proper storage of solid waste generated in the public areas in appropriate storage equipment is important. This keeps the solid waste covered and prevents the smell, breeding of vectors and decaying waste from polluting the environment and health of the people. The majority of the respondents commented that in Goroka town the storage equipment used in the public areas are empty 44 gallon fuel drums used as bins. These drums are provided mainly by the Goroka town council for the public to discard the solid waste there for storage until the collection. Apart from

the council, it was established that two other organisations provided empty 44 gallons drums at different times. These two organisations were Pastors Fraternal and the Bank of South Pacific through their litter prevention and awareness campaigns.

Some of the households indicated that the drums were provided in the past but not now as they hardly see any. There are two challenges of proving bins in public areas as identified by the households. These challenges were lack of resources and users' anti-social behaviour in relation to the public property. These challenges are illustrated in Figure 7.2.

Figure 7.2: Challenges of providing public bins and the bin-users' behaviour



Source: Field work 2011

The challenges of having limited resources mean that the organisations were not able to provide enough storage facilities for solid waste produced in the public areas. Adding to that challenge the negative public behaviour in caring for the public facilities, through removal and destruction of the bins meant that there are even fewer bins, resulting in overflowing of bins leading to the public discarding solid waste everywhere. The councils provide the bins as that is its responsibility. However the Bank of South Pacific and Pastors Fraternal provide bins as to create awareness of proper storage of solid waste in public spaces to prevent littering as part of their cooperative responsibility. There is no data to discuss whether there is any partnership between these organisations to maximise the resources and awareness. The negative behaviour of the public in not caring for and maintaining the storage facilities needs to be changed. This is a huge task as there is a huge cultural diversity that sometimes impact individual attitudes towards SWM. A quote from a respondent shows the common opinion regarding public behaviour and attitudes in relation to respect and care for public property:

'The town council provides drums on main streets but some people come and remove them. These people do not have respect for public property. We had an experience where the council placed two bins on the street outside our house and someone tried to remove them. My husband argued with him and they almost fought.'

This indicates that some members of the public care about and respect public storage facilities and are willing to express these values to the others.

The limited storage facilities were evident in the researcher's observation from the collection of solid waste with council staff. There were very few bins in strategic areas along main roads mainly in the central business district, and as one moves away from the CBD the bins became

fewer and further apart. In some areas solid waste was piled on the ground where the bin used to be evident from the stand where the bin used to be placed.

7.4.2 Facilities available to collect and transport the solid waste generated in the public space

The type of resources used to collect, handle and transport the solid waste from the public space in Goroka was limited and labour intensive. This factor with other related factors led to the delay in collection and disposal services making them ineffective and problematic in Goroka Town. The resources that were available for use in managing solid waste are discussed here.

(i) Vehicles used for collecting and transporting solid waste

The common type of transport used by the council for collection was mainly open back trucks. At the time the data was collected it was observed by the researcher and from the respondents that there were only two trucks that the council used for collection of solid waste in public areas as well as the domestic waste. Apart from using the two trucks for collection, transportation and disposal of solid waste, the trucks were used for other council operations. It was also observed that a garbage compactor truck was making collections in town in the public areas but was not owned by the council; therefore, the coordination of when and how the compactor was used to make the collection of solid waste was vested with another organisation with very little council influence.

The factors stated here indicate that the council has limited capacity to collect the solid waste that is produces by the public on daily in the public areas as well as the domestic waste. Having open back trucks for collection and transportation means that the council can collect and transport less solid waste at a time compared to a compactor truck that can compact and hold more volume of solid waste. It also shows that there is a lack of cooperation between the council

and other stakeholders in the collection and transportation of solid waste in Goroka town to maximise the resources needed for effective performance.

(ii) Safety equipment used and council staff employed for collection of solid waste in Goroka town

The collection of solid waste in Goroka town is done manually by the council staff making it labour intensive and time consuming. Employing enough staff to do the collection is important for the council to complete collection in all the sections of town in a day. Goroka town council has a collection team that consists of a supervisor who oversees the collection, transportation and disposal process and 4 to 5 staff per collection staff. There are sixty established positions for permanent collection staff in the solid waste collection and disposal section with ten casual positions that are utilized by the section to hire employees when needed. However, at the time when the study was carried out there was only fifty permanent staff employed with no casuals, as there were financial constraints. These fifty garbage collection staff collected the solid waste in the different sections of town including the public space. Having this number of staff to collect the solid waste manually with normally only one open back truck for the three main sections of town, North Goroka, Town- Seigu and West Goroka –Faniufa with a population of about twenty thousand (NSO 2009), is a huge challenge. There is a further constraint on the resources used for collection as there is a daily influx of commuters moving from villages to the town to sell their produce and generate the solid waste resulting in an increase in solid waste generation as observed by the researcher and stated by the household respondents.

The lack of manpower to conduct the manual collection of solid waste with a low volume capacity to hold solid waste in an open back truck results in a slow and time consuming collection service that ends in incomplete collections on any given day. This was evident in the researcher's four observations of the collection staff where the majority of staff were picking up

or racking the solid waste littering the town and piling it up in one spot in the public areas for collection. There were about four to five staff lifting the bins and emptying them into the truck and using spades to scope up the solid waste piled on the ground to load the truck.

Furthermore the bins that are located along the main streets are welded to their stands to prevent people from removing them. This made it difficult for the collection staff to lift the bins and empty their contents. Therefore, the bins are tipped upside down with their contents spilling to the ground which was later scooped up onto the truck with spades or by hand. This practice, plus the fact that collection sometimes started after the official time of eight a.m. and the money for fuel was controlled by another officer other than the supervisor or the driver, meant that the collection team had to travel to the fuel station and wait for the staff responsible to come and pay for the fuel before the collection started. This further delayed the collection and transportation process resulting in only three to four truckloads of solid waste collected, transported and disposed in a day covering about a quarter of the whole town. The coordination of finance for collection by another officer besides the supervisor indicates distrust and break down in the organisational system of the council staff.

The huge amount of solid waste generated in the public space compounded with the negative public behaviour of littering everywhere meant that the bulk of the collection was done in the public area with very little collection of domestic waste. The four observations of collection and disposal activities established that collection and disposal of solid waste was done daily in the CBD, and along main roads in town close to the CBD with the council hardly going out into the residential areas to collect domestic waste in that week. This was due to overwhelming solid waste generation and littering by the public which led to increased workload for collection staff.

With limited manpower and vehicles combined with lack of time management and financial coordination and a breakdown in the organisational chain of command, the end result was uncoordinated, operational and collection activities. There was no systematic routine for collection and disposal. With uncoordinated operations, huge workload for the collection team with limited resources, it is likely that the occupational health and safety of the staff would be overlooked with regards to provision of appropriate safe equipment and methods of collection, transportation and disposal. This is discussed in section (iii).

(iii) Appropriateness of equipment provided for collection and transportation of solid waste by council staff

The comments made by some household respondents that the open back truck used by the council and its contractors to collect the solid waste in Goroka town was not appropriate was also evident in the observations made by the researcher. The use of open back trucks meant that council staff worked in unhealthy conditions where they were exposed to bad smells, harmful solid waste and toxic chemicals that were produced by the mixture of decaying solid waste. There were very limited gloves used by the staff to gather and load the trucks. It was observed that there were about four to five council collection staff members loading the garbage truck with only two staff having glove for only one hand while the rest had no gloves to pick the SW and load the garbage truck. There were no masks or safety boots used during collection and the loading of the garbage truck.

Apart from that, the only equipment provided for the staff with which to pick up solid waste from the ground and load the trucks were spades. However, there were only two to three spades used during the collection and loading of the solid waste. This meant only two or three staff loaded the truck with SW while other staff waited or loaded the solid waste onto the truck

without the use of protective gear both on the truck and the ground. The garbage collection supervisor commented that each team of collectors used between two to three spades to load the solid waste from the ground onto the truck. This practice is therefore a potential health hazard for the council staff and needs to be improved. A quote from the collections supervisor who worked for the council for twenty years with twelve of those years as collections supervisor indicates the lack of resources faced by collection team:

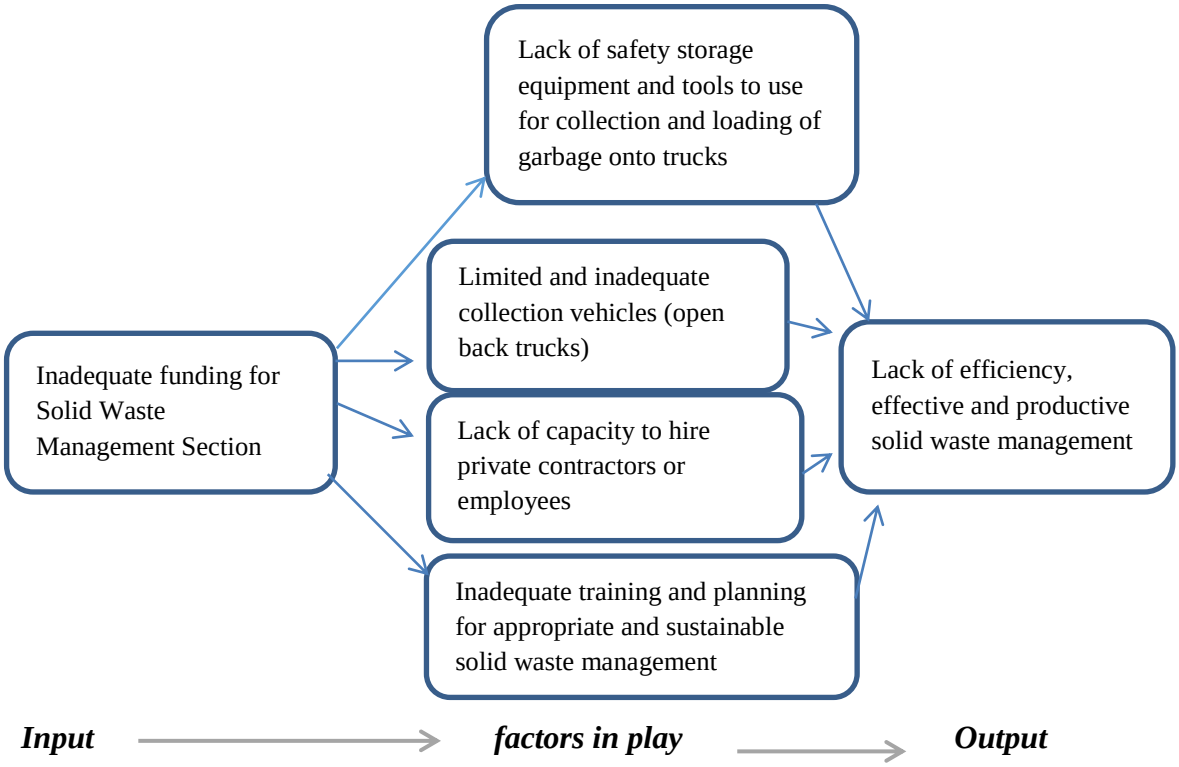
'*Usually, we use gloves and safety boot or safety wear but at the moment there is no safety wear used to collect the rubbish. We use our bare hands with the spades to collect the solid waste and throw it into the truck. And sometimes our staff work bare foot during collection and transportation of solid waste.'*

This insufficient provision of the safety gear indicates lack of funds to provide such simple but vital equipment for collection staff. This shortfall and challenges are discussed in Section 7.2.5

7.4.3. Financial capacity of the Council's Garbage Division and the challenges faced

The responses of the two council officers, education officers, and households showed that the lack of financial capacity for solid waste management impacted on all aspects of its management leading to inadequate supply of equipment and insufficient funds for operational activities for efficient and effective work output as shown in Figure 7.3.

Figure 7.3: Inadequate financial capacity for the garbage collection sections in Goroka town council and its impact on the operations of the SWM in Goroka



Source: Field work, 2011

According to the collections supervisor the lack of finance to fund storage equipment leads to the solid waste collection and disposal section providing forty-four gallon drums as bins for public spaces especially for major streets, and small public institutions such as schools and private institutions such as hospitality businesses that provide accommodation facilities such as hotels and guest houses. The other private institutions, larger public institutions such as universities and households are not provided with the forty-four gallon drums by the council. Therefore, the other private and larger public institutions provide their own bins while the households use bags to store their domestic waste for collection. The households' comments in Chapter 5 in section

5.5.4 indicates that apart from councils providing the storages bins, both public and private institutions, landlords and individuals provided bins with some also collecting and disposing their own solid waste.

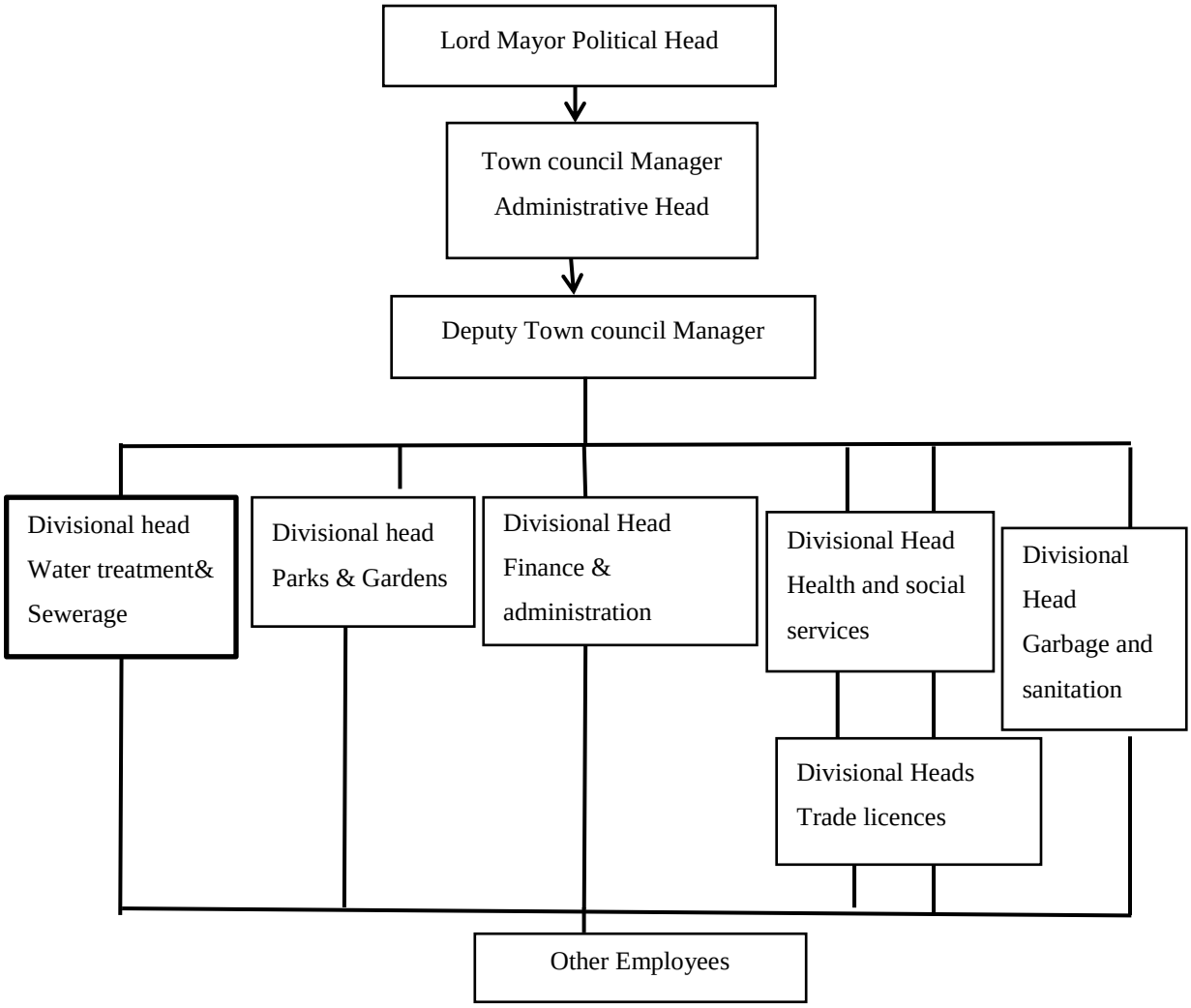
This indicates that the residents and public in Goroka town are able to provide their own storage equipment which takes the constraint away from the council but this also results in uncoordinated efforts. Therefore, the actual operational cost for managing solid waste in Goroka town is not realized by the council, nor is it translated into their budgetary planning. The reasons for councils not providing the solid waste storage equipment for the other private and public institutions are not established here. However, the main reason for individual households not being provided with bins is because, individual households are required to provide their own storage bins according to the council regulations. Furthermore, the households segregate the SW at source and manage it using the resource recovery methods hence they do not generate much solid waste individually compared to the organisations. Hence, this practice of non-provision of storage equipment by the council leads to households taking their domestic solid waste to common garbage areas or bins in town disposing it there and, thus, littering public spaces adding to the council's workload.

7.5 The organisational structure and financial implications for solid waste management of Goroka town council

The organisational structure and establishment of departments or sections and their operations determine the funds budgeted and allocated. In planning and budgeting for an organisation it is important to have a bottom-up approach where the planning and budget process starts with the divisional or departmental heads before it is submitted for final planning and budgetary processes by the top managers. This process is lacking for Goroka town council where the

divisional head of solid waste management is not involved in the budgetary planning and decision making for funds needed by their division. This indicates that vital information on the challenges and strength of the solid waste management available to the divisional heads is not fully discussed for an informed decision on the funds to be made. The organisational structure that an organisation develops and use can be a challenge or constrain on its own. The organisational structure of the Goroka town council is shown in Figure 7.4.

Figure 7.4.: Organisational structure of Goroka Urban Town council



Source: Fieldwork, 2011

The council's decision-making and chains of communication and command flow through this hierarchical structure and reach the employees who implement the planned activities thus providing services to the town community. The decisions on recruitment of staff, budgetary plans and allocation of funds to each division flow through this organisation structure.

It was established from the interviews of the council staff that the decisions on staff recruitment for garbage collection and disposal are made by the supervisor and the council managers. However, when it comes to the budgetary planning and allocation of funds, the supervisor is not involved as shown in the quote here:

'*At the moment, only the top management team which includes; the manager, deputy town manager, accountant does our budget. In other words, I'm not part of the budgetary process.'*

This budgetary process that excludes the contributions of the divisional heads that are directly involved in the implementation of the activities leads to an allocation of funds that do not reflect the actual operational costs resulting in the short fall in funding for each division. According to council officers, the total budget allocation for the solid waste management section was about K250 000 or quarter of a million kina in PNG's currency. The funds allocated are used to pay staff salaries, to buy vehicles, and for operational costs of managing solid waste. It is not clear whether this funding allocation includes costing of the sanitation. According to the council officers, this amount is inadequate for the division; however, as the true operational costing of solid waste is unclear, the inadequacy of the funding remains unclear. Nevertheless some household respondents express their view that the lack of funding is a result of bad management practices especially mismanagement of funds.

7.5.1 Causes of the challenges encountered by the solid waste management division

There are many different challenges encountered by the solid waste management division of Goroka town council. These challenges have a cause and effect system which is complex. Hence a factor that maybe a cause for a factor can become an effect at the same time of another factor. The responses from the household respondents and the council officers indicated that the main problem in Goroka was an ineffective solid waste management system which is evident in the inadequate collection and disposal of solid waste in the public areas as well as in residential areas. The causes of ineffective solid waste management are many as identified by the household respondents and council officers. These causes were classified into four main categories which are shown in Table 7.4.

Table 7.4: Causes of ineffective solid waste management in Goroka town

Main causes of ineffective solid waste management	Specific causes
1. Bad management practices	-Lack of leadership and cooperation from the political to the administrative level -Lack of planning and systems in place for municipal solid waste management -Mismanagement of funds -Non-performance of duty
2. Inadequate resources	-Inadequate infrastructure and facilities -Inadequate human resources -Inadequate funding
3. Public behaviour, attitude and practice	-Inadequate education and awareness -Attitude problem of the public -Ignorance
4. Rural - urban migration	-Movement of people from villages to squatters settlements

Source: Field work, 2011

The four factors that contribute to the ineffective solid waste management are caused by the public as well as organisations. Causes 1 and 2 are organisational while causes 3 and 4 are attributable to the people or the public. The majority of household respondents commented that the council's management of solid waste in the public areas and its collections from residential areas are ineffective: however, they viewed that the methods of solid waste management used to manage their domestic waste within their own households are effective. Moreover, several households stated that they have some constraints to the methods used to manage domestic solid waste, hence impacting the health of the environment and the public. Since these factors impact on the council's performance, there is a need for the council to address the in-house challenges before tackling the two causes that are related to the public. Nonetheless, this can be a difficult process unless there is cooperation at all level in the organisation. The result of the factors or causes discussed above leads to ineffective solid waste management in Goroka which causes several other problems discussed below.

7.5.2 The impact of ineffective solid waste management by the Goroka town council and its partners for the town community

The ineffective solid waste management especially in their collection, transportation and disposal result in further problems such as uncollected SW in households and public spaces. The solid waste collected from the public and residential areas are collected together without being separated. Collection staff pick up any useful item that they can retrieve, mainly drink cans, scrap metal, beer bottles and plastic drink bottles that can be reused and sold for recycling. This practice and the factors discussed earlier cause the following problems:

(i) Health risks

(ii) Environment pollution

(iii) Enhanced flooding and infrastructure damage

(iv) Portrayal of bad image of Goroka thus hindering business opportunities

The majority of the household respondents and the council officers expressed the view that ineffective solid waste management is a health risk. That is, when solid waste is not collected and disposed of regularly, it breeds insects such as flies and mosquitoes that cause diseases such as malaria and diarrhoea. The piles of uncollected mixed garbage decay producing a stench that can lead to respiratory problems for the public especially the people who have existing medical conditions.

In addition, a quarter of the household respondents and the council officers commented that ineffective management of solid waste also leads to environmental pollution. The pollution to the environment occurs when the solid waste decays and releases toxic waste into the atmosphere. Furthermore, when solid waste is not collected people burn it which releases pollutants into the soil polluting both land and air. Finally, solid waste, when not collected, leads to it being washed into the drains and eventually ending up in rivers. This is because storm water drains do not have any netting to catch debris, nor are they well maintained. The solid waste ends up polluting the rivers or destroying the drains causing flooding that damages infrastructures. The ineffective collection and disposal also lead to waste generators disposing of solid waste near or in the river polluting it.

The pollution of the general town and the natural environment threatens the health of the people who depend on the environmental services that nature provides. It is important that the solid waste generators and managers understand the vital relationship between the health of the environment and the public health, as when environmental health is negatively impacted this

affects public health. To minimise the impact of solid waste, the generators and managers need to be educated and made aware of the impact of inappropriate solid waste management and policies and strategies that are needed to be developed to guide the implementation of this management.

7.6: Solid Waste Management policies and strategies used by Goroka council to guide in the management of solid waste

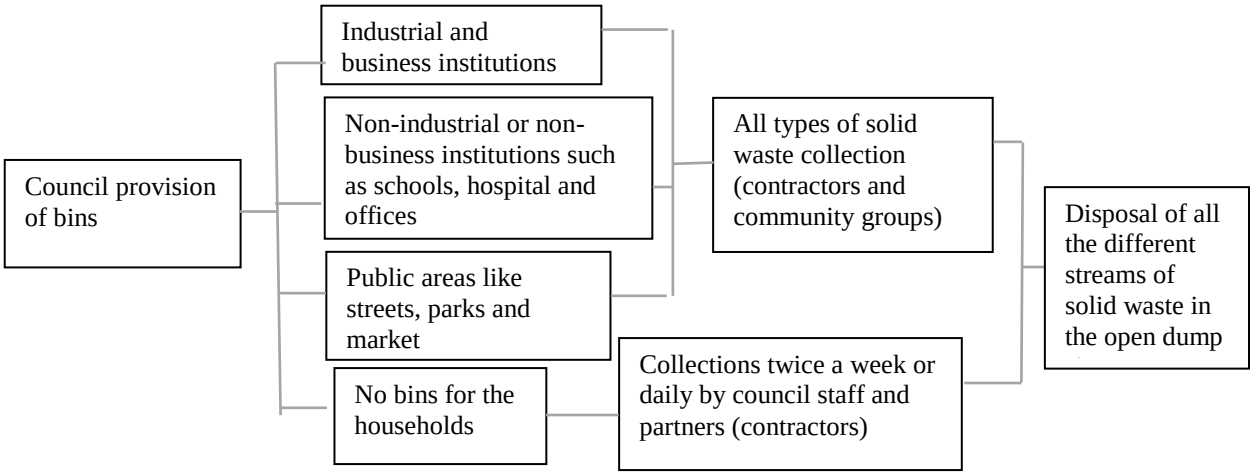
Solid waste management legislation, policies and strategies are important as they guide and regulate its management. A quarter of the household respondents commented that the cause of ineffective solid waste management in Goroka town was due to bad management practices with one aspect being inadequate planning systems established to guide the operation of solid waste management in Goroka town. This view was confirmed by the council officer who noted that there was no solid waste management or strategy developed for the organisation to use when managing solid waste in town as shown in the quote below:

'*There is no policy, plan or strategy to guide us to manage solid waste in an effective way. The management should develop the plans, policies and strategy for town SWM and give these documents to us to use but that is not done. I'm just giving direction and instruction the way I think it should be done that was used in the past. My aim is to make sure all the rubbish are collected and disposed despite the fact that there are no policies. Therefore the SW are collected together and disposed together at the dumpsite.'*

The solid waste management practices that the council are using were established in the colonial era with very minimal change .This was expressed by the majority of the households and was confirmed by the responses of the council officers. This practice does not take into account the changes that the town has gone through in its expansion and growth of population, infrastructure and institutional operations. The response of the officer clearly indicates that there is no

coordination in the organisation to establish who should be developing the plans, policies and strategies for solid waste management. Consequently, developing the current solid waste management system is a problematic one. The current practice of solid waste management by the council is shown in Figure 7.5.

Figure 7.5: Current solid waste management system in Goroka town



Source: Fieldwork, 2011

The number of bins provided for industrial and business institutions as well as non-industrial or non-business institutions ranges from one to five bins depending on the population and operational activities. The bins for the public areas such as streets, parks and markets were few with one to two bins that are provided in a given location.

7.6.1: Possible mitigation strategies to improve the challenges of managing solid waste in Goroka town.

The possible mitigation strategies to minimise and improve the challenges faced by the waste generators and managers in management firstly lie with addressing the causes of the challenges. The challenges of bad management practices, inadequate resources, negative public attitudes and

behaviour plus rural-urban migration have to be addressed. The responses of the council officers and the households indicated that there are needs for the goals below to be considered in order to realize any improvement:

(i) Improve management practices

(ii) Provide adequate resources

(iii) Change public attitudes and behaviour

(iv) Reduce rural to urban migration.

To achieve these four goals the majority of the household respondents and the council officers viewed that education and awareness of the public need to be encouraged using different modes to change their behaviour. Training for council staff is vital with employment of qualified skilled and experienced personnel who have knowledge of different methods of solid waste management by the council. The challenge of rural-urban migration is a complex issue that can be addressed with legislation at a provincial and national government level.

7.6.1.1 Improving management practices and adequate resources

To improve management practices there has to be cooperation between the different levels of leaders, commitment by the staff to their duties, proper management and controls of funding with improved planning and implementation of the solid waste management activities. The majority of the household respondents remarked that improvement in management practices will minimise the shortfalls in funding and maximise work output.

Furthermore the majority of the households and council officers expressed that the councils' ineffectiveness and inappropriate solid waste management would improve firstly when it was

provided with adequate resources or more funding from the government with the fees that are charged for the services provided fully paid by the customers. The current fee charged for garbage collection is K10.00 to K16.00 a month for residential areas and K500 or more for businesses and non-profit making institutions which are both private and government institutions. The charges are different as the institutions and businesses generate more solid waste than the individual households do. The total amount of funds generated from the garbage and sanitation fees is about one million kina a year, however, not all the solid waste generators pay the fees so there is a loss of revenue. Furthermore according to one of the council officers, the cost of collection, transportation and disposal of solid waste is about K10, 000 a week. Apart from that, a monthly fee of K1000 is paid to the landlord at Kamaliki for the disposal site. If this estimation is accurate, the operational cost of solid waste collection, transportation and disposal in a year would be K521000 (half a million kina) when, according to officers, the budget allocation for the garbage management team division is about a quarter to half a million. There is a shortfall in allocation and operational costing and whether this shortfall is met by the funds generated from the fees is unclear and not all fees charged are paid by the solid waste generators. Therefore more funding is needed of solid waste management in Goroka town.

Secondly, the households remarked that the council has to employed trained and expert officers with technical knowledge of SW to manage it, especially, the solid waste management section with adequate workers to provide collection and disposal services. Furthermore this could be met when council staffs are trained both in-house and outside of the organisation to enhance their skills. However according to the council officers, there are some awareness programs in existence but the actual training to improve the skills and knowledge of the council employees in solid waste management is lacking and there is no plan to implement this in the future. There

is a need to train staff to understand the different methods of solid waste management and use them within the organisation. There is already some understanding of different types of solid waste, therefore, the training will enhance and allow for development and implementation of appropriate solid waste management systems. Moreover, the labour intensive manual workload of collection, loading, transporting and disposing of the solid waste management section/division has called for more employees who will increase the amount of work completed in a day. Finally, household respondents claimed that adequate infrastructure and facilities need to be provided. The infrastructure, in terms of proper disposal sites such as landfills and bins, provided for all solid waste generators and adequate vehicles, especially compactor vehicles that have a large capacity to carry solid waste to disposal sites.

7.6.1.2: Change of public behaviour, attitude and practice

Changing the attitudes and behaviours of the solid waste generators (mainly the public) is a difficult and challenging task in a community such as Goroka Town where individuals of different cultural groups have varying cultural values and practices that shape their mindset as shown in the Chapter 5 where the participants come from almost all the provinces in PNG. PNG is a diverse country in terms of culture (Anderson, 2015). Even though there are some general similarities in cultural values there are also huge differences in the culture of the residence and the public in Goroka town due to this cultural diversity. For instance a responded from the highlands of PNG state that all SW are rubbish so it is disposed together while a respondent from the coast of PNG responded that it is important for process segregation as unsegregated SW deposed can collect water and breed mosquitoes. Therefore changing the behaviour and practices of individuals means that their attitude towards management of solid waste has to change so that

each person is encouraged to gain ownership and be responsible for the solid waste they generate especially in public. The concept of communal ownership that exists in the indigenous communities in PNG (Anderson, 2015) which was also evident in the management of the SW in public space in Wamonagu is an important concept to promote in management of SW in public space in Goroka. There should be special emphasis on the benefits of such approach to individuals as well as the community as a whole.

(i) Change of behaviour and attitude through Education and awareness

Education and awareness is vital in order to change the attitude and behaviour of the public. The majority of the households viewed that when people are educated and made aware of the advantages of careful and proper management of SW as well as the disadvantages of careless improper management of SW there would be positive behavioural change amongst the public. Hence people will not litter and manage SW well as individuals and as a community. The disadvantages of careless and improper solid waste management lead to environmental and public health risk as well as loss of resources when the resource recovery/waste reduction activities are lacking. The advantages of careful and proper solid waste disposal on the other hand are that it improves and maintains the good health of the environment and the public. In addition, there are opportunities of resources recovery that would lead to reduction in spending and increased opportunity to generate income.

There are some form of education and awareness which is conducted by the council and other stakeholders, such as the pastors fraternal an organisation established by pastors of Christian churches in Goroka, the Bank of South Pacific, schools and non-government organisations such as the church community, especially youth and women's groups as discussed earlier. However,

the focus of the awareness is litter prevention with the organisations providing bins and collecting the solid waste that litters the public space to raise awareness to dispose the solid waste in bins. The council as the town's primary solid waste manager spreads the word through the use of local radio and loud speakers to inform people not to litter and encourage them to use the bins in the public space.

Only a few household respondents commented that churches, especially the women's ministry, conduct informal sessions on the health and hygiene of families. These sessions cover some aspects of proper handling and disposal of solid waste as well as teaching the public about reusing certain empty tin cans to bake cupcakes to sell or for their own consumption, thus reducing the financial cost of buying from the shops and at the same time generating household income. Some respondents also commented that health officers also create public awareness when treating patients about the health impact of improper solid waste management practices.

Even though there are awareness campaigns targeting the public as the main audience, this is an uncoordinated effort and is randomly done without continuity. The uncoordinated random approach of public awareness makes it difficult to get the message across to the public to change their careless attitude and behaviour as solid waste generators and act positively when there are benefits for them in the solid waste management practices. This, thus impacts on the behaviour change of the public. The two possible benefits to begin with in this case would be environment and public health benefits; income generation and cost reduction opportunities need to be emphasised to target behavioural change. The mode of communication to raise awareness regarding the two benefits has to be appropriate and inclusive of the different age groups. The

household respondents viewed that education and awareness had to be conducted by different stakeholders targeting various groups of people. The groups identified were shown in Table 7.5.

Table 7.5: Groups identified to be suitable for carrying out education and awareness

Education and awareness campaigners on solid waste management	**Target group**
1. Council staff	The public (adults and children)
2. Health workers	The public (adults and children)
3. Churches	The public (adults and children)
4. Other NGOS	The public (adults and children)
5. Education institutions (schools)	Children and young adults
6. Parents and family members	Children and young adults

Source: Field work, 2011

The majority of the households' respondents stated that the council needs to implement awareness campaigns to educate the public. The suggestions are that the first four groups shown in Table 7.5 focus on the public while the last two groups focus on the education and awareness of children and young adults. The attitude and behavioural change in adults could be difficult as they have already developed their believes and values regarding life, however the children and young adults are at their developmental stage so the values and benefits of careful and proper management of solid waste introduced to this group of people are vital for positive public attitude and behaviour. Therefore, the involvements of the institutions that nurture these young minds are needed to bring the message across. Learning starts at home for children before they go to school, however only a handful of household respondents identified this factor while the majority commented that it is the responsibility of people in other organisations including schools. Parents need to take ownership to be the first educators of their children regarding

positive and appropriate attitude and behaviour towards solid waste management. The common views of the majority are reflected in the quotes of two respondents here:

'*There is very little or no awareness campaigns conducted by the council for the public to properly manage the solid waste in town. Solid waste management is also a livelihood issue and not just environmental so everyone should be concerned about it. People need to be educated through using churches, educational institutions, health institutions and NGOS about the impact of improper management of waste and benefits of proper management.'*

'We need to plan for a long term change of about 10 to 20 years and educate the children in primary school teaching them the appropriate methods of managing solid waste. With the new generation, things can change. I personally believe that all people need to go to church so they can have the wisdom to change their attitude and bring human sense back.'

The modes of communication for education and awareness are important and the households and council officers identified them as follows.

Table 7.6: Channels of communication identified to be suitable for carrying out education and awareness with a target group of people

Channels of communication for general public awareness	**Mode of communication for children and young adults**
Media (local and national radio and newspapers)	Teaching school curricula about solid waste management
Public campaign (open campaign, door to door)	Practical activities
Targeted information session (medical worker to patient discussions)	Projects involving communities and schools-
Newsletter and pamphlets	Workshop for older students year 9-12
Cleaning activities of public space	

Source: Field work, 2011

The education and awareness of proper solid waste management in schools depend on the curriculum that is developed. Therefore, six senior education officers from six different educational institutions were interviewed to confirm the claims by some household respondents that educational institutions teach some components of solid waste management. These education institutions began with primary schools up to the colleges and university. The main focus of all educational institutions was to educate and developed the children and young people in all aspect of life so that they live in a community as good citizens of the country. That is integral human development which is a national goal for PNG as a nation.

Moreover, educational officers commented that there are some curricula in environmental studies that are integrated into the subjects taught. In primary schools, they are part of the subject called Society and Environment, while in secondary school they are part of social science, especially Geography, Biology, and Agriculture in the science subjects. At the University of Goroka, Environmental Studies is a program which is coordinated by the social science section with courses taught by staff of the University's partner, the Research and Conservation Foundation of PNG. In addition, their other programs in the social science and science disciplines also teach about human activities and its impact on the environment and the people that briefly cover SWM. However, from the responses of the educational officers and some households, the curriculum on the environment mainly in primary and secondary schools is general and mostly covers topics on natural resource management. However at the university level, the subjects become specialized and environmental studies issues such as environmental degradation are covered and solid waste management is taught as a problem. Another university discipline that has solid waste management and public health in its curriculum is the Health Science section of the science faculty according to a household respondent employed by the University of Goroka.

Apart from the lessons in the class, the primary and secondary schools have students doing extra-curricular activities during which students clean the school yard with minimal segregation activities. Students are encouraged to be responsible for the solid waste they produce at schools to collect and dispose of it in the school disposal sites. However these practices vary from school to school. For instance, a teacher responded that the school was involved in the UNICEF funded project called 'Child friendly school'. This is where schools are given equipment to assist in keeping their schools clean. Therefore cleaning is done as part of school activity. However as there is only one school involved in this project there are minimal practical activities for children as it depends on the teachers and their initiatives while another school only collects aluminium cans for recycling but students are not involved in any practical activities. Even though there are minimal resource recovery activities for the students to participate in at school, some of the household respondents' were teachers and lecturers; therefore they recover resources from their households and classrooms to reuse as teaching materials.

It is evident that institutions have some curricula on environmental studies that are broad and focused on natural resource management and conservation of biodiversity. They become more specialized with different levels of education with some teaching of solid waste management at primary and secondary schools. At the university level there is a topic on solid waste management and its impact on the people but again it is brief with minimal practical activities.. Therefore, there is no specific curriculum or program on solid waste management in the curriculum of the secondary and primary schools. There are very minimal practical hands-on activities that would encourage a positive attitude and behaviour from the students at a younger age regarding proper SWM. It also lacks information on the benefits of resource recovery

methods and negative impacts of improper SWM on the health of the environment and the public.

7.6.2 Can income earning opportunity in urban solid waste change the attitude and behaviours of the public in Goroka town concerning littering and improper solid waste management?

The majority of the households' respondents and the council officers stated that there are some income earning opportunities for the households and individual solid waste generators and managers. The income earning opportunities are available when the waste generators and managers used the resource recovery/waste reduction methods of composting, recycling, reusing and burning. The benefits of using these methods are financial where costs are reduced and income is generated as discussed in Section 6.5 regarding the benefits of using solid waste reduction/resource recovery methods in Chapter 6

There is one metal and glass recycling company in Goroka that is currently collecting scrap metals to be sold to overseas companies for recycling. The metals are restricted to only a few specific items like aluminium cans and car parts that are paid a certain amount for each kilogram. This narrows the opportunity for other items to be recycled. The glass bottles which are recycled are beer bottles sold to the beverage company South Pacific Brewery and Kalapi Scrap metals.

When the benefits of managing solid waste using resource recovery methods are encouraged through the overall system using legislation, policies and facilities that enable these activities, more people will participate thus changing their views, attitudes and behaviour about solid waste. The general perception of the public in Goroka is that solid waste 'is just waste', therefore their behaviour reflects that view. In order to change that view and impact the change in the

behaviour of the public especially, the adults' awareness of the financial benefits need to be increased to maximise the recovery efforts that the households in Goroka are already involved in.

7.6.3 Partnership between the council and other stakeholders.

The partnership between the council, other stakeholders and the wider community is vital for the success and effective operation that brings about high work output in solid waste management. The partners with which the Goroka town council engage are classified into three groups:

(i) Those which have direct involvement with the council in managing solid waste

(ii) Those which manage solid waste without direct involvement with the council

(iii) Those potential partners that have no involvement with the council or solid waste management

The different groups of partners that the council have or may have are compiled from the responses of all the respondents from households, council officers, education and other government officers. Table 7.7summarises the council partners and the activities in which they are involved in.

Table 7.7: Partnership between the council and other stakeholders in solid waste management

Type of partners	Name of the partners	Activities they are involved in
Partners with direct involvement to the council and solid waste management	-Private contractors with vehicles -Community Groups that are contracted or volunteer - Landowners Businesses	-Collection and disposal of solid waste - to clean and collect solid waste - paid to make land available for as disposal sites Collection and disposal of solid waste
The partners that are managing the solid waste without direct involvement with the council	Individuals households Landlords Industrial and business institutions (recycling by Kalapi scrap metal and SP brewery for beer bottles) Pastors Fraternal and the church community and Bank of South Pacific. Community groups and organisations Private and government institutions	-Collections and disposal as well as resource recovery activities -Collection and disposal of solid waste -Collection and disposal of solid waste and resource recovery activities -Provision of equipment and awareness by collecting and disposing -Providing equipment and collecting solid waste to raise awareness. Collection and disposal of solid waste -Collections and disposal of solid waste -Education and awareness by Schools, University and health workers and inspectors
Potential partners	NGO Environment and conservation department Other businesses Media Tourism Department	-Education and awareness programs -Policies and strategies for solid waste management Involved in resource recovery activities Awareness and education -Awareness and education to generate income

Source: Fieldwork, 2011

The table indicates that the council has some important groups as partners and needs to strengthen the partnership relationship to explore the option of shared responsibility and ownership with the partners to maximise the work output and reduce costing. As indicated in the table, the council has an active partnership relationship with only a few of its partners; therefore

it needs to engage in an active relationship with all its partners. One such partnership is the recycling companies and public who collects the metals and sell to the recycling companies.

The partnership that is used for the management of solid waste in Goroka town is the public-private partnership (Rocha & de Sousa, 2011) and public to public partnership regarding the collection and disposal of SW. There are four types of public-private partnership according to Rocha and de Sousa (2011): consultative partnerships; contributory partnerships; community development partnerships; and substantive partnerships. There are two types of public-private partnership that exist between the council the private-organisations. They are: contributory partnerships, where there is a contractual partnership between the council and the private organisation for the collection and disposal of solid waste in town; and community development partnership.

In the first partnership, community groups and individuals are contracted to clean, collect and dispose that solid waste. Furthermore individual customary land owners have a contracted partnership with the council to lease a piece of land as a disposal site. Through this partnership the council pays private institutions to provide collection and disposal services. In the second partnership, there is an agreement between the private organisation to collect and dispose of the solid waste at that town dumpsite without a cost being incurred. However with this type of partnership there is the possibility of the private institutions not performing well and the council not releasing the funds for the activity. This could lead to solid waste not being collected properly and the private organisations being double charged. For instance, in Goroka, when the council failed to pay the rent for the dumpsite, the landlord charged the organisations the disposal fee even when that fee has been collected by the council.

The second partnership is community development. In this partnership, there is some participation of private institutions in collecting and disposal of the solid waste as well as education and awareness campaigns on a volunteer basis. There is also involvement of the private institutions in the waste reduction and resource recovery efforts through recycling that the council is not a part of.

Apart from that, there are public to public partnerships in collection and disposal of solid waste. In this case, the public institutions collect and dispose of the solid waste produced by their institutions and dispose of it in the dumpsite with permission from the council. This practice again can result in double payment when council fails to pay rent for the disposal site. This has been a problem for the waste collectors in Goroka resulting in illegal dumpsites inside the town.

Table 7.7 thus clearly indicates that the type of partnership that exists in Goroka with regards to the management of solid waste is the public-private partnership. The common type of public-private partnership used is community development. In this case the general community contributes in trying to solve a public problem.

7.6.4 Programs that change people's attitude and behaviours towards processes of solid waste management

There are many ways of targeting behavioural change from the waste generators to reduce solid waste and prevent littering in public areas. However there were two methods that the households and focus group discussions established. The first one is programs that involve yearly competitions of various kinds that encourage the businesses organisations, non-business organisations, households, schools and local council wards (LLG) to keep their areas clean. The reward is given at the end of the year that would discourage people from littering. The second method is to encourage people to use the principles of 3 Rs to manage the solid waste by

establishing legislations and policies to promote recycling and reusing in order to reduce solid waste. These policies and legislation should target all solid waste generators and managers focusing on source separation rather than the end of the process during disposal that most developing countries focus on (Makwara &Magudu, 2013). The principles of 3Rs were established as solid waste managers were faced with the challenge of finding appropriate disposal sites (Damanhuri et al., 2009). The use of 3Rs reduces that challenge promote sustainable development. According to the World Commission on Environment and Development (WCED) 1987 in Bouanini (2013), sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their needs. Therefore, the 3Rs reduce solid waste and recover resources preventing further extraction of raw materials thus conserving the natural resources for future generations.

In Goroka, almost all households viewed that there were benefits for the use of the Indigenous resource recovery and waste reduction activities that involved the reuse, recycling and reductions of SW through the varies ISWMP that were discussed in the earlier chapter. The IRRP is similar to the modern concept of resource recovery in SWM of reuse, reduce and recycle also known as 3 Rs in the principle of Integrated Solid Waste Management that is promoted in the world as an appropriate approach for SWM. The use of the principles of 3Rs benefits the different stakeholders involved in the generation and management of solid waste. These benefits are shown in the Table 7.8. The benefit of using the resource recovery and waste reduction activities benefits a whole range of people and changes people's perception.

Firstly, this change in people's perception would contribute to people viewing solid waste as a resource. This resource then reduces the cost of buying new materials. It also maximise their

income generation when products are sold and made for sale through the process. Secondly, it improves solid waste collection and disposal efforts to maintain the good health of the people and the environment. This change in perception may lead to people changing their attitude and behaviour toward littering and improper solid waste management. This, in turn, could lead to effective management of source separation and resource recovery to reduce solid waste disposal in landfill.

Table 7.8: Benefits of using resource recovery and waste reduction techniques for different stakeholders

Stakeholders (Groups and organisations)	**Benefits**
Households	Improve household finance by reducing cost and promoting income generation
	Promoted household food production through composting and mulching
	Clean health environment
	Beautification
	provide family education and awareness
	Reduces times for domestic solid waste management
	Personal satisfaction
The Public	Clean environment
	Education of the public
	Financial
	Improved public health
	promote environmental services by nature
Town and Province	clean environment
	generate income and improve economy through tourism and other business opportunities
	improve health and reduce cost of health services
	improve beautification and image of town
Collection and disposal service providers	Reduce operational cost through reduced collection time and workload
	improve health and safety of the workers
	the money is diverted to improve the service delivery

Source: Fieldwork, 2011

Table 7.8 indicates that the major benefits of effective waste management through solid waste reduction and resource recovery effects are centred on three factors. These are: improved financial benefits; maintenance of environmental; and public health and production of household food supply. How the different stakeholders benefit depends on their individual needs.

7.6.5. Conclusion

Interviews with the households selected for this study and the researcher's own observations, shows evidence that solid wastes generated in the public space of Goroka town are both biodegradable and non-biodegradable SW produced by the activities of the public (both local residents and the transiting population passing through). However, some of the SW in public spaces is domestic solid waste that is disposed of in pubic bins and illegal dumpsites in the public spaces created by some households as the council fail to collect the DSW from these households. This practice results in solid waste littering the public spaces in Goroka town. The bulk of the solid waste littering the public space that is visible is non-biodegradable. The most common non-biodegradable solid waste in the public space is plastic products. However, the composition of the type of SW littering the public spaces depends on their location and the predominant activities of the people there. For instance, even though non-biodegradables are common types of solid waste visible, there are huge amounts of biodegradables discarded in the places where vegetables and fruits are sold.

The public is responsible for littering the public space by generating the SW and discarding them everywhere. The council and its contractors are responsible for providing solid waste management services but have not executed that role effectively. Hence, due to lack of service delivery, individuals, community groups and private and public institutions have taken up that

responsibility to provide collection and disposal services for the households and the various institutions.

The ineffective solid waste management services are caused by various factors which include bad management practices, negative public attitudes and behaviours, and lack of resources. Therefore, in order to improve the system of service delivery these factors need to be addressed. Several good starting points are education and awareness for public and active participation by the solid waste generators and managers to engage in income-generating activities through resource recovery practices. The council on the other hand needs to cooperate and work towards a common goal of effective and sustainable solid waste management with active partnership relationships with its current partners and potential future partners. This would maximise their work output.

CHAPTER 8:

SUMMARY, CONCLUSION AND RECOMMENDATIONS

8.1. Summary

The thesis investigated the generation and management of solid waste in rural and urban PNG with examples from Wamonagu (rural) and Goroka town (urban) and the potential of using indigenous (local) knowledge and practice in the management of solid waste by households in urban PNG.

This chapter begins with a brief summary of the main findings and an evaluation of the degree to which the study has addressed the objectives. From these main findings, the theoretical and policy implications of the research are outlined, and the course of future research is considered.

Reports from the PNG Auditor General's Office (2010) and SPREP (2000) indicate that the bulk of the solid waste in urban PNG, especially in Port Moresby is not segregated at source. The rise in population and the daily generation of solid waste by residents of urban areas imply that there has been an increase in consumption by the urban residents. The bulk of the solid waste generated by the urban centres in PNG is biodegradable (SPREP, 2010). But solid waste generated by the urban residents is not managed effectively, which has an impact on the environment, health, the economy and social aspects of the urban centres and its people (ADB, 2014; PNG Auditor General's Office, 2010). Indigenous way of managing SW based on local knowledge minimises the effects mentioned above (Rogers, 2004). Therefore, in the urban areas of PNG, there is an urgent need to establish local knowledge systems about solid waste management used by indigenous societies of PNG, as more than one half of the solid waste generated in urban centres in PNG and other Pacific Island nations is biodegradable (SPREP,

2009). According to the last survey by SPREP in (2000), the total percentage of weight of biodegradables for Port Moresby was 50%. The majority of the population of PNG lives in the rural villages, which are subsistence farmers and produce solid waste that is primarily organic biodegradable in composition. The skills and knowledge of ISWMP are passed on from generation to generation focussing on resource recovery activities.

The use of local knowledge that promotes and maintains the health of the people and the environment, as well as enables constant food supply and builds healthy social relationships among the people in the community must be encouraged.

As mentioned, the rural villages in PNG produce solid waste that is primarily organic biodegradable and only minimum amount non-biodegradable solid waste, while the urban centres generate solid waste which, though mostly biodegradable, contains significant amounts of non-biodegradables as well. How these two types of solid waste are managed by residents of rural and urban areas depends on the leading institutions of these places that are responsible for Solid Waste Management (SWM). In the urban centres in PNG, the household producers are responsible for the management of SW at the source of solid waste production. The collection, handling and disposal of SW are done by leading agencies which include the town and city councils and their contractors. Sometimes individual organisations collect, dispose of and pay a tipping fee for the disposal of solid waste (ADB, 2014). The rural communities (villages), on the other hand use solid waste management knowledge and practice at the household level which has been handed down through the generations. The households in the villages gain ownership of the whole waste-stream from generation to disposal while in the urban centres, the different institutions and agencies manage the SW at each stage from collection to disposal. The in the

urban area the generators of SW therefore assume ownership from generation to storage. Collection and disposal is carried out by the leading agencies including town or city councils and the contractors. This division in the management of SW by different agencies leads to the SW generators lacking understanding of the challenges faced by the city councils and the contractors to collect and dispose of SW. The public is not made aware of these challenges and their responsibility in the whole SWM system. This leads to lack of responsibility by the waste generators and non-segregation of SW to reduce the volume and lack of proper storage of SW in bins leading to littering in public places.

Centred on this situation, the current study examined the roles of the knowledge and skills of ISWMP in a rural indigenous village in Eastern Highlands Province (EHP) and how these skills and knowledge can be transferred and used by households in urban centres in a system that does not emphasize source segregation of SW. The Eastern Highlands Province in PNG has eight districts with most district capitals being small stations. The two main towns are Kainantu and Goroka. The land in the stations and towns is alienated (land bought from the customary owners for development by government in PNG) and owned by the government. The rest of the land is owned by customary landowners who live in villages. This study covers two sites in Eastern Highlands province (EHP), namely Wamonagu village, and Goroka town.

The thesis is centred on the study of a sample group of people in Goroka town in Goroka district that has the town council as the leading SWM agency. For comparative purposes, a sample of the Wamonagu village community who had knowledge and skills of ISWMP where households were responsible for the overall SWM were selected from Wamonagu in Unggai in the Unggai-Bena district in EHP.

The current study differs from several previous studies cited in this thesis. The previous studies researched SWM in Port Moresby and Lae regarding the composition of solid waste produced and the different stages of their management. They also covered the challenges of the current urban SWM overlooking the actual SWM practices of the households in urban centres and how the knowledge and the skills of SWM were acquired. Furthermore, the studies did not compare the SWM practices of the urban centres and rural villages either to explore the possibility of using local knowledge to manage SW. This thesis has the following objectives as mentioned in Chapter 1:

(i) To examine the current municipal waste management system used in Goroka

(ii) To investigate the Indigenous Solid Waste Management Practice (ISWMP) used in Wamonagu

(iii) To identify the appropriate Indigenous solid waste management practices and techniques used in Wamonagu that can be integrated with the policies of the current SWMS in Goroka to promote effective, sustainable solid waste management systems.

(iv) To evaluate ways of educating the public in the management of solid waste

(v) To identify and strengthen the partnership between the actors involved in SWM in Goroka to promote effective SWM for the common good of all partners

8.2 Main Findings of the Study

The first objective was to examine the current municipal waste management system used in Goroka. The management of DSW is done in two parts in Goroka. Firstly, the household generate, store, collect and disposal at the household level. Secondly, the households generate and store the DSW with the council and its partners collecting and disposing of DSW.

The second objective of the study was to investigate the use of ISWMP and its application in rural and urban areas to find out whether indigenous knowledge and skills of ISWMP used by the rural community are transferable to the urban population. It also sought to investigate the partnership relationship between groups in the SWM and the different SWM techniques used by the urban community. Therefore, the main focus of the study has been on SWM in Goroka town which has a problem with SWM.

The current study has shown that there is a very high daily production of organic biodegradable solid waste per household in Wamonagu village as the villagers are subsistence farmers. Most of the biodegradable solid waste produced daily is food waste, mainly from fruits and vegetables. The main non-biodegradable solid waste comprises of plastics and empty tin cans from manufactured food products, which are produced when the households occasionally buy manufactured goods from the shops when they go to Goroka town to sell their agricultural produce and/or visit relatives or friends. The Wamonagu people use ISWMP to manage their SW at different stages, from generation to disposal. On the other hand, the SW generated by the households in Goroka town differs in the proportions of biodegradable and non-biodegradable solid waste compared to the SW generated by the households of Wamonagu. The main findings of study at Wamonagu and Goroka are discussed in Sections 8.2.1 and 8.2.2.

8.2.1 Indigenous Solid Waste Management Practices in Wamonagu village

The knowledge and skills of ISWMP for Wamonagu people are traditionally based on production and management of biodegradable organic solid wastes. The ISWMP apply the principle of integrated solid waste management (ISWM) where households at Wamonagu utilize the concepts of the three 3Rs namely: reduction, reuse and recycling through the use of IRRP.

The Wamonagu households use the 3R approach and focus on IRRP to limit the extraction of new resources in the natural environment, thus conserving it. Through this practice they are able to reduce the solid waste before disposing of a minimal amount, thus maintaining the health of the people and the environment. According to Memon (2010), SWM in the world in the past was concerned with maintaining public health and the environment. However, this has changed to include resource recovery and conservation. The ISWM principle focuses on preventing and reducing SW before disposal ((USEPA 2013) and recover resources and conserve the natural resources (Memon 2010).

The knowledge and skills of ISWMP have been passed on informally by word of mouth, practical application and observation through the generations. The use of the 3Rs approach in IRRP at the household level requires fewer human resources, low funding and simple equipment as the solid waste is predominantly biodegradable. Being subsistence farmers, all the activities required for the livelihood of Wamonagu householders are provided at the family household level. Living in a tribal community where land is communally owned, with individuals given the rights to use the resources in a geographically restricted area, the households try to maximise their resources' used and at the same time conserve them for later use. This understanding leads to the households using the 3Rs through the IRRP to manage the solid waste to recover resources. The approaches they use to recover resources are with a deeper understanding that the practices will benefit them directly and indirectly or benefit the next generation. It is through this knowledge of the benefits they have as a household and a community that they maintain the continued use of 3Rs.

The 3R approach in the IRRP used by Wamonagu households was designed to manage the biodegradables that are now used to manage non-biodegradables as well. The initial approaches involves segregation of biodegradable solid waste at the source before composting (biological recycling), burning to retrieve energy, or for ashes to be used as compost and pesticides, reusing to feed animals and giving away to other households to be reused. With the introduction of the non-biodegradables from manufactured goods, SWM practices today are still using the ISWMP to manage some non-biodegradables by burning and reusing the DSW. There was no initial recycling of non-biodegradables in the ISWMP; therefore any non-biodegradables that were not reused or burnt were disposed of. The common disposal site for the households is dug up pits, tall grasses, under bamboo trees and sometimes in the river during floods. The absence of recycling non-biodegradables in Wamonagu means the valuable resources that can be recycled to recover resources are disposed of. Moreover, reusing SW is a short term resource recovery method as, when the SW reused wear out, the biodegradables SW are composted or burnt while the non-biodegradables are burnt or disposed of. The burning of non-biodegradable is hazardous for the people and the environment. The burning is open burning area, both inside the house and outside, leads to the release of pollutants into the soil and the air. The non-biodegradables are disposed of in sites that are not designed to collect the leachate; hence they contribute to the pollution of the soil and the underground water. The burning of biodegradables release carbon dioxide into the atmosphere as well as affect the health of members of the households, particularly when the burning is done with an open flame intended to produce energy for cooking and warmth.

The solid waste produced in the public space in Wamonagu, such as meeting places, church grounds and aid posts is seen to be the responsibility of the whole community. The members of

the community collect and dispose of the SW generated in the public areas. The cleanliness of the public spaces, which is also the responsibility of the community, is coordinated by the village elders and councillors. The individuals understand and value the importance of a healthy community and environment for the health and wellbeing of the family unit.

8.2.2 Indigenous Solid Waste Management Practices in Goroka Town

In contrast, to Wamonagu, Goroka Town is an urban settlement where the population is involved in a modern cash economy. In the urban settlement, welfare services and livelihood of the residents are provided by mandated organisations. There are two stages to the solid waste production and management in towns and cities. The first stage is the generation and management of domestic solid waste while the second stage is the generation and management of non-domestic solid waste. The management of solid waste in Goroka involves huge amounts of biodegradables that are both of domestic and non-domestic, with substantial amounts of non-biodegradable as well. The overall management of the SW is delegated to Goroka town council which in turn hires contractors, mainly for the collection, transportation and disposal of the SW in town. However, the overall management of SW in Goroka is ineffective due to inadequate resources, lack of SWM legislation and policy and negative public behaviour of littering where people discard SW everywhere.

Goroka town council does not have any SWM policy and uses the Public Health Act 1973 and Public Health Regulation of 1973 to manage its solid waste. The Public Health Regulation of 1973 includes fines to be paid by people who illegally dump (ADB, 2013) and litter in the town. However, this regulation is not implemented and people are not charged for littering and illegal dumping. The community organisation that is contracted by the council does not consistently

implement the regulation where offenders are fined on the spot for littering. The organisation that operated in the past to charge offenders who littered is not in operation now due to lack of funding. The behaviour and negative attitude of the public's "do not care" attitude leads to SW being discarded, littering the town everywhere. With a lack of council resources to manage the SW, littering adds an extra burden on the town council as it is the leading agency to manage the SW effectively. Apart from these factors, the ineffectiveness of the overall SWM by the Goroka town council and contractors is due to the focus on waste disposal efforts. The collection, handling, transportation and disposal become expensive which lead to incomplete collection resulting in solid waste piling up in all the corners of town. Therefore, there is a need to promote resource recovery and waste reduction efforts at the source with techniques that are basic and simple for the bulk of the population to understand and use with the limited resources in Goroka. Under the SW collection and disposal schedule for Goroka town, DSW is supposed to be collected twice a week and non-domestic SW from businesses, offices and cooperate bodies including public areas is supposed to be collected daily. However, this is not the case as there is ineffective and inconsistent collection and disposal of SW by the council and the contractors, leading to three systems of SWM (described below) occurring concurrently due to a lack of coordination by the council.

In the first system households manage the domestic solid waste (DSW) at the household level. The majority of the households segregate the SW at source into six categories that are for composting, reusing, burning, recycling, giving away and disposing. The composting/mulching and burning of SW are done at the household level. The solid wastes are either reused by the households or it is reused in their work place. Some households store SW and give it away to people in Goroka town and the villagers who visit them to be reused while others give away

recyclable SW to other people in Goroka town to sell to earn income. As there are few companies that buy and trade metals, the households store and sell the aluminium drink cans to the traders. The rest of the SW that is not reused, composted, burnt and recycled is disposed of.

The SW that is disposed of is mainly non-biodegradable. These bon biodegradable SW are collected by the council, landlords, employers and the households themselves. The council collection of SW does not include all households, therefore, the employers and landlords of some households provide that service. There, council services are concentrated in the public area with less attention given to the household. The DSW that is collected and disposed of by the other organisations apart from the council are either disposed of in the two legal dump sites, Fimito and Kamaliki, or in illegal dumpsites in town or at the edges of town. When the SW is disposed at Kamaliki and Fimito with a council pass, it is free but without a pass it costs about K180 for each tip at the dumpsite. This leads to people illegally disposing of SW in dumps on vacant land around town to avoid paying the tipping fee. There are also some households where there are inconsistency or no collection and disposal services by the council. In this case the households disposed of the solid waste themselves wherever they could.

The households who collect and dispose of their own DSW do so in pits dug up in their yards and compounds, in the river or gullies with water near their house, in the public bins near their house, and in the illegal dumps in town. When the households dispose of solid waste in the pits they control it by covering it with soil when it is full and dig a new pit when they have land space. However, there is no control and management of SW at the other disposal sites mentioned above by the households. This poses threats to the health of the public and the environment. The skills and knowledge that households in Goroka use to manage their DSW include the 3Rs of the

IRRP that are acquired mainly from ISWMP from their societies and from some formal education. However, the majority of the people use the knowledge and skills from ISWMP from their society in PNG. This ISWMP is almost the same in all the society in PNG with very minimal differences due to the geographical location and values of each society that initially manage the solid waste at the household level. The only other resource recovery activity that households are using that is not part of the ISWMP is the recycling of non-biodegradables which are mainly drinks cans and glass bottles. This recovery effort is not common amongst the households even though it is an important method of reducing SW and recovering resources, as it is not encouraged by the Goroka town's SWM system and is absent in the ISWMP.

In the second system the council collects the solid waste from the residents, public areas such as markets, streets and shopping centres, and other government and corporate organisations. The management of solid waste is done with little or no segregation at the source, as all the solid wastes are mixed together and stored in one bin to be collected by the council. As the solid wastes are mixed, there are huge amounts of solid waste to be collected from these areas resulting in the council focussing on collection and disposal mainly in the public areas daily. The SW from the public areas and cooperative organisations was collected by councils or contractors and was disposed of in the two towns' dumpsites, Kamaliki and Fimito.

And in the third system of SWM organisations collect and dispose of SW for the whole organisation. The solid wastes collected are of both DSW and non-DSW in nature. In this case organisations either pay the tipping fee whenever they dispose of the solid waste or dispose of it with a pass from the council. The SW collected by the organisations is collected as mixed rubbish even though most households do initial segregation at the source using the 3Rs to

recover resources. However, it is unclear whether the offices and businesses are involved in resource recovery activities when the educational institutions carry out very minimal recovery activities by reusing and recycling activities.

The bins for the public area are provided by the council and sometimes by the cooperative bodies and church organisations through their education and awareness program. The households are not provided with any bins. This is because The Public Health Regulation requires the households to provide their own bins for the storage of SW (AGO, 2010). The majority use shopping bags to store the DSW with some using the small bins for storage inside the house. The residents who live in their own houses do not provide large bins outside for storage and use the bags that are occasionally collected by the council. The households that live in institutional houses or rental properties were provided the large bins by the landlords and the institutions they or their spouses were employed in.

The council charges fees for the households and the cooperative bodies for collection and disposal services, however not all the fees charged were collected. The fees for the households ranged from K10- 20 per month and for the cooperative bodies from K500 or more per month. These charges were for garbage, water and sanitation. These rates did not reflect the amount of solid wastes that were produced daily as they were lower and included three different services. This led to lost revenue that the council needed for the services to be provided for SW collection and disposal.

The third objective was to identify the appropriate and techniques used in Wamonagu that can be adopted with the policies of the current SWMS in Goroka to promote effective, sustainable solid waste management systems. The prevalence of diseases such as diarrhoea, typhoid and increased

occurrence of malaria in Goroka may be related to the ineffective solid waste management where there is environmental pollution and breeding of vectors. The contamination of water by SW causes diarrhoea and typhoid, while collection of water in tins, bottles and plastic bags provide the environment for the breeding of mosquitoes that causes malaria. The open dumping and dumping in pits lead to chemical contamination of the soil and the underground water as there is mixture of non-biodegradable SW from DSW to non-DSW disposed in the sites. There is evidence of decaying SW around Goroka town and in the dumpsites that are near the villages and so there is pollution of the environment that impacts the health of the people.

The pollution of the environment and its impact on the health of the people can be tied to the some SW disposal and reduction methods that produce toxic materials. The household that disposed of SW into the river and gullies are aware that this disposal method is inappropriate as it pollutes the environment and impacts other people's health. However, they sometimes do not have any other way of disposing as there is no collection service provided. In addition, the households that burn SW to reduce its quantity and also retrieve energy are aware of the pollution caused by burning non-biodegradables but sometimes do not have any other options due to non-provision of collection and disposal services and lack of land to dig pits for disposal.

The fourth objective was to evaluate ways of educating the public in the management of solid waste. There are some forms of volunteer participation by community groups mainly from the churches and cooperative organisations who collect and dispose of SW in public places to create awareness of the problem of public littering and how it affects the town community. The council also conducts verbal campaigns using loudspeaker occasionally targeting the general public. The program is based on promoting public awareness to prevent littering in public places. Primary

and secondary educational institutions and the university have several curricula on general environmental issues that cover solid waste and health and hygiene. However, there is no specific curriculum and program developed by the educational institutions or other organisations to consistently target a specific audience using different modes of communication to disseminate information. In addition, even though few people assume that education and awareness on proper management of SW is the responsibility of the parents, the majority of the people have a view that the council and other organisations including educational institutions should take the lead to educate and do awareness on SWM. The education and awareness have to include source segregation, resource recovery and SW reduction to disposal. It was also identified that the negative impact of improper management of solid waste has to be included in the awareness program.

The fifth objective was to identify the partnership that existed between the public and private actors in managing solid waste. There are several organisations that collect and dispose of solid waste and create awareness, mainly of proper storage of SW and prevention of litter within Goroka town. However, there is a lack of collaboration and cooperation between these organisations and the council and other stakeholders to maximise the resources to manage the SW and drive the awareness programs in Goroka Town. The public-private partnership in managing SW is already established but there is a lack of collaboration to strengthen the cooperation between the two. Moreover, there is active community participation where households segregate the SW at the source and manage it using the 3Rs to recover resources and reduce SW through the IRRP. The resources recovered are used to generate income for each individual household. However the principle of the 3Rs is not used and encouraged in the overall SWM system of Goroka town by the town council, thus resulting in more SW to be collected.

8.3. Theoretical implications

The current study investigated the SWM practices used by the urban community in Goroka and the rural Wamonagu community and established the relationship between the management of SW by households in the two communities. The finding of the current research shows that households in Wamonagu have knowledge and skills of ISWMP and use those which include the 3Rs of the IRRP that is similar to the approach in the principles of ISWM. In Goroka, the majority of households have knowledge and skills of ISWMP but not all of them are being used to manage SW due to limitation of resources, space, time, ignorance and, to some extent due to the collection and disposal without segregation of SW at source by the council. The households that consistently use the 3Rs of IRRP to manage and dispose of the DSW using traditional disposal methods had no council services to support their SWM, even when the type of disposal sites posed a threat to the environment and the public due to the disposal of non-biodegradable solid waste composition. The behaviour and attitude of the households in managing SW using the IRRP approach to a large extent is based on the individual's norms and values from their societies and the skills and knowledge of ISWMP they acquired in addition to the formal education that vaguely covers SWM. The ISWMP using the 3Rs similar to the approach of the ISWM principle seem to be commonly used by the households with low incomes or those which are self-employed in the informal sector of the economy. This portrays lead to the concept of limited resources in a given geographical environment where practices are focused on the recovery of resources to conserve them for the future as in rural indigenous community like Wamonagu village, and Unggai-Bena district. It is shown that the acquisition of the ISWMP using the 3R approach does not effectively reveal the use of ISWM using the 3R approach by residents of Goroka town. The findings of the study indicate that a majority of the households in

Goroka have acquired knowledge and skills of ISWMP through IRRP that are centred on the principle of integrated solid waste management where the resources are recovered through the 3R approach. This is important for the management of their SW. However, at the same time these ISWMP are not empowered and embraced by the town council in the overall SWMS to encourage active participation by the households in the management of SW. The use of ISWMP through IRRP that focuses on the principle of ISWM using the 3R approach can be a practice that empowers the people to use their local knowledge to find some solution to the issue of ineffective municipal solid waste management in light of the lack of resources through funds, facilities and expertise that the town council is faced with. This will give the people the confidence to search solutions from the indigenous knowledge that exists locally and make decisions on the problems that they face with the current pressure of consumer-based cash economy and the external ideas that may not be applicable in their context.

The findings in this study demonstrated the need for a change in the research on solid waste management. A change where indigenous societies look for solutions to address the SWM issues in the community from foreign ideas and knowledge that focus on technology and complex systems that are costly and difficult to understand and sustain in the long term. A recent study on indigenous solid waste management in Marshall Islands by Roger (2004) established that the community use of indigenous knowledge on SWM in the research sites was a success. This empowered the community to develop their community SWM plan and that was used as a platform for the development of the national strategic plan in the Republic of Marshall Islands (RMI). Based on this finding, Roger (2004) established that ISWMP existed in the societies but was not utilized as there was a break down in the traditional leadership system. That is, in the past the community elders were respected by the whole community and people follow the

decisions they made. However Roger (2004) indicated that there was break in this system as the young generation lacked cooperation and respect for the traditional authority due to the modern form of leadership leading to break down in the society's norm and values that was there to enforce the traditional practices. The empowerments of the traditional leaders paved the way for the older generation to transfer the knowledge and skills of ISWMP to the younger generation. Empowering the community leaders helps bring back the traditional authority and draw respect for authority from the younger generation, hence building community cooperation and empowering the whole community to seek solution to their problems using their own local knowledge. This resulted in communities managing their solid waste effectively and reducing the amount of solid waste that was disposed of.

This current study of the Wamonagu community corresponds with Roger's findings that recognising and empowering traditional leaders and their authority through knowledge transfer is important to establish their respect from the younger generation. The respect that the village elders gain from the community, especially the youth, leads to a safe community where people listen to their traditional leaders' instructions on issues such as proper management of solid waste at the domestic level as well as public areas. The nature of the concept of ISWMP encompasses its approach that is captured in the conceptual framework of sustainable municipal solid waste management (SMSWM). The SMSWM aims to incorporate a strategy that includes the following management dimensions -political, social, economic and environmental, with different stakeholders (actors) involved in the management of SW, that includes the driving forces in MSWM and diverse systems that are related to the MSWM.

This process aims at integrating all actors, systems, drivers and management dimensions to achieve a sustainable MSWM. This forms a structure of the MSWM framework that can be used by the actors and managers in MSW (Schubeler, 1999). The ISWM incorporates the factors that are vital for SMSWM as mentioned above. ISWMP through IRRP uses the approaches of ISWM by using the 3Rs for resource recovery. This resource recovery methods developed by the indigenous society can be called indigenous resource recovery practice (IRRP). The overall ISWMP integrates these four different management dimensions -political, social, economic and environmental- with all the different actors in SWM, using diverse SWM systems that are driven by various forces in SWM. The qualitative efforts to describe how exactly ISWMP address the process of SMSWM would certainly provide an informed explanation as to why the knowledge and skills of ISWMP is vital for SMSWM

This study is a contribution to the role of indigenous knowledge in addressing complex political, social-cultural, economic, environmental and religious issues in transitional societies where resources are limited and technologies are not viable options leading to sustainability concerns. As mentioned earlier, the ISWMP of Wamonagu society is embedded in the culture and is passed on from one generation to another at the household level. It is at this level that all management decisions are made. There is a defined division in the role of each gender with females being responsible for the management of SW. Therefore, a theoretical framework for a complete understanding of ISWMP in tribal societies in PNG has to include the various socio-cultural, environmental, political, economic and religious practices that exist in these societies.

The current study had been restricted to the Wamonagu village because of its location away from urban centres and its accessibility by road from Goroka town. About 80% of the Papua New

Guineans live in tribal communities and would have same SWM practices with varying differences between each tribal community depending on their geographical locations that is whether they are located on the coast or in the highlands. Further detailed research comprising populations from the coastal communities (towns and villages) would definitely contribute to a better understanding of role of ISWMP which influences the management of SW in urban communities in PNG. This form of study will not only facilitate the understanding of how people make decisions about SWM in different contexts and their behaviours nationally regarding SW, but also provide vital information on how the SW can be managed in an effective, efficient and sustainable way. The use of foreign ideas, knowledge, skills and practices that are not understood can hinder the decision-making as well as the management process in developmental issues such as municipal SWM. However, research and use of local ideas, knowledge, skills and practices that are understood by the mass can bring about change. As Jones (1977 in Saikia, 2004) stated, individual researchers who are aware of and understand the culture of a society well can make a vital contribution to the field of study.

This study claims that for an in-depth understanding of the ISWMP and its role to empower the people to manage SW in urban PNG, there is a need to go beyond the environmental and public implication of ISWMP to consider the broader concept of people empowerment using the different dimensions to manage SWM especially the socio-political dimension of ISWMP that empowers people to create partnerships and manage SW. This will highlight how this partnership dynamics influence the behaviour and attitude of people in the management of SW at domestic level as well as in the public space

As indicated in this research, the migration of people from the rural areas to the urban areas in PNG in search of employment and educational opportunities has seen the transfer and use of the ISWMP and their values by the households in urban areas. However the move and settlement in urban areas impact on the behaviours and attitudes of people towards SW management as there is a breakdown in the traditional values and norms that encouraged respect for others and their properties through a close community relationship amongst the residents. This aspect of the study had not previously been researched until it was identified by this current investigation. The future study on ISWMP and its role in managing urban SW in PNG should include this aspect as it will enable the understanding of the change in the behaviour and attitude of management of SW and increase the understanding of the change that will lead towards an effective policy on the overall SWM in PNG.

The current study had difficulties in researching in-depth the priority of the provincial government on its budgetary allocation in making funds available for the management of SW in Goroka town as the officers had tight duty schedules where they were often out of office to organise an appointment for interviews. In future, this can be rectified by including studies that examine the priority given to SWM by the different levels of government including resource allocation and human resource development through training and its impact on the SWM in urban areas. This study can be done using a design that assesses the budgetary allocation for the council in the past 30 years through interviews of long term and new government officers in Goroka town. Nevertheless, this kind of study is possible at all levels of government. With increased recent allegations of misuse of funds by government officer's nationwide, future research on the impact of government funding for SWM is vital, especially for PNG.

8.4. Policy Recommendations

The policies and strategic plan development is vital for all levels of government and sections of an economy. The different sections and departments need policy documents to guide them to plan and execute any implementation program. In Papua New Guinea there is no national policy or strategic plan for solid waste management even though there was a master strategic plan for the Pacific Island Nations developed by Japan in 2005 (SPREP, 2010). Only a few Pacific island nations had fully developed their National Solid Waste Strategy (NSWS) that was then used to develop Waste Minimisation Strategies (WMS) especially Waste Recycling Strategies. PNG was not one of those countries. The revised Pacific Regional Solid Waste Management Strategy 2010-2015, PNG's National Solid Waste Management Strategy (NSWMS), was listed as started or ongoing (SPREP, 2010). Some nations of the Pacific have gone ahead to develop and improve the disposal sites from open dumps to a well-developed Sanitary Land field. This is yet to be realized in the towns and cities in PNG as the government through the relevant institutions lacks the will power to complete the NSWMS. With no specific policy on waste management and NSWMS, the legislations that are in place to guide the waste managers to manage the solid waste in the urban centres are few and are out dated.

8.4.1 The current legislation on environmental management in place for PNG

The constitution of PNG promotes the protection and sustainable use of the country's natural environment as written in the 4th Goal of the National Constitution and Directive Principle: 'Papua New Guinea's natural resources and environment should be conserved and used for the collective benefit of all and should be replenished for future generations' (DEC, 2007).

The policies that were developed from this goal initially had three environmental values, air, water, soil and biodiversity with a recent inclusion of carbon in 2006 (DEC, 2007). The goal replicates the principle of sustainable development that promotes the use and development of natural resources to meet the needs of the current generation without compromising the ability of future generation to meet their needs. The government through various departments such as the Department of Environment and Conservation (DEC) develops legislation that targets and promotes mainly sustainable development and management of natural resources (DEC, 2007). Moreover, PNG as a member of the global community has signed a number of conventions that promotes natural environmental protection as shown here. PNG adopted the UN millennium declaration in 2000 that developed the Millennium Development Goals (MDG) of which the seventh MDG was focused on environmental sustainability. The MDG was used by the Government of PNG to develop the country's Medium Term Development Strategy (MTDS) for 2005-2010 (DEC, 2007). However, the MTDS main focus was on economic development through natural resource extraction and poverty eradication with a very vague focus on environmental protection.

Apart from this, PNG has signed three conventions that promote the conservation of natural environment. These conventions are the convention on biological diversity(CBD); the convention to combat desertification (CCD); and the United Nations Framework Convention on Climate Change (UNFCCC) according to DEC, (2007). The entire international policy framework of which PNG is a part focuses on the sustainable use of natural resources and conservation of the environment to prevent over-exploitation of natural resources and prevent species extinction. Therefore the national policies follow that by focusing on conservation efforts of biodiversity and sustainable economic activities.

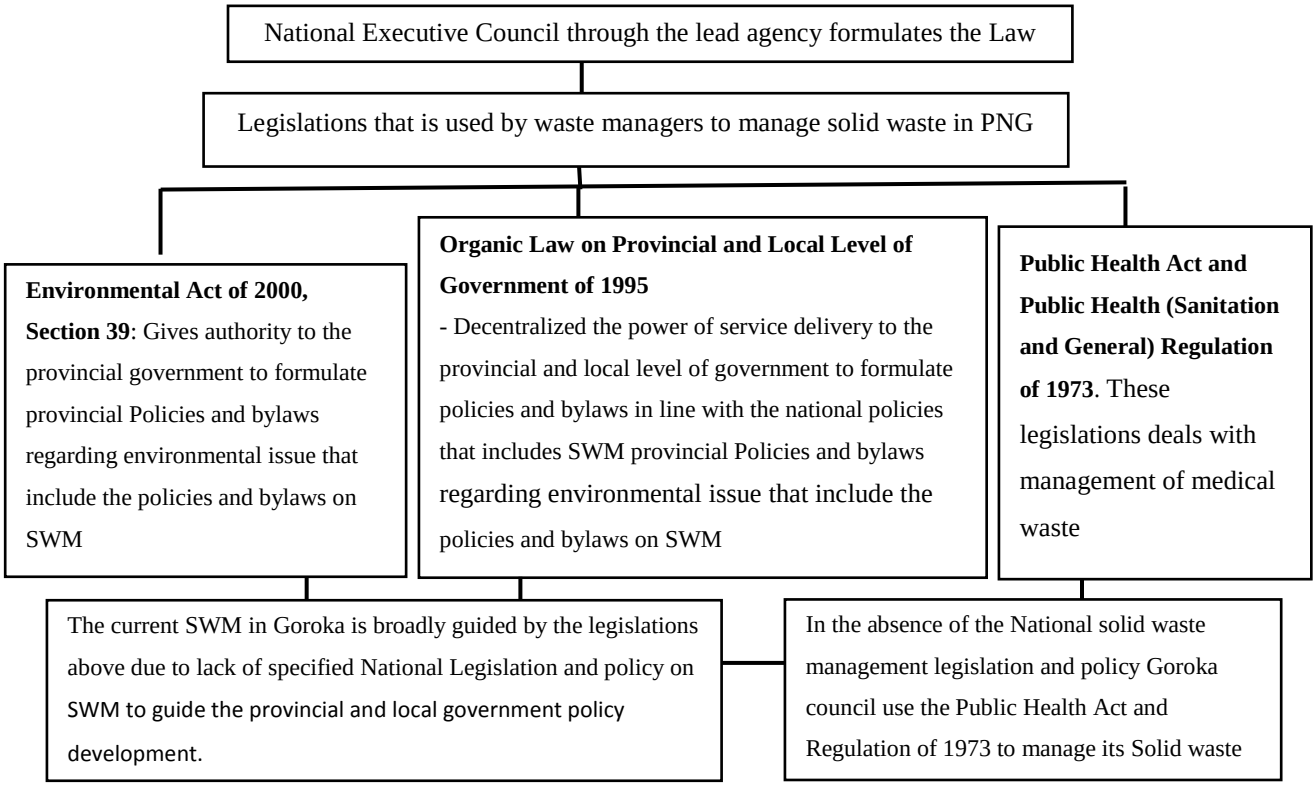
There is very little emphasis on pollution reduction through sustainable waste management. The legislation that addresses the pollution in a broader sense is the Environmental Act 2000 which merged three previous acts. The three acts were the Environmental Planning Act 1978; the Environmental Contaminant Act 1978; and the Water Resource Act 1982. There are three pieces of legislation that have been used by the town and city council the leading government agency that provides solid waste management service in urban centres to assist them with the management of solid waste in towns and cities. These legislations are the Environmental Act of 2000, the Public Health Act of 1973, and the Public Health (Sanitation and General) Regulation 1973. These legislations are used by the town and city council to manage the SW as there is a lack of specific legislation and policy on SWM both at the national and local levels. A National Solid Waste Audit carried out by the PNG Auditor General's Office (2010) recommended that the leading government agency DEC formulate and facilitate specific national legislations, policy and management strategy that is specific to management of solid waste. This legislation and policy framework can then be used by the provincial and local level government to develop their own policies (PNG Auditor-General's Office, 2010). The current legislative frameworks use by Goroka Town Council is summarized in Figure 8.1 below.

Even though the urban centres in PNG used the legislation discussed earlier as a guide to deliver SWM services, PNG's rural population which lives in villages hardly use the legislations discussed and so tend to use the ISWMP in their own local contexts. With 80% of the people living in villages who consume some manufactured goods at varying quantities depending on their proximity to the urban areas (towns and cities) and socio-economic status that produce non-biodegradable, these legislations are not applied in the villages. The production of non-biodegradable waste in the villages that generated only biodegradables traditionally is a

challenge for the villagers, as it poses threat to their livelihood which they may not be aware of. In addition, the rural communities are not recovering important resources that are disposed of due to a lack of recycling non-biodegradables in their traditional system. Hence, there is a need for ISWMP to adopt the recycling of non-biodegradable solid waste to be used by the urban households to recover these vital resources. Therefore, the SWM policy framework from national, provincial and district level would then include the various council areas. Currently there is little to no application of the existing legislations used to manage solid waste well in the rural community except for random rural health awareness regarding health and hygiene by health officers.

The existing legislations were developed before PNG's Independence and though there had been some significant changes in the population and the composition of the waste stream in the urban areas there had been lack of legislative reforms to address the current needs. The legislations used by the urban councils are shown in figure 8.1 below.

Figure 8.1: National legislations used by town and city councils to manage SW in PNG



Source: Adapted from Auditor-General's Office, 2010

The dependence of the provincial and local government in adopting and using the Public Health Act and Regulation of 1973 means that there was a need to appoint an Environmental Health officer to be part of the Town council staff (Auditor-General's Office, 2010). However, for Goroka this position was vacant as the council lacked funding to fill it when the study was carried out. Therefore, the technical advisor on the impact of improper management of solid waste on the health of the people and impact on the environment is missing for the council. In addition, the lack of specific solid waste legislation and policy mean the legislation used by the waste generators and managers are open to various interpretations making policing and implementation of the legislation difficult.

Having no specific solid waste legislation, strategy and policy document for the management of solid waste leads to the inconsistency in the management process in Goroka town especially with collection, handing, transportation and disposal of solid waste. This waste management process is focused on the end of the pipe solution (Makwara and Magudu, 2013). This causes the council to focus on identifying new disposal sites and techniques to control the volume of solid waste in the open disposal sites. In Goroka, the council and its contractors manage the solid waste at the disposal sites by burning it or moving and compacting the solid waste to create space for the waste that is disposed of later. This practice actually draws the solid waste generators and managers' attention away from the resource recovery, and waste reduction activities that are focused on principles of integrated solid waste management where waste is avoided and the concepts of 3 Rs (Reduce, Reuse and Recycle) are used.

8.4.2 Possible policy and strategy development to be used to manage solid waste in Goroka Town and Wamonagu village

The policy development and framework strategies for the SWM need to be developed from the local council level to provincial to the national level. To develop a solid waste management policy and strategic framework for Goroka Town council there is the need for an internal capacity building through staff training and empowerment. Secondly, the provision of funds and human resources through cooperation between different stakeholders for the policy development is essential. Finally, the interest and involvement of politicians on the issue regarding SWM can add value and empower the solid waste generators to manage their SW effectively and managers to develop appropriate policies on the matters of SWM. The lack of SW policy documents from the national to the local level of government leads to low budgetary priority given to the SWM in the country. According to the National Audit (2010), DEC had a SWM section that lacked

financial capacity as there was no individual budget for the division to implement SWM activities and programs. The same challenge is faced by the provincial and local level government making it extremely difficult to manage SW effectively especially in EHP in Goroka town where the study was carried out.

The policy documents on SWM need to take into account the effective and environmental sound practices that are already in place at the household level and in the commercial and industrial sectors. The town community are already using the 3Rs to manage their SW. These 3Rs are reusing, recycling and reduction of SW by both people who are living in both formal and informal households in Goroka. The 3Rs are the ISWMP passed on to them by their parents from their different societies. The values and views that people place on the SW reflect the indigenous knowledge and skills to which they were exposed. Much of the DSW is managed using the 3Rs as the collection and disposal service becomes inconsistent for the formal households who pay for the services while there is no service delivered for the squatters' settlers who live in informal housing that is not a part of the town plan. The other factor that enabled the use of 3Rs by the households is the benefit that it brings for the households, in terms of finance, supply of food production and maintenance of family health due to reduced SW at the source. In addition, there is opportunity for all waste generators and managers to generate income through recycling of metals and glass beer bottles which needs to be extended to other types of SW. The recycling activities generate income for the businesses and the households with employment creation for the residents thus leading to reduced SW for collection and disposal hence improving the quality of the environment and health of the public (Makwara and Magudu, 2013). To promote the resource recovery and SW reduction efforts the public-private partnership is important. There has to be funding of community groups that are already participating in SWM. In Goroka, church

organisations especially women's and youth groups are either contracted by the council to clean the town or volunteer to collect and dispose of SW in public areas. These actions also create awareness for people, discourage littering, and promote proper storage of SW in public areas. Community participation in SWM with cooperative sectors support through sponsorship of SW segregation at the source has proven to be successful for three cities in India and similar efforts involving community neighbourhood source separation is currently used in Santa Maria in the Philippines (Makwara and Magudu, 2013).

The policy development for SWM in Wamonagu village has to include the ISWMP that people understand as it is embedded in their culture and is part of their livelihood. The policy document must be relevant to the geographical location they live in and the council area they belong to. The policy development must be a participatory document where people are consulted through community discussions. This would empower the community to gain ownership of the program that is established but at the same time revive important indigenous practices and values that keep a community peaceful and stable but could be eroding due to modernisation. The community leaders should take the lead in the policy development especially the councillors with participation of all stake holders.

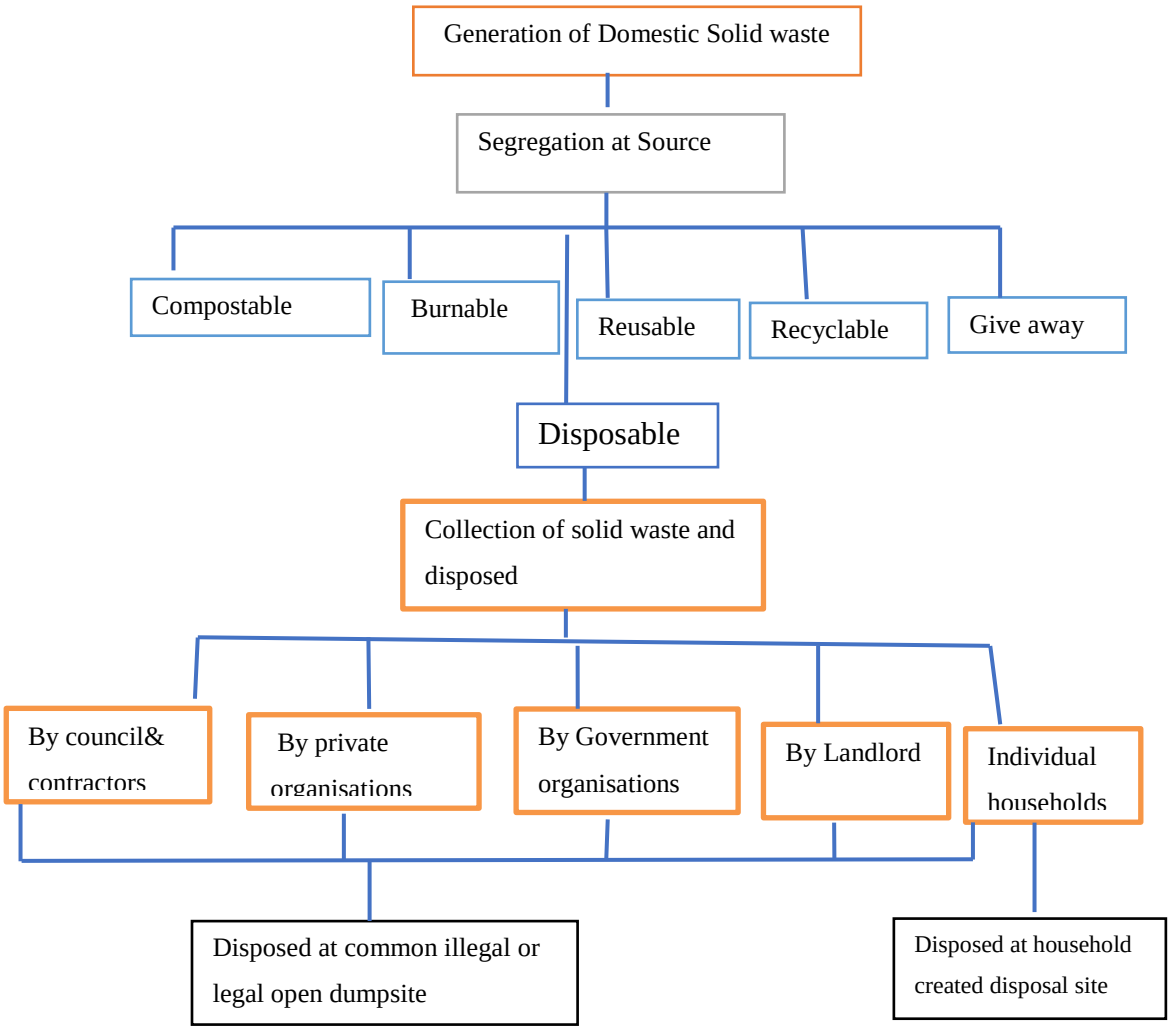
8.4.3 Establishment of solid waste management model using the current local system

The establishment of an appropriate solid waste model that encompasses all waste generators and managers promoting source separation and resource recovery and waste reduction of both biodegradable and non-biodegradables at all stages of management is a strategy that must be adopted. This will minimise solid waste and maximise resource recovery.

8.4.3.1. The household SWM system in Goroka Town

There is already a system of SW segregation at source to recover resources and reduce waste by the households in Goroka town and Wamonagu village. The systems in place are shown in Figures 8.2a and 8.2b.

Figure 8.2a: Current Domestic solid waste management systems in Goroka Town

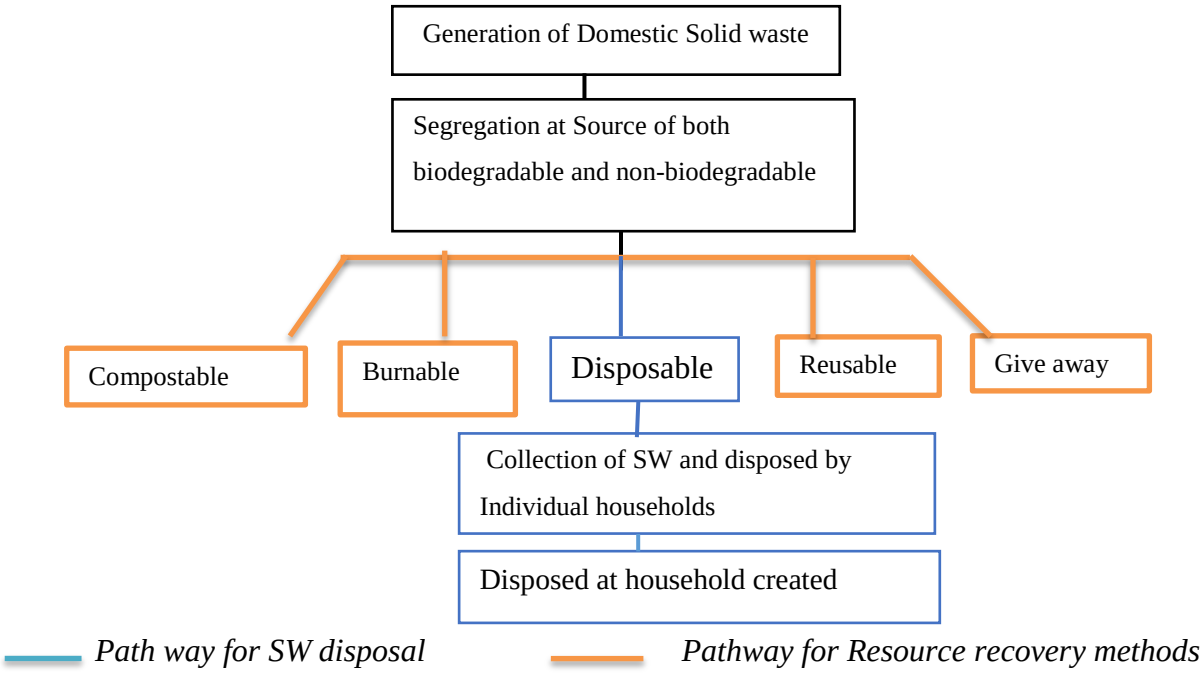


Source: Field work, 2011

The domestic solid waste management system with source separation in Goroka is vital for households. The separation and resource recovery reduces the solid waste for disposal. Even though sometimes there are mixtures of both biodegradable and non-biodegradable waste disposed of, the amount is reduced greatly. This is because for some households there are no collection and disposal services provided at all. For others there are inconsistent collection and disposal services delivery. Therefore development of household waste management system by the households themselves allows them to manage the waste in the best possible way. The equipment for the storage of SW inside the house is provided by the households and for few households by the landlords. For the storage of solid waste outside the house before collection, some households are provided with large drums or bins that are shared between several houses. These bins and drums are not provided by the council but by the private and government organisation for their employees or by landlords for their tenants. The majority of the households who do not have large bins for storage of solid waste outside the house hence they use bags to store their DSW. These bags are hung outside on homemade hanging places or on any high places including tree branches until they are collected for disposal. Most of the time, they are left hanging there for weeks. However some practices used by the households pose threats to the health of the public and the environment and they need to be discouraged when there are policy and strategic plans developed by the council. The practices that promote reduction and resource recovery need to be adopted into the policy document. This would contribute to an efficient and effective domestic waste management as people understand the practices and have used them without assistance from the authorities. Working with a known SWM practice and later introducing the unknown practices can promote sustainable solid waste management (SSWM) and improve the MSWM system in PNG's urban areas.

The management of SW at Wamonagu village on the other hand occurs at household level as the daily activities of the villagers are centred around households with occasional community gatherings that generate SW in common or public areas. The SW produced in the common areas by the community is the responsibility of all members of especially the females. There is a mutual understanding by the villagers that any SW generated in the public area is the responsibility of all the members of the village. However the management of SW generated by household are the sole responsibility of the household members. The households have individual dumpsites for each household with occasional shared ones. There is hardly any common dumpsite for SW generated in common meeting areas unless it is in public institutions such as clinics, schools and church areas which are managed by the officers in charge of the institutions. Therefore Wamonagu's household SWM system is simplified as shown in Figure 8.2b.

Figure 8.2b Current domestic solid waste management systems in Wamonagu village



Source: Field work, 2011

At Wamonagu the resources recovered from the biodegradable organic SW are greater compared to the non-biodegradable SW that is occasionally generated due to occasional consumption of the processed goods consisting mainly of food products. There is no recycling of non-biodegradable SW at Wamonagu village, hence all non-biodegradable SW that cannot be recycled is disposed of. This indicates a need for the introduction of recycling methods into the system that exists in the village. As the recycling of non-biodegradable is a new concept for the villagers there has to be a connection with the recycling activities in Goroka town and the village. The way to introduce this new concept is to train and disseminate the information to their village leaders and elders who would then disseminate the information to the villagers as their normal mode of communication. The village leaders and elders in this case include the elected leaders (councillors), church leaders, education officers who are seen by the community as leaders, health workers and clan leaders or elders.

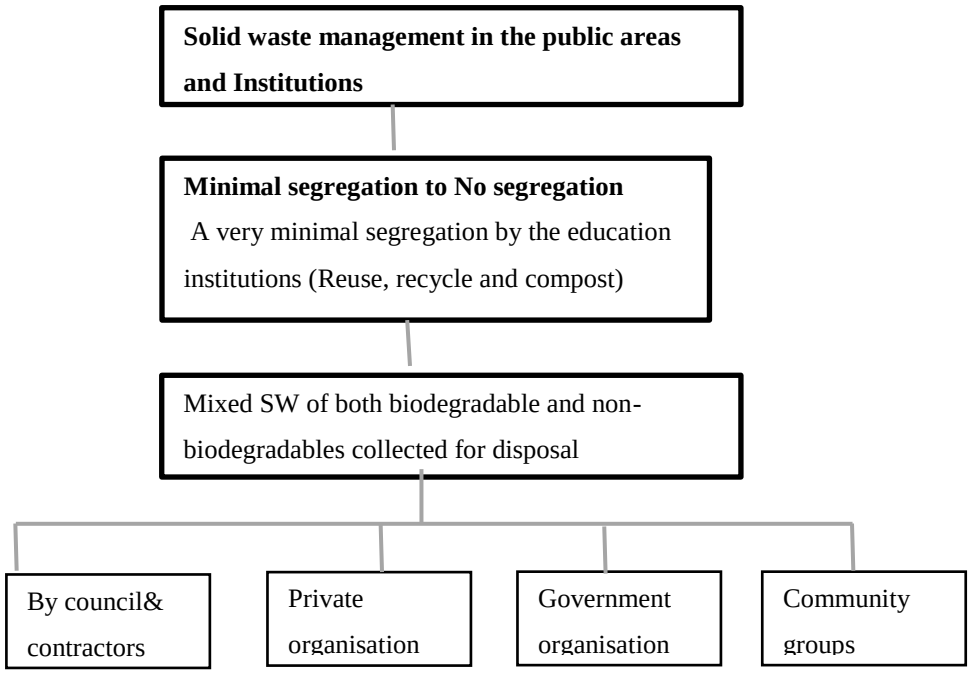
As the amount of non-biodegradable SW generated at Wamonagu village is minimal, the recycling efforts can be focused at a community level, where all recyclable materials as long as there is a market for trading in the urban centres, can be collected, stored and traded to raise funds for any community project. Through this collective communal effort the recycling activity can be productive and not seen as wasted effort. This could also empower the community to develop strategies of mitigating any SWM issues or other issues affecting their community through cooperation and participation amongst them.

8.4.3.2The management of non-domestic solid waste in Goroka Town

The management of non-domestic solid waste comes from the public space and the corporate sectors. This type of solid waste that is generated is not segregated at the source and a mixture of

all the different types of SW are collected and disposed of together in one dumpsite as shown in Figure 7.2

Figure 8.3: Non-domestic solid waste management system in Goroka Town



Source: Field work, 2011

The collection and disposal of solid waste in public areas are done by the council and its contractors who are individuals with trucks and sometimes community groups. The contractors are contacted when the council needs trucks to collect solid waste due to break down of the council vehicles. The community groups are contracted to clean and collect SW in public areas when SW is not collected with bins overflowing and littering the public space as the council lacks manpower and equipment to clean and collect the SW themselves. Other times the members of Goroka town community volunteer to clean and collect rubbish as the filth from the rubbish increases causing a bad odour and threatens the health of the public. Bins in public places are provided by the council and occasionally by businesses and community groups through their anti-litter awareness and campaign programs. The bins for the public areas do not

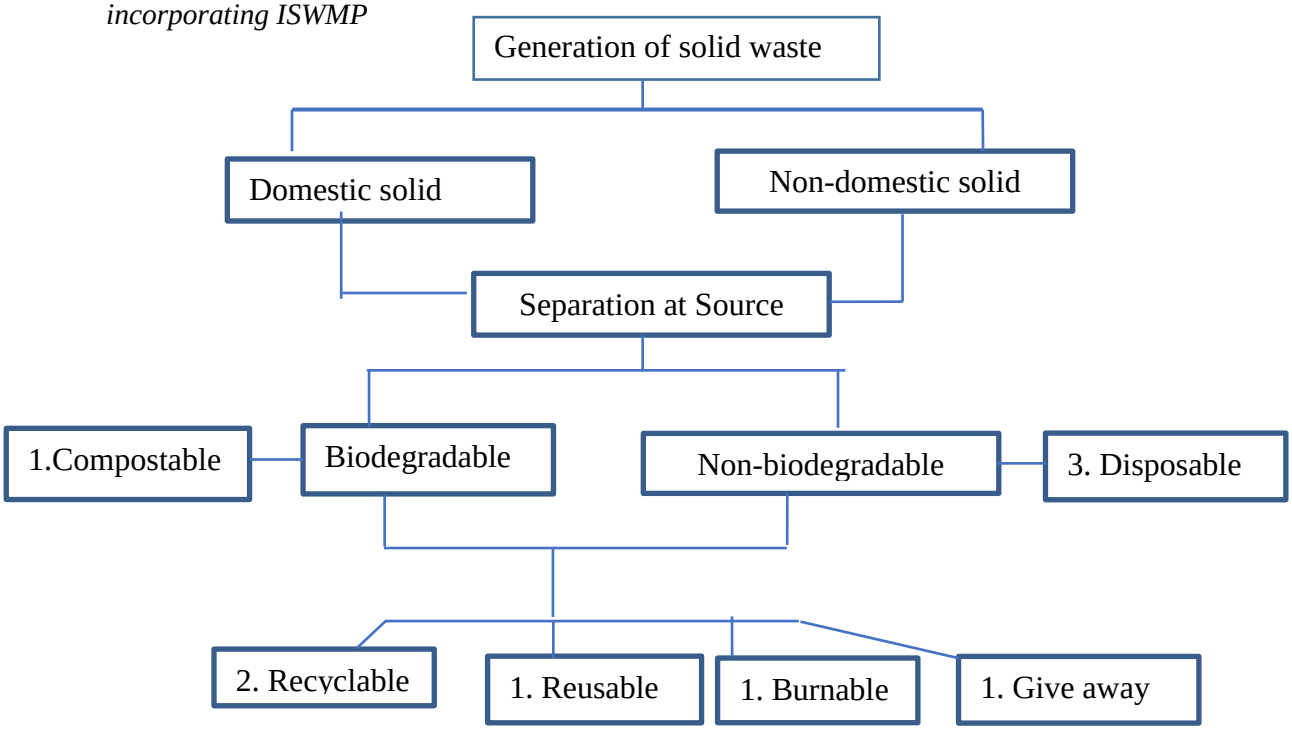
last long as they are vandalised and stolen by the public. The collections of SW from corporate sectors (industrial, commercial and offices) are done by the councils but sometimes by corporate sectors themselves when councils have problem with collection vehicles and funds. The storage bins for corporate sectors are either provided by the council or by themselves.

The lack of segregation at source in the public areas and by corporate sectors results in the build-up of the solid waste that is beyond the resource capacity of the council and the contractors. As the government is not directly involved in the recycling of non-biodegradables, the bulk of it is discarded for disposal. This causes overflow of solid waste in bins littering the public areas while more SW is generated daily and discarded on top of the uncollected SW in the bins making the roads, street and parks filthy. As SW collection in the residential areas is either provided or inconsistent some households discard their DSW in the public areas for the council to collect. This adds to SW that is littering the public areas. In the corporate sectors there is very minimal source separation for the non-domestic SW. The bulk of the SW is put out for collection making collection and disposal challenging and expensive for the council as well as for them. This practice need to change and source separation and resource recovery efforts promoted through an incentive system that is appropriate. In the 1970s and early 1990s, there were competitions run by the council for best-street or garden for residence to promote proper storage of SW hence resulting in keeping the town clean. These programs can be revived through private-public partnership with cooperate partners sponsoring the programs.

In addition, the collection and disposal fees that are currently charged are insufficient compared to the daily production of production of solid waste in town by all generators. The charge of K10- K16 month for formal housings and about K500 to K700 annually for corporate sectors is

not sufficient to fund the different operational costing of the council as there is lack of budgetary priorities from the government toward solid waste. The charges needs to change and a polluter pays system adopted to promote waste reduction and resource recovery efforts at all stages of waste production. Through reduction of waste and resource recovery less waste will end up in the disposal site addressing some challenges of acquiring land as disposal site. Therefore an appropriate solid waste management model for Goroka is needed to be incorporated into the policy and strategic planned documents. A SWM model for non-hazardous waste for Goroka town can be presented in this way incorporating current SWM system used by mainly household as shown here in Figure 8.4.

Figure 8.4 Non-Hazardous solid waste management models for Goroka Town and Wamonagu village incorporating ISWMP



1. *Resource Recovery present in the ISWMP*
2. *Modern Resource recovery method*
3. *Collection for disposal to a transfer and treatment facility before going to the landfill*

Source: Field work, 2011

The section in figure 8.4 that is numbered 1 shows the ISWMP that can be incorporated in the SWM of Goroka town. The number 2 in figure 8.4 indicates the modern resource recovery method that is practice in Goroka town but is not encouraged through council SWM system while number 3 is basically showing what can be disposed.

This model includes the ISWMP used by the household in Goroka town as well as Wamonagu village that is centred on resource recovery hence reducing the SW disposed. The only other resource recovery method used by the households in Goroka town that is not practiced by households in Wamonagu village is the recycling of non-biodegradable from SW produced from processed goods. This is an introduced resource recovery method that households have adopted as businesses trading non-ferrous used metals buy from the people to be sold overseas for recycling. The collection of the SW for disposal is the responsibility of the town council. The council can strengthen the partnership it has with the private organisation and the community, promoting cooperation in solid waste management. The domestic waste and non-domestic waste generators need to understand their responsibility for proper storage and resource recovery efforts. The council needs to promote the resource recovery efforts through corporate sector sponsored activities. The resource recovery efforts can be done at the household for domestic solid waste and for the public area and corporate sector solid waste at a designated location or at the location where waste is generated. For the solid waste management system recommended to work, awareness targeting different audience according to the type of waste generated is vital. The council needs to invest in sanitary landfills and proper compactor solid waste trucks. The provincial government needs to invest in recycling facilities by engaging more businesses to

invest in the industry. It also need to include more types of solid waste to be recycled instead of only the metal and glass beer bottles that are currently recycle.

8.4.4. Education and awareness of SWM

The education and awareness should include all aspects of solid waste management starting with the solid waste management system that is in place for the people to understand how it works. There has to be very maximum collaboration efforts between the council and the other stakeholders in creating partnerships and conducting education and awareness programs. Hence the different partnerships in place should be emphasized regarding its importance to the solid waste management system. The education and awareness need to promote the use of ISWMP at the households as well as by corporate sectors in their establishment and by the town community in public space as the households already have knowledge and skills of ISWMP.

The awareness needs to begin at home then into schools targeting teachers and students then corporate sectors, employees and employers and finally, the public at large. The awareness in schools should be conducted in workshop mode for teachers and in lessons and project mode for students. There should be workshops for corporate sectors and the public through representatives. Furthermore the education and awareness of the solid waste management system and the resource recovery efforts including their benefits and negative impacts should be done using all mode of communication including media, through newspapers, television and radio programs, and through posters, brochures, booklets in both English and Pidgin. In addition there should be drama, songs and public campaign to get the message across to the people. Finally, an effective way of creating awareness for the residents is the door to door awareness campaign called *door stepping* -a program where the members of the community are trained and engaged

to disseminate information on SWM activities to individual households. This education and awareness should be carried out by all the relevant organisations including community organisations. The community organisations are mostly women's and youth groups who are self-employed. Therefore their involvement will empower them and put values to their efforts in developmental that they would normal miss out on due to cultural values that portray male as leaders and decision makers of the society. Using community organisations to create awareness through door stepping would empower the youth who are unemployed and divert their attention from any anti-social activities that they may be involved in. The awareness and education on SWM should be incorporated into the school curriculum in the subjects taught in both the primary and secondary schools using the themes and topics in each subjects. This could lead to the change of behaviour and attitude of future generation in managing SW in an effective and sustainable way leading to improved SWM in Goroka.

On the other hand, there is a need for education and awareness in Wamonagu to highlight the importance of using the ISWMP properly and the impact of the ISWMP on the village community, environment and the global community. It is vital to disseminate information on the possible chemical contamination of their environment and their health through the decomposition of non-biodegradable SW. This awareness can be done at the household level and later transferred to the schools, churches, health clinics and other community gatherings in the village. The leaders (councillors) should utilize the youth and women's groups in the community and train them to carry out the community SWM projects with the assistance from the government institutions and individuals with knowledge and skills in the SWM. Furthermore, awareness on other alternative SWM techniques that could improve and make the overall SWM in the village effectively should be introduced, such as recycling. This education and awareness

can be incorporated into the community work program that the villages have when dealing with important issues that concerns them.

This thesis has advocated the incorporation of local knowledge and practice into solid waste management, especially in urban PNG. But, whichever way one proceeds, the rural and urban communities that generate and manage solid waste and the government and non-governmental institutions that are responsible for managing solid waste must be continuously made aware of the usefulness of local knowledge in managing solid waste, combined with modern ways of addressing the disposal of biodegradable and non-biodegradable waste. These must be backed up by policies, resources and sanctions at each level of administration.

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APPENDIX 1: TOPIC: The Role of Indigenous Solid Waste Management Practices (ISWMP) in Management of Solid Waste in Urban Centres in PNG

Interview questions for the In-depth participants in rural site:

Rural Household Member

SECTION A: PERSONAL INFORMATION

Identification Number Gender: Age: Section of Village:

Which Tribe or Clan are you from? Have you been to school?

What is the highest level of education you have attended?

SECTION B: MANAGEMENT OF SOLID WASTE AT THE HOUSEHOLD LEVEL

a) What types of solid waste do you produce in your house?

b) Which types of solid waste do you produced the most?

c) Which types of Solid waste is the one you produce the least at home?

d) How many bags of waste do you produced in a day?

f) What are the sizes of the bags used? 5kg, 10kg, 20kg or bigger than 20kg)

g) How are the different types of solid wastes stored in your house?

h) Where are these wastes stored in your house?

i) How long does it take to store the waste before it is disposed?

J) Where is the rubbish disposed?

K) Who is provides the bags for you to keep the rubbish in?

L) Does it cost for the bags to be provided?

a) If yes, how much?

b) If no, why?

M) How often is the garbage collected and disposed from your house?

N) Who collects and carry the rubbish from your house to the dump site?

O) Do you pay to dispose your rubbish in the site?

a) If yes, how much do you pay?

b) If no, why not?

Q) How far is the final dumpsite from your house?

R) How far is it from of the village?

S) How far is the dumpsite from the rivers or creeks that villagers use?

T) What do you think about where the dump is located whether it's effect the rivers or creeks?

U) What do you think about where the dump is located and health of the villagers?

SECTIONC: MINIMISATION OF SOLID WASTE AT HOUSEHOLD LEVEL

a) Have you tried cutting down on the amount of rubbish that you produce daily before it is disposed in the dumpsite?

(i) If yes, in what way have you done that?

(ii) If no, why not?

b) How does reducing the amount of rubbish in your house help in cutting down the amount of rubbish thrown away in the dump?

c) Do you separate your rubbish to cut down on the rubbish produced?

(i) If yes, how that is done?

(ii) If no, why not?

d) Where do you separate the rubbish?

e) Do you have any traditional way of reducing rubbish before it is disposed?

(i) If yes,

a) What are the ways of reducing rubbish?

b) How do you use each of the ways you mentioned above?

c) Which types of rubbish do you use each of the ways mentioned to cut down on amount of rubbish produced?

ii) If no, why not?

F) Do the other villagers use the same ways to take care of their rubbish?

(i) If no, in what way do they manage their rubbish?

G) How long have these ways of taking care of rubbish being used by the villagers?

H) What are some of the reasons for taking care of the rubbish in this manner?

I) Who is responsible for the collection and disposal of waste produced in the public areas in the village?

J) Are you involve in the collecting and removal of rubbish to the dump that is produced in public areas in the village?

(i) If yes, why are you involved in taking care of the rubbish produced in the public areas in the village?

ii) If no, why are you not involved in this activity?

SECTIOND: EFFECTIVENESS (SUCCESS) OF THE WAYS USED IN REDUCTING RUBBISH AT HOUSEHOLD LEVEL

a) How successful (good) is your ways of reducing the total amount of rubbish produced in your house that is thrown away in the dump?

b) Are there any benefits of using this way of taking care of the rubbish in your house?

(i) If yes, what are the benefits?

ii) If no why?

c) Are there any problems faced with the way of reducing the rubbish in your house?

(i)If yes, what are they?

(ii)If no,why?

d) Is there any other ways the garbage produce is managed to reduce the amount thrown away?

SECTIONE: EFFECTIVENESS (SUCCESS) OF THE TRADITIONAL SOLID WASTE MANAGEMENT

a) How successful (good) is the way of collecting and removing rubbish you used in your house to keep your house and area clean?

b) Are there any benefits of these ways of taking care of the rubbish for your family?

(i)If yes, what are they?

(ii) If no, why?

c) Are there any benefits for the environment (surrounding) by using these ways of taking care of the rubbish.

(i)If yes, what are they?

(ii) If no, why not?

SECTION F: EDUCATION AND PASSING ON OF TRADITIONAL KNOWLEDGE

a) Do you think it is important to keep practicing these traditional ways of taking care of rubbish in your house?

(i) If yes, what have to be done to make sure these ways of taking care of the rubbish are practices later on?

(ii) If no why?

b) Have you taught your children the different ways of taking care of the rubbish in the house? (Collection, carrying away of rubbish, separation, Reuse (using old materials again), composting, mulching and dumping)

(i) If yes

(a) How is the information passed to them?
(b) How do your children practice what they have learnt in the house?

(ii) If no, why not?

c) Who is job is it to make sure these traditional practices in taking care of rubbish in the house is taught and practice by the young people?

d) Are there any other ways of taking care of the rubbish in the house and the common areas in the village that existed in the past that can be used to take care of the rubbish produced better to reduce the problems of rubbish that exist today?

SECTIONF: ANY OTHER COMMENTS

APPENDIX 2: TOPIC: The Role of Indigenous Solid Waste Management Practices (ISWMP) in Management of Solid Waste in Urban Centres in PNG

) **Interview questions for the In-depth participants in rural site:**

Rural Elderly

SECTION A: PERSONAL INFORMATION

Identification Number

Gender Age Section of Village

Which Tribe or Clan are you from? Have you been to school?

What is the highest level of education you have attended?

SECTIONB: HISTORY OF THE VILLAGE

(a) How long have you lived in this village?

(b) Has the village been always located on this site?

(i) If no,

(a)Where was the other village located?

(b) What was the name of that old village?

(c) Did you live in the old village?

(ii) If yes, why was the village moved?

(c)Have you observed any changes in the way the villager's lives are now from the past?

(i) If yes, what are some of them?

(ii) If no why?

SECTION C: MANAGEMENT OF SOLID WASTE IN THE VILLAGE

(a) In the village are there any rubbish you see lying around?

(i) If yes,

(a) Who produces the rubbish?

(b) What are the different rubbish you see lying around the village?

(ii) If no, why?

b) The different rubbish you have named are put into organic (made from plant animal materials) and non-organic waste (not made from plants and animal materials).Which of these two types of rubbish mentioned above are common in village?

c) Who is responsible for the collecting and removing of the rubbish in the public areas (eg meeting place) in the village?

d) Are there any payments for keeping the public area clean?

(i) If yes, what is it?

(ii) If nowhy not?

e) How often is the garbage collected and removed from around the village?

f) What are the tools available for use to collect and remove rubbish in the village waste?

g) Who provides the tools for collection and removal of the rubbish?

h) Are there any village dumpsites for dumping of rubbish?

(i) If yes,

(a) Where is the dumpsite located?

(b) Is the dumpsite close to any creeks or rivers?

If yes, how close is it to the river or creek?

(c) Who takes care of the dumpsite?

ii) If no, why not?

(I) Are there any traditional laws or taboos in the village on how the villagers should take care of their rubbish?

i) If yes,

a) What are they?

b) How it is applied in the village.

c) What is the punishment for breaking the laws or taboos?

d) Who makes the laws and make sure it is followed by the villagers?

ii) If no why not?

J) When collecting, carrying and removing the rubbish from the village are the rubbish separated into different groups?

i) If yes,

a) How is the separation done?

b) Are the separated wastes disposed in the same dumpsite?

i) If yes, why?

ii) If no, where are the different groups of separated rubbish dumped?

ii) If no why?

K) How is the rubbish taken care of at the dumpsite to control and reduce the amount rubbish at the dumpsite?

L) When the dumpsite is full, what do the villagers do?

M) How is the dumpsite selected?

N) Is there any payment for the use of the dumpsite?

i) If yes, how much?

ii) If no why

O) How long has this way of taking care of rubbish at the dumpsite being used in the village?

SECTION D: EFFECTIVENESS (SUCCESS) OF THE TRADITIONAL WAY OF TAKING CARE OF RUBBISH

a) How successful (good) is the way of collecting and removing rubbish in the village to keeping village clean?

d) Does traditional way of taking care of the rubbish have effect on the people?

i) If yes, are the effects good or bad?

ii) If no, why not?

e) Does the traditional way of taking care of the rubbish have effects on the environment (surrounding)?

i) If yes, are the effects good or bad?

ii) If no, why?

f) What are some reasons for the effects of the traditional way of taking care of rubbish on environment?

SECTION E: CHANGES IN THE TRADITIONAL WAY OF TAKING CARE OF THE RUBBISH

a) Have you seen any change in the way people take care of their rubbish today from the way it was in the past?

i) If yes,

a) What have you seen?

b) What do you think caused the change?

c) How long ago has the change started?

d) Are these changes good or bad?

i) If the changes are bad, what can be done in village to stop these bad practices?

ii) If the changes are good, what can be done in village to help the people continue these good practices?

ii) If no why?

b) How are the young people in the village taught about the traditional way of taking care of the rubbish?

c) At what age is he/she taught about the traditional way of taking care of the rubbish?

d) Are there any other ways the rubbish were taken care of solid waste in the past that can be used to taking care of rubbish better to reduce the problems with rubbish that exist today?

SECTION F: ANY OTHER COMMENTS

APPENDIX: 3 TOPIC: The Role of Indigenous Solid Waste Management Practices (ISWMP) in Management of Solid Waste in Urban Centres in PNG

Interview questions for the In-depth participants in urban site:

Urban Household Member

SECTION A: PERSONAL INFORMATION

Identification Number:

Gender: Age: Province: Section of town:

How long have you lived here? What is the highest level of education?

Are you employed? If yes where do you work

SECTIONB: MANAGEMENT OF SOLID WASTE AT THE HOUSEHOLD LEVEL

a) What types of solid waste do you produce in your house?

b) Which types of solid waste do you produced the most?

c) Which types of Solid waste is the one you produce the least at home?

d) How many bags of waste do you produced in a day?

e) How many bags of solid waste do you have each week?

f) What are the sizes of the bags used?

g) Explain how the different types of solid wastes are stored in your house?

h) Where are these wastes stored in your house?

i) How long does it take to store the waste before it is disposed permanently?

j) Are there any equipment provided to carry out this activity?

(i) If yes, what are they?

(ii) If not, why not?

k) Who is responsible for provision of the equipment?

l) How much do you think cost for the equipment to be provided?

m) Who is responsible for the final collection, handling and disposal of your household Solid waste?

n) How often is the garbage collected for disposal from your residence? o)Do you pay for the collection and disposal services?

(i) If yes, how much and for how long?

(ii) If no, why?

p) How much are you willing to pay for the service?

q) Where are the solid wastes finally disposed?

r) How far is the dumpsite from your house?

s) How far is it from the boundary of the town?

t) What do you think about its current location in relation to the town?

u) Are there any rivers close to the dumpsite?

v) What do you think about its current location in relation to the river?

SECTIONC: MINIMISATION OF SOLID WASTE AT HOUSEHOLD LEVEL

(a)Have you tried reducing the amount of solid waste that you produce daily before it is disposed?

(i) If yes how do you do that?

(ii) If not, why?

b) What reduction methods have you used to reduce the amount of waste you produce and dispose? No

c) How does your reduction action assist in reducing the total amount of solid waste collected and disposed at the dumpsite?

d) Do you separate your solid waste at home in-order to use the waste reduction methods you mentioned above?

If yes, explain how that is done?

If no, why ?

Follow up questions

There are different types of waste reduction methods that are used to reduce the amount of waste produced in the households in other countries.

(i) Have you heard of reusing, recycling, composting and incinerating as methods to manage your waste thus reducing the amount produced?

(ii) Do you use any of these methods?

(iii) Why do you not use any of these methods?

e) Is there any other method of dealing with the garbage your produce at home? If yes what is it?

d) Are you aware of any traditional way of managing solid waste? If yes, what are they?

(i) If no,why?

e) Have you tried using the traditional solid waste methods?

(i) Why?

SECTION D: EFFECTIVENESS OF WASTE REDUCTION METHOD AT HOUSEHOLD

a) How successful is the waste reduction method in reducing the total solid waste produced at home?

Explain……

(b)Are there any benefits of using this method to manage your household waste? If yes, what are they?

(i) If no Why

c) Are there problems associated to waste reduction method use?

Explain

SECTION E: MANAGEMENT OF SOLID WASTE IN TOWN

(a) What are the types of solid waste that you see disposed around the town?

The wastes you have named are divided into organic and non-organic waste.

(b)Which of these two types of solid waste is the most common in town? Non -biodegradable one is the most common

c) Who is responsible for waste you see lying around in town? People in Goroka and mainly the supermarkets

d) Who is responsible for collection, handling and disposal of the solid waste in town

e) What facilities are available for people to dispose waste in?

f) What are the waste management services provided by the organization?

g) When handling and collecting solid waste from the residential area, industrial area and institutional offices are the garbage separated into different types of waste?

(i) If yes, explain how?

(ii) If no, explain why?

h) Do you know of any other organizations who provide collection, handling and disposal services?

If yes, name them

i) What type of waste do they collect handle and dispose?

j) Are you aware of any income earning opportunities or facilities provided in town to encourage residence to be involved in the waste reduction activities?

(i) If yes what are the opportunities or facilities provided?

(ii) Who provides that service?

(iii) If no, explain why?

K) How long do you think this system of managing solid waste existed in town?

SECTIONF: EFFECTIVENESS OF THE CURRENT SOLID WASTE MANAGENT

a) How successful is the solid waste collection system in town?

b) How successful is the collection system in the residential areas?

c) Where do you think the solid wastes generated from the public places in town are finally being disposed?

SECTION G: PROBLEMS OF CURRENT WASTE MANAGEMENT

1: Problems caused by improper management of Solid Waste

a) How do you view the solid waste issue in Goroka town?

b) What do you think will happen, when the collection and disposal of solid wastes are not done properly?

c) In your opinion explain if you think any environmental pollution causing public health problems within and around the town?

(i) What are the actual environmental pollutions?

(ii) What are health problems?

d) How does this affect the lives of people within and around the town?

e) What is your opinion on the severity of impact on the environment and the people?

2: Causes of improper management of Solid Waste

a) In your opinion what do you think are the contributing factors of the improper management of the solid waste in town?

SECTION H: STRATEGIES OF MITIGATING THE PROBLEMS

a) How do you think the factors contributing to the improper management of the solid waste be minimized?

b) How could the impact of solid waste on the environment be mitigated?

c) How can the problems of solid waste on people's lives be mitigated or improved?

d) What incentives could assist you to reduce waste?

d) Are there any other methods of solid waste management that exist in the country that can improve the management system and mitigate the problems of solid waste that exist today? Explain.

Education and Awareness

a) Are you aware of any public awareness done to inform people of the problems associated with solid waste?

(i) If yes, who is responsible for that?

(ii) If no, why?

b) Give your opinion on how the awareness on solid waste can be done?

SECTION I: BENEFITS OF PROPER MANAGEMENT OF SOLID WASTE

a) How do you think your reduction and improvement in managing waste will;

(i)Benefit your household?

(ii) The public?

(iii) The service providers (council and partners)

(iv) The businesses?

(v) The province?

Tourism Promotion

b) Are you aware of the income that is generated from tourist?

(i) If yes, how did you learn about?

(ii) If no, why?

c) In your opinion how will generation of income from tourism benefit the following group?

(i) Individuals
(ii) Business

(iii) Town and province

SECTION J: ANY OTHER COMMENTS

APPENDIX: 4 TOPIC: The Role of Indigenous Solid Waste Management Practices (ISWMP) in Management of Solid Waste in Urban Centres in PNG

Interview questions for the In-depth participants in urban site:

Council Manager

SECTIONA: PERSONAL INFORMATION

Identification number:

Gender: Age: Province: location of your residence::

How long have you lived here? What is the highest level of education?

SECTIONB: ROLES, RESPONSIBILITIES AND STAFF

a) What is your main role in the organization?

b) What are your responsibilities in this role?

c) How many departments or sections do you have in your organization?

e) Which department is responsible for the management (collection, transporting and disposal) of solid waste in town?

f) How much is budgeted each year for the management of solid waste in town?

g) Who is responsible for the budget and allocation of the money for the council?

h) What is the total number of staff for your organization?

i) How many staff members are involved in managing solid waste (collection, transporting and disposal) in the council?

j) How is the employment of total number of staff in each department decided on? And who decide on the total number?

k) Are you involved in making any of the decision on number of staff to be employed and budget allocations?

(i) If yes

(a) Are you able to influence the decisions made?

(ii) If no, Why not?

l) How many of your staff has permanent position?

m) How many staff members are part-time and casuals?

n) What is the main purpose or aims for the council's management of solid waste in town?

SECTIONC: SOLID WASTE MANAGEMENT POLICIES, STRATEGIES AND METHODS

a) Are there any solid waste management policies or strategies for the town?

(i) If yes,

(a) When were they developed?

(b) How are the policies and strategies being used?

(c)) Who is responsible for the development of these documents?

(ii) If no, why?

b) What is the main way of collecting, transporting and dumping of garbage used by the council in town?

c) How many proper council dumpsites are there for the residents and council dump garbage from the town?

d) Is the dumpsite on state (government) land?

(i) If yes,

(a) Is it large enough to cater for the garbage from town?

(ii) If no,

(a) Who owns the land?

SECTION D: OPERATIONAL COST OF PROVIDING THE SOLID WASTE MANAGEMENT SERVICE

a) What is the total staffing cost for the solid waste management department?

b) What is the total cost of providing collection, transportation and dumping services for the town?

c) Where does the funding of the delivering service for the management town's garbage come from?

d) Are there any fees charged for by the council for the delivering the services of garbage collection and removal in town?

(i) If yes, how much?

e) Is the amount charged the same for all garbage producers?

f) How much money made from that activity in a year?

g) How successful is the fees collections?

SECTION E: PROBLEMS AND EFFECTIVENESS OF THE CURRENT SOLID WASTE MANAGEMENT

1: Effectiveness of the methods used

a) How successful is the waste collection, removal and disposal method of the council in keeping the town clean?

b) What the reason for using the current way of collection, removal and disposal of garbage by the council?

2: Problems faced by the councils

c) Are there any problems that your organization experiences with current way of collecting, removing and disposing garbage in town?

(i) If yes,

(a) What are they?

(b)) what do you think are the causes of these problems?

(ii) If no, why?

3: Effect of the solid waste on the public health and environment

d) Do you see any problems that the current way of collecting, removing and dumping the garbage can cause to the health of the residents in town?

(i) If yes, what are they?

(ii) If no, why not?

e) Are there any environmental problem related to the way garbage is managed in town?

(i) If yes, what are they?

If no, why?

SECTIONF: POSSIBLE SOLUTION OF THE PROBLEMS

a) What plans have you developed to deal with these problems?

b) How successful are the plans carried out to minimize the pollution of the environment caused by garbage?

Explain

c) How successful are the plans carried out to minimize the health problems (diseases) related to the garbage problem?

d) How can the council use the waste produced by the town to generate income for its operations?

e) Are there any garbage reducing activities such as reusing of materials, recycling of materials (aluminum), composting/mulching of organic materials and burning of garbage in town?

(i) If yes, what are they?

(ii) If no, Why?

SECTION G: TRAINING AND AWARENESS

The training of staff and educating the public can assist in improving the management of garbage in town.

a) Are there any training programs for the staff of the council?

(i) If yes, explain its operation

(ii) If no, why?

b) Has the council engaged in any public awareness and education on ways of managing garbage in town?

(i) If yes,

(a) How have you done that?

(b)Who are the target audience?

(ii) If no, Why?

SECTION H: PARTNERS INVOLVED IN SOLID WASTE MANAGEMENT

(a)Are there any partners involved in the collection, removal and disposal?

(i) If yes,

(a) Who are they?

(b) What type of waste do they collect and disposed?

(c) How can they contribute further in they services?

(ii) If no, why?

b) Are there any partners in the activities of reducing garbage such as recycling, reuse, composting of garbage in town?

If yes

(i) Who are they?

(ii) Which of the activities above are they involved in?

If no,

(i) Why ?

SECTION I: ANY OTHER COMMENTS

Interview questions for the In-depth participants in urban site:

Officer in charge of the collection and disposal

SECTION A: PERSONAL INFORMATION

Identification Number:

Gender: Age: Province: location of your residence::

How long have you lived here? What is the highest level of education?

SECTION B: ROLES, RESPONSIBILITIES AND STAFF

a) What is your main role/job with the council?

b) What are your responsibilities in this role/job?

c) How many staff works under you?

e) How much is budgeted each year to manage the garbage (collection, transporting and dumping) in town?

f) Who is responsible for the budget and allocation of the funds?

g) How are the staff members in you organization employed?

h) Are you involved in all their appointment?

(i) If yes (go to I)

(ii) If no, why are you not involved in?

I) How many of your staff has permanent position?

j) How many staff members are part-time and casuals?

k) What is the main purpose or aim of your department the council's management of garbage in town?

SECTIONC: SOLID WASTE MANAGEMENT POLICIES AND STRATEGIES

(a) Is there any solid waste management policy or plan in your department?

(i) If yes,

(a) When were they developed?

(b) How is the policy and plan being used?

(c) Who is responsible for the development of these documents?

(ii) If no, why?

(a) Is there a plan to develop any plans for managing garbage?

SECTIOND: METHOD OF SOLID WASTE MANAGEMENT USED FOR COLLECTION AND DISPOSAL

a) How many times is the waste collected from;

(i) Residential area?

(ii) Industries/businesses?

(iii) Offices/ schools?

(iv) Other public areas (market)?

(b)What is the main way of collecting, transporting and dumping of garbage used by the council in town?

(c)How many proper council dumpsites are there for the residents and council dump garbage from the town?

(d) Is the dumpsite on state (government) land?

(i)If yes, Is it large enough to cater for the garbage from town?

(ii) If no, who owns the land?

e) Are there other organization involved in the collection, removal and disposal of solid waste?

(i) If yes,

a) Name them

ib) What solid waste do they collect and dispose?

(ii)If no, Why not?

f) How is the amount of garbage dumped at the dumpsite to reduced to stop it from filling the dumpsite?

g) How far is the dumpsite from water sources such as rivers and creeks used by people?

h) How far is the dumpsites from town and the villages nears the town area?

The use of many different ways of managing garbage called integrated solid waste management is used in many countries to reduce waste. It includes activities that encourage reusing (using old materials for other purpose), recycling (using old materials to make new thing to be used), composting/mulching (allowing plant and animal rubbish to break down for use as plant food) and burning garbage to produce energy that can be use by people.

g) Does the council use any of this method?

(i) If yes,

(a) Which one of the method is used?

(b) What type of garbage is used with each of the methods used by the council?

(ii) If no, why?

Solid waste can be separated into different groups before being reused, recycled, composted and burned to produce energy

h) When collecting waste, is there separation done?

(i) If yes,

(a) What groups are the garbage divided into?

(b) Where doe the garbage separation begin?

(ii) If no, why?

g) Are you aware of separation where organic garbage (plant and animal garbage) and non-organic (non plants and animal garbage) are collected separately?

(i) If yes Is your department using it?

(ii) If no, why?

h) Do you think you will apply this technique if you are given the opportunity?

SECTIONE: EQUIPMENT FOR COLLECTION AND DISPOSAL OF SOLID WASTE

*(*a)What are tools provided for the houses, businesses, offices/schools and hospitals and public areas to throw their garbage in for collection?

(b) Is it provided for all the groups mentioned above?

i) If yes (go to c)

(ii) If no, why?

C) How many are provided for each of them?

(i)houses?

(ii) Businesses?

(iii) Offices/schools/hospitals

(vi) Public areas (markets)

(d)What tools are used to collect, remove and dispose the garbage?

(e) Is there enough tools to use and carry out this activity?

(i) If no, why?

(f) Are there different bins for dumping different types of garbage?

(i)If yes how many are there?

(ii) If no, why?

(g)Are there any tools provided for the workers to use to protect them when collecting removing and disposing waste?

(i)If yes what are they?

(ii)If no, why

SECTION F: OPERATIONAL COST OF PROVIDING THE WASTE MANAGEMENT SERVICE

a) What is the total staffing cost for the solid waste management department?

b) What is the total cost of providing collection, transportation and dumping services for the town week?

c) Where does the funding of the delivering service for the management town's garbage come from?

d) Are there any fees charged for by the council for the delivering the services of garbage collection and removal in town?

If yes,

i) How much?

e) Is the amount charged the same for all garbage producers?

i) Why?

f) How much money made from that activity in a year?

g) How successful is the fees collections?

Effectiveness of the methods used

c) How successful is the waste collection, removal and disposal method of the council in keeping the town clean?

d) What is the reason for using the current way of collection, removal and disposal of garbage by the council?

SECTION G: PROBLEMS AND EFFECTIVENESS OF THE CURRENT SOLID WASTE MANAGEMENT

1: Problems faced by the councils

(a) Are there any problems that your organization experiences with current way of collecting, removing and disposing garbage in town?

(i) If yes,

(a) what are they?

(b) What do you think are the causes of these problems?

(ii) If no, why?

2. Effect of the solid waste on the public health and environment

(b) Do you see any problems that the current way of collecting, removing and dumping the garbage can cause to the health of the residents in town?

(i) If yes, what are they?

(ii) If no, why not?

(c) Are there any environmental problems related to the way garbage is managed in town? m?

(i) If yes, what are they?

(ii) If no, why?

SECTION H: POSSIBLE SOLUTION OF THE PROBLEMS

(a) What plans have you developed to deal with these problems?

(b) How successful are the plans carried out to minimize the pollution of the environment caused by garbage?

(c) How successful are the plans carried out to minimize the health problems (diseases) related to the garbage problem?

(d) How can the council use the waste produced by the town to generate income for its operations?

(e) Are there any garbage reducing activities such as reusing of materials, recycling of materials (aluminum), composting/mulching of organic materials and burning of garbage in town?

(i) If yes, what are they?

(ii) If no, why ?

SECTION I: TRAINING AND AWARENESS

(a) Are there any training programs for the staff of the council?

(i) If yes, explain its operation

(ii) If no, why?

(b)Has the council engaged in any public awareness and education on ways of managing garbage in town?

(i) If yes,

(a) How have you done that?

(b)Who are the target audience?

(ii) If no, Why?

SECTION J: PARTNERS INVOLVED IN SOLID WASTE MANAGEMENT

(a)Are there any partners involved in the collection, removal and disposal?

(i)If yes,

a) Who are they?

b) What type of waste do they collect and disposed?

c) How can they contribute further in they services?

(ii) If no, why?

b) Are there any partners in the activities of reducing garbage such as recycling, reuse, composting of garbage in town?

(i) If yes

(a)Who are they?

(b) Which of the activities above are they involved in?

(ii) If no, why not?

SECTION K: ANY OTHER COMMENTS

APPENDIX 6: TOPIC: The Role of Indigenous Solid Waste Management Practices (ISWMP) in Management of Solid Waste in Urban Centres in PNG

Interview questions for the In-depth participants in urban site:

Environmental Officer

SECTION A: PERSONAL INFORMATION

Identification Number:

Gender: Age: Province: location of your residence::

How long have you lived here? What is the highest level of education?

SECTION B: ROLES, RESPONSIBILITIES AND STAFF

a) What is your main role in the organization?

b) What are your responsibilities in this role?

c) How many sections do you have in your department?

d) Which section is responsible for policies and plans on environment and health in town?

e) How much is budgeted each year for your department's operations?

f) Who is responsible for the budget and allocation of the funds?

g) What is the total number of staff for your department?

i) Is your department involved in monitoring and evaluation of projects to compile with the policies you have?

(i) If yes how is this done?

(ii) If no, Why?

j) How much of the departments funding is allocated for this activity (monitoring and evaluation)?

k) Is the funding enough to carry out the monitoring and evaluation??

(i) If yes (go to section D)

(ii) If No, Why?

ECTIONC: SOLID WASTE MANAGEMENT POLICIES AND STRATEGIES

a) Are there any solid waste management policies or strategies for the province?

(i) If yes,

a) When were they developed?

b) How are the policies and strategies being used at the provincial level?

c) Who is responsible for the development of these documents?(go to b)

(ii) If no Why? (Go to b)

b) Do you have any role in the site selection for dumpsite for council to dispose the garbage?

(i) If yes,

(a) How are you involved?(go to c)

(ii) If no, Why? (Go to c)

c) Are there any impact assessments of the dumpsite and the town environment conducted by your officers?

d) How would you rate the impact of the towns garbage on the;

(i) Health of the public?

(ii) The environment?

e) How do you deal with these two problems?

f) Is there any other way of addressing any negative impact of the town's garbage?

SECTIOND: TRAINING AND AWARENESS

a) Is there any training program for your staff regarding management of the garbage in town?

(i) If yes, how does it operate?

(ii) If no, why?

b) Has the department been engaged in any public awareness or education ways of managing garbage in town?

(i) If yes,

(a) How have you done that?

(b) Who are the target audience?

(ii) If no, why?

c) How would your department assist in contributing towards the awareness and proper way of managing garbage in town?

d) What are some difficulties that your department faces in relation to the issues of garbage management and other environment issue?

e) How have you tried to solve this problem?

f) What is the result of your problem solving efforts?

SECTIONE: ANY OTHER COMMENTS

APPENDIX 7: TOPIC: The Role of Indigenous Solid Waste Management Practices (ISWMP) in Management of Solid Waste in Urban Centres in PNG

Urban Site Focus group Discussion Questions

Q1: How is the solid waste being by the people in your community?

b) At home by house holds

b) In the public areas (streets and common areas)

Q2. What are advantages of the methods use?

Q3. What are the disadvantages of the methods used?

Q4. How can the problems of the current methods used be minimized (reduced)?

Q5 How can the advantages of the methods used be applied to the whole town area to address the current solid waste issue that exist in town?

Q6 How is the solid waste managed traditionally in you villages?

Q7 How can your community and group participate in addressing the current solid waste management problem in Goroka town as active partners to finding solution for the problem faced.

Q8 How can the solid waste produced be used to generate income for individuals and groups in your community?