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Thesis Title: Potential Environmental and Financial Benefits of Composting and Solid Waste Recycling in Suva City, Fiji

Date of completion of requirements for award: 2/February/2016

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POTENTIAL ENVIRONMENTAL AND FINANCIAL BENEFITS OF COMPOSTING AND SOLID WASTE RECYCLING IN SUVA CITY, FIJI

by

Kana Miyamoto

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in Environmental Management

School of Geography, Earth Science and Environment
Faculty of Science, Technology and Environment
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February, 2016

Declaration

Statement by Author

I, Kana Miyamoto, declare that this thesis is my own work and that, to the best of my knowledge, it contains no material previously published, or substantially overlapping with material submitted for the award of any other degree at any institution, except where due acknowledgement is made in the text.

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Statement by Supervisor

The research in this thesis was performed under my supervision and to my knowledge is the sole work of Kana Miyamoto.

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Acknowledgments

I would like to thank all the members of the project for their invaluable assistance and support given to my thesis; I especially owe my gratitude to my supervisors Dr. John Lowry and Dr. Eleanor John for guiding me with patience to complete my thesis, and to a former JICA volunteer, Mr. Kentaro Tanaka, for giving me the opportunity to do this research. I also would like to thank the Senior Assistant Health Inspector & 3R Project Officer, Robert Randolph, and the Health Educator, Taito Rauluni. My friend, Peter Holm, also played an important part by instructing me in writing a thesis in English which is my second language.

I have been interested in the recycling of wastes as a key factor of sustainable development for some time, and have been wanting to study its impacts on the formation of a sustainable society and protecting natural environments. I strongly agree with the Japanese traditional concept that "wastes" can become "treasures" as a source of new products, and therefore they must be recycled.

A few years back, I was fortunate to encounter a JICA volunteer, Mr Kentarou Tanaka, who was then serving in the Health Services Department at the Suva City Council. Thanks to his support I received the necessary assistance from SCC to do my research for a major project on the topic: "Explore the capabilities of compost disposal to reduce wastes and produce organic fertilizer in Nasese district". That study became a foundation to start this research as a developed project.

I should mention the great flexibility demonstrated by SCC during the project. Their obvious respect for relationships with local people made this project especially valuable. Furthermore, I should state that workers working for SCC DEPO and composters always encouraged me during my research. To express my gratitude, I focused on how I could contribute to Fijian society through my thesis research. I believe that the SCC Home Compost Bin Project plays a key role in sustainable waste management in the South Pacific region.

Finally, I am grateful to the University of the South Pacific for giving me the opportunity to conduct this study.

Last but not least, I thank my family for their role in bringing me up to where

I now find myself and trust I can continue to contribute to society in ways to make them proud of me. My family includes a mother-figure in Fiji, Dr Noriko Dethlefs, who has believed in me and has encouraged and supported me both practically and emotionally.

Abstract

Composting organic waste is a key to ensure an environmental sustainability in Fiji that will benefit key stakeholders: households and local government. Since December 2012, the Home Composting Project operated by Suva City Council (SCC) has been organizing households to dispose organic compostable waste into compost bins provided by the council and thereby reducing both damage caused by landfill disposal, and emissions of carbon dioxide and methane. To date, about 400 households in Suva have been voluntarily participating in the project with the SCC to assist in the reduction of greenhouse gases (GHG). This study investigates how much this Home Composting Project is currently reducing CO_2 and CH_4 in Suva and analyses other related potential benefits. Primary data was obtained using the Customer After-Care Survey conducted by the survey team made up from three sectors: SCC, Japan International Cooperation Agency (JICA) and the University of the South Pacific.

The study revealed: (*i*) the quantity of organic waste produced by each household and the quantity of organic fertilizer this would create, how much CO_2 and CH_4 this amount of waste would produce if disposed of in landfill or in an incineration, how much carbon dioxide, methane and disposal costs can be reduced if all or half households in Suva City utilized a compost bin; (*ii*) how much CO_2 emission by garbage collection trucks can be reduced by the reduction of the organic waste using compost bins since the amount of garbage for collection would decrease; and (*iii*) how much recyclable waste the household sector is putting into rubbish bins as in plastic PET bottles, aluminium cans, and papers. The research includes discussion related to the challenges and the economic benefits for the local government (SCC).

Further to the above research, the paper evaluates other opportunities to reduce food waste, carbon dioxide and waste disposal costs. The first is to reduce the frequency of pick-ups from three to two days weekly, and the second is to start a recyclable waste collection service. Three types of recyclable waste are considered: plastic PET bottles, aluminium soft-drink cans, and paper accumulated by households.

Finally, the study aims to assist the local government's decision-making on the best possible waste disposal service for the city council as this matter has long weighed heavily on government finances in Fiji. Moreover, it is the hope of the author that this research will also encourage other cities and countries in the South Pacific to consider changing their methods of waste management for the environmental sustainability of this region.

Keywords: Fiji, Suva City Council, composting disposal, sustainability, household, local government, kitchen waste, landfill disposal, carbon dioxide, garbage collection trucks, recycling

Abbreviations

CO_2	Carbon dioxide
CH_4	Methane
EU	European
GHG	Greenhouse gases
JICA	The Japan International Cooperation Agency
NZ	New Zealand
SCC	Suva City Council
UNDP	The United Nations Development Programme
UNFCCC	The United Nations Framework Convention on Climate Change
USA	American
USP	The University of the South Pacific

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Chapter 1: Introduction

General introduction

Waste management in Fiji is now approaching a major turning point considering the urgency in its policies to protect its environment. Fiji needs to lead the rest of the South Pacific Islands in implementing recycling policies in order to reduce the amount of compostable and recyclable materials. Characteristics of small island countries in the South Pacific with their small land mass and limited resources make this even more important. Landfill disposal has been the only option to date. The problem with this option is that there is only a limited landfill space available in a small island nation (Fathimath, 2003). This option also creates negative impacts on islands, both environmentally and financially. This research investigates whether the reduction of the amount of wastes can play an important role in reducing waste materials and negative impacts to the environment.

In order to exemplify the positive affect of recycling waste as the way forward to protect the environment for the islands in the South Pacific, an experiment took place in Suva with the cooperation of the Suva City Council. Waste Management is a major responsibility for local government, and is significant socially, environmentally and economically (Qian & Burritt, 2007). Although there are many challenges, the Suva City Council (SCC), which manages the capital city of the republic of Fiji, started waste recycling through composting which was possible because of its positive local characteristics: the friendly community, the low boundary between local government and local people, and social flexibilities. The SCC project was carried out in conjunction with the assistance from JICA and USP. A year after SCC began its organic waste composting program the program is continuing with many positive results.

Composting disposal is viable in the South Pacific region due to its suitability for tropical and subtropical environments, and its low cost (Dalzell, 1987). Compost is nature's process of recycling decomposed organic materials into a rich soil (Whelan, 2003). Compost is beneficial in many ways: producing rich natural fertilizers containing macro and micronutrients, a mobilizing nutrients, and improving soil structures. Improving the soil structure means that the soil will better retain water and cause less runoff (Bettina Fos Ehrig, 1986). Most importantly, composting disposal results in a reduced amount of methane gas compared with that produced by landfill disposal; significantly, this also leads to a reduction of waste disposal costs because less waste goes to landfills (Lou & Nair, 2009).

Suva City Council now employs compost bins to reduce collection of organic waste produced by the household sector. The SCC hosted their official launching of the SCC Home Compost Bin Project at their Chambers on the 10th of December 2012 (webmedia Fiji, 2012). Composting disposal reduces the negative impacts on the environment and also the financial cost of waste collection and disposal (Askarany & Franklin-Smith, 2014). The number of households working on the project with SCC has increased to about 400 since the project began in 2012, and the achievements demonstrated has brought the project to the next step. Currently SCC initiates a compost customer after-care service to further reduce the amount of organic wastes and recyclable wastes in landfill, and to help people compost more efficiently. The after-care service team visits each composter for an interview survey. The data in this thesis were collected during the after-care service visits as interviews with households that happened through a cooperative agreement made in December 2014 between Suva City Council, Japan International Cooperation Agency and the University of the South Pacific. The interviews also looked into matters regarding the disposal of recyclable wastes; an investigation was made to ascertain if the amount of recyclable wastes from households warranted the SCC to start a regular council recyclable collection.

The city of Suva is divided into six geographic areas for garbage collection. These six geographic areas were used for collection and arrangement of data. Included in the research to assist the local government to wisely choose the methods of dealing with waste is the investigation of how much CO_2 is emitted from the waste collection trucks. The data were extracted from records kept by the SCC DEPO, which manages garbage collection service. Using the figures indicating the quantities of disposed wastes at the landfill and distances driven by the pick-up trucks, an analysis was made to show the relationship between disposed garbage amounts and the trucks' running distance. The analysis enables one to see how much using compost bins would contribute to reducing CO_2 emitted during collection service, and to the financial saving of collecting waste. Furthermore, the analysis allows insight into the possibilities and the feasibilities of reducing the frequency of waste collection by the council.

Another important factor of the study is to provide data to assist local government decision-making on waste disposal services to provide the government with relevant information to base their policies for optimal solutions to managing waste.

Research context and background

Suva City Council (SCC) started the SCC Home Compost Bin Project in December 2012 with the support of the UNDP small grant program. The purpose of the project is to encourage local people to utilize compost bins for reducing compostable wastes and producing organic fertilizer. Compost bins are subsidized by SCC and UNDP, so composters were able to buy the bins through the department in SCC at a reasonable price, below market rate. Thanks to the subsidy and efforts, the number of composters is increasing moderately, and reached about 400 households in 2015.

However, the first challenge recognized by the SCC was that some users of the compost did not understand how to correctly use it. As a result, the need for a customer after-care service was considered for the first time. In addition, SCC found it necessary to analyze the project performance, and if any other possible ways should be considered to further reduce waste amount.

With that in mind, a meeting was arranged to gather three organisations in December 2014: Suva City Council (SCC), Japan International Cooperation Agency (JICA) and the University of the South Pacific (USP), in order to start a customer after-care service. The roles of each sector were:

- SCC - Providing customers' information, transport and workforce for a survey
- JICA - Providing workforce for a survey and skills and knowledge
- USP - Providing workforce for a survey, analysis techniques using a Geographic Information System, and reporting

This survey team was organized to interview people who compost using a questionnaire. This is the first time data has been collected to analyze the benefits of compost bins in Fiji. Objectives of the survey will be explained in detail in the next section.

Research objectives

The overall goal of this study was to learn more about the potential benefits of composting and solid waste recycling based on information collected from participants of a Suva City Council composting project (already on-going).

The specific objectives of the study were to:

1) Quantify the organic wastes and organic fertilizer produced by selected participant households.
2) Estimate CO_2 and CH_4 emissions from participant households that were reduced (avoided) by composting rather than sending organic wastes to the landfill.
3) Estimate CO_2 and CH_4 reduction and disposal cost savings in Suva if everyone composted organic wastes.
4) Estimate CO_2 emission from rubbish collection trucks and evaluate how composting might affect rubbish waste collection.
5) Quantify the amount of recyclables produced by participant households, and assess their willingness to recycle.

Outline of thesis

This thesis consists of seven chapters following the objectives presented in the above section; and also considers the benefits of composting disposal.

Chapter 1 is a comprehensive description of the study. The general introduction, context and background, objectives, and outline are arranged in order.

Chapter 2 is a literature review, and describes composting disposal, the characteristics of organic waste, the difference between organic and chemical fertilizer, the difference between CO_2 and CH_4, the role of weather, and solid waste management, to facilitate better understanding of composting disposal. The chapter also explains the difference between CO_2 and CH_4 emissions in disposals by composting versus landfill.

Chapter 3 describes study area and project background. The chapter defines issues and conditions surrounding the project, while describing the Suva city area, the SCC Home Compost Bin Project, and Suva city solid waste collection services which are important parts of the project.

Chapter 4 provides details of the methods used in the research. The chapter explains the six methodological steps: selection of participating households and questionnaire design; estimation of amount of organic waste; calculation of amount of organic fertilizer generated; calculation of CO_2 and CH_4 emissions avoided by composting; estimation of CO_2 emissions from garbage trucks; estimation of amount of recyclable wastes and willingness to recycle.

Chapter 5 presents the results of the collected research data. The chapter presents estimates of how much CO_2 and CH_4 these organic wastes could produce if these reduced organic wastes were disposed of in a landfill; and if all or half of the people used composting disposal, how much they would reduce CO_2 and CH_4 during the disposal process. The chapter also estimates carbon dioxide emissions from garbage collection trucks. In addition, from these analytical data, this study explores the possibility of reducing garbage collection frequency from three times to two times a week. The chapter also analyzes research data on how much recyclable waste is produced by the household sector, to consider potential for further waste reduction. Three types of recyclable waste (plastic bottles, cans and paper) are considered in the study, in order to investigate the possibility of starting recyclable waste collection in Suva.

Chapter 6 is a discussion section, presenting and interpretation of the results and the data analysis to explore the benefits, potential and challenges for reducing wastes and greenhouse gas emissions. The chapter also examines the recycling system in Suva. A recycling system for three types of recyclable materials (plastic bottles, cans and paper) is described as a potential avenue for further reduction of wastes.

Chapter 7 summarizes the results, and makes a conclusion about the importance and value of composting. The chapter also defines challenges, and identifies a need of further research for establishing recycling collection service in Suva.

Chapter 2 : Literature Review

Introduction

To make the benefits of composting disposal clear, it is first necessary to discuss the features of composting disposal. This second chapter offers an overview of composting and waste recycling. Composting is not only a way to dispose of organic wastes, but it is also a source of fertilizer that differs from chemical fertilizer. However, the process of composting disposal releases greenhouse gases. The chapter will describe greenhouse gases generated by three methods of waste disposal: composting, landfill and incineration. In addition, weather performs an important role in decomposing wastes and producing fertilizer. At end of the chapter, it will be suggested that composting disposal opens up an important role for the South Pacific region as a practical model of the need to shift methods of disposal from landfill to composting disposal.

Overview of composting

Waste disposal by composting is an environmentally friendly way to dispose of organic wastes and convert them into organic fertilizer. Singh et al. (2006) describe composting as a natural recycling process that transforms organic wastes into nutrients. Common ingredients of compost are vegetables and fruits peelings, tealeaves, grass and leaves. This can be done in the backyard (Golds, 2010). Composting breaks down these organic wastes with a mixed population of micro-organisms (microbes) in a warm, moist, aerated environment.

Composting is proving to be economically viable (Villareal, 2003). It does not require high technologies or a difficult process, and is therefore not only environmentally friendly but also economically feasible. Composting disposal requires lower tipping fees compared to the cost of disposal at incinerators and landfills. “This type of waste management is well accepted when compared with other types, such as incineration or landfill” (Anwar et al. 2015, p. 68). Therefore composting is an invaluable aid in waste disposal for small island countries like Fiji, which has a small land mass and few resources.

Compost is beneficial in many ways: Anwar et al. (2015) describes composting as an environmentally sound way to minimize organic waste and produce organic fertilizer (Anwar et al. 2015). This fertilizer provides nutrients, increases organic matter, improves aggregate stability and increases water- holding capacity. Anwar et al. (2003) reported favorable changes in the organic matter and elemental composition during composting of livestock manure for the use as soil enhancement (Anwar et al. 2015). These nutrient-rich fertilizers are used in organic farming. They improve the natural recycling system and offer economic benefits especially when employed by subsistence farmers and in home organic gardens (Ouédraogo et al. 2001).

Composting is important for a number of reasons: environmental, social and economic, and it is inseparable from sustainable thinking (Brinton, 1998). Viable waste management is essential to sustainability, and connects with responsibilities of local governments. Reduction of negative impacts on the environment including greenhouse gases (GHG), and more importantly improvements in economic efficiency, are all related to concept of composting.

Composting contributes significantly to improving the natural environment through composting processes such as soil decomposition. Socially, composting as disposal method is a key factor in eliminating some social issues. Landfill disposal in Fiji creates several negative impacts on local communities. For instance, mangrove forests provide a variety of goods such as marine seafoods, medicines and materials that help to relieve poverty, a common problem in small island countries in the South Pacific. However mangrove forests are destroyed through expansion of landfill space. Furthermore, the smell generated by landfill causes psychological suffering for local people living in the surrounding area. This creates a gap between local government and local people, affecting their relationship and communities. Even though composting disposal is an alternative approach, it is obviously an appropriate method for small island countries. Fiji is fortunately in a position to take advantage of their climate, as composting requires warm temperatures. This enables Fiji to advance their sustainable waste disposal management.

Composting should be considered from the aspect of economic value. Composting is financially feasible, does not require advanced technologies, or expensive equipments. Landfill disposal requires large spaces to fill with waste, and this creates negative impacts on environments and local communities. Incineration disposal requires high technology and expensive facilities such as an incinerator (Villareal, 2003). The financial reality of burning trash is that it is more expensive than both landfill and composting (Eco-Cycle, 2011). Local government can get even more benefits as composting saves landfill costs. Therefore for Fiji, their negative characteristics such as small land mass, few resources and lack of finance become sources of inspiration for shifting from landfill to composting disposal. Thus, composting is important to cope with environmental and social matters, and simultaneously economic benefits are explicitly linked to composting.

Composting as an organic fertilizer

Another important aspect of composting is that composting offers a safe alternative to chemical fertilizers (Ogwueleka, 2009). Composting disposal produces healthy farming soil as the organic fertilizer it produces leads to a reduction in usage of chemical fertilizer. Organic fertilizer is made from natural matter such as vegetable peelings; in contrast, chemical fertilizer is made from minerals such as phosphate rock, which are nonrenewable resources. "Yet there are significant differences between organic and chemical fertilizers in terms of nutrient availability and the long-term effects on soil, plants, and the environment" (Julie, 2015). For instance, organic fertilizer helps soil microorganisms, but chemical fertilizer may kill these helpful microorganisms, Table 1.

Chemical fertilizer can take effect quickly, and makes crops grow faster (Hornick, 1992). Although this is an advantage of chemical fertilizer, chemicals also have the capacity to desolate the soil, leading to soil degradation. This normally occurs in industrial agriculture. "Excessive use of chemical fertilizers in agriculture, resulting in a large number of environmental problems because some fertilizers contain heavy metals (eg. cadmium and chromium) and high concentrations of radionuclides" (Savci, 2012, p. 77). For example, chemical fertilizers contain inorganic elements such as phosphate and potassium that cause soil pollution. Furthermore the soil polluted by chemical fertilizer is not covered by a protective layer of plants or decaying organic matter, which increases the rate of soil erosion

(Balesdent et al. 2000). Therefore, because of the high consumption of chemical fertilizers used to meet human demand, degradation of the land is occurring (Singh et al. 2011).

Table 1. Comparison of organic fertilizer and inorganic fertilizer

Object	Organic fertilizer	Inorganic fertilizer
Source of fertilizer	Vegetable peelings, food leftovers, dry grass, flowers, leaves	Phosphate, nitrate, ammonium, potassium salts
Effectiveness	long-term	short-term
Process	Organic fertilizer needs to be broken down by bacteria and worms. These invertebrates produce excretions that propagate soil micro-organisms that work on microbe decomposition and release nutrients. After ionization, vegetable roots can absorb these nutrients. It takes a long time and ensures long-term fertility of the soil. Source:http://www.greenback.com.sg/product/compost/organic-and-chemical/	Nutrients are in ready-to-use form and when mixed into the soil, can be immediately absorbed by the roots. Excessive nutrients cause burn to the roots and plants. Source:http://www.greenback.com.sg/product/compost/organic-and-chemical/
Insects, microorganisms	Micro-organisms such as bacteria, fungi, and actinomycetes account for most of the decomposition that takes place in a pile. They change the chemistry of organic wastes. The larger decomposers, or macro-organisms, in a compost pile include mites, centipedes, sow bugs, snails, millipedes, springtails, spiders, slugs, beetles, ants, flies, nematodes, flatworms, rotifers, and earthworms. They grind, bite, suck, tear, and chew materials into smaller pieces. Source:http://web.extension.illinois.edu/homecompost/science.cfm	Chemical fertilizer may kill insects and microorganisms. Source:http://www.greenback.com.sg/product/compost/organic-and-chemical/
Corrects Imbalances:	As the soil goes through the cycle of planting, harvesting and de-cropping, it becomes stripped of nutrients and the pH balance is also affected. Organic fertilizer helps correct imbalances in the soil pH to make it suitable for plant growth. It does not disturb the balance of the soil as it does not leave artificial compounds behind.	Makes soil acidic. Direct application of high dosage can burn the roots of the plants due to high salt concentration.
Water Holding Capacity and Aeration:	Organic fertilizer binds sandy soil and loosens clay/muddy soil. This provides the soil both the capacity to sustain water and good aeration for movement of microbes and healthier plant growth.	Causes the soil to dry up, resulting in caking or hardening, which makes planting difficult or impossible.

In contrast, organic fertilizers act as a part of natural cycles, and contain necessary proteins for improving agricultural soils. They perform roles of considerable importance for sustainable farming. They reduce soil erosion; and as they form healthy soil, this increases food productivity. Organic fertilizer is made from natural elements such as plants and animal products, and provides a home for numerous types of organism that contribute to improvements in the soil condition. In addition, a healthy soil improves the water-holding capacity of soil (Bot & Benites, 2005). The capacity of soil to retain and release water depends on a broad range of factors such as soil texture, soil depth, soil architecture, organic matter content and biological activity (Bot & Benites, 2005). However, as organic fertilizer is a natural fertilizer with no immediate effect, this needs a little help from chemical fertilizer, as chemical fertilizer is fast-acting. However it can be said that organic fertilizer is an environmentally friendly material compared with chemical fertilizer.

Thus, the differences between organic and chemical fertilizer consequently cause different effects on the soil condition. A better usage of fertilizers is to consider using chemical fertilizer in smaller quantities, and use organic fertilizer as the main supplement. Therefore, ensuring a sufficient quantity of organic fertilizer is a matter of national safety, as it sustains food production through sustainable agriculture.

Composting releases CO_2 more than CH_4

Composting disposal produces carbon dioxide during the process. In aerobic composting, microorganisms consume organic matter and release heat and carbon dioxide (GRID-Arendal, 2014). This may lead to the misunderstanding that composting is contributing to global warming. However this adds up to zero because plants release oxygen when they absorb carbon dioxide (Appenzeller, 2004), and this offsets the CO_2. In addition, most of the carbon contained in the organic matter is retained in the compost and therefore not released into the atmosphere (Epstein, 1996). Therefore composting is a superior method compared with others such as landfill, which is a significant contributor to methane gas emission.

When organic wastes are buried in a landfill they begin to produce methane gas because they are not able to receive oxygen under the ground. Methane is normally emitted by industry, agriculture, and waste management activities, and landfills are a large source of CH_4 emissions (United States Environmental Protection Agency, 2015). A distinctive attribute of methane gas is that it is more efficient at trapping radiation than carbon dioxide, and the comparative impact of CH_4 on climate change is greater than CO_2 (GRID-Arendal, 2014). Hao et al. (2004) investigated greenhouse gases emission during composting, and stated that the effect of CH_4 on global warming is 21 times greater than CO_2 (Hao, Chang, & Larney, 2004).

Thus the difference between CO_2 and CH_4 emission during disposal process in composting and landfill respectively is related to the difference between aerobic composting (presence of oxygen) and anaerobic composting methods (absence of oxygen). Because compost is exposed to oxygen, either by turning it or through the use of worms and other living organisms, it produces CO_2 (carbon dioxide) instead of methane (Sustainablog, 2014).

The role of weather in composting

"In aerobic composting proper temperature is important" (Washington State University, 2015). Composting disposal requires warm temperatures and moisture during the process, because decomposer organisms work to break down compostable materials in only a certain level of temperature. Thus, temperature is a parameter to evaluate evolution of the composting process (Anwar et al. 2015). "In soils they live in a film of water around plant roots or other particles, and their activity is dependent on the temperature and the amount of available moisture" (The University of Michigan, 2010). "As a result the temperature of the heap rises, thereby speeding-up the basic degradation process of nature which normally occurs slowly in organic wastes which fall on to the surface of the ground" (Dalzell, 1987, p. 1). Therefore, in places with a cooler climate, composting is effective only in summer since composting needs warmth and moisture to do its job. The effectiveness of organic fertilizer is also limited seasonally (Julie, 2015). In the South Pacific regions including Fiji, thanks to a tropical wet climate, processing by compost disposal is available throughout the year. In addition, the higher humidity assists decomposer organisms in breaking down organic matter. Therefore Fiji has a natural advantage, and is an ideal place for the composting process.

Estimating gas emissions from composting material

Estimating and visualizing amount of emitted greenhouse gases in figures plays an important role to raise awareness of the issue facing the world today. Data visualization helps people to take account of the fact that human activities create an impact on climate change, and to mull measures aimed at reducing global warming.

In Japan, the Ministry of the Environment provided formulas and units for estimating CO_2 and CH_4 emissions from mainly waste disposal and vehicle gas emission. These were made following the United Nations Framework Convention on Climate Change (UNFCCC) adapted in 1992. The effectuation of the UNFCCC in 1994, thereby all local governments have been had to provide their policies in climate change (Ministry of the Environment, 2015). Thus these formulas and units were necessary in order to creating feasible policies for them.

Therefore those are the most common formulas and units in Japan. The estimation conducted in this study was calculated by using these formulas and units to provide results at the same level as the nation standard.

Solid waste management

Sustainable waste management is a major challenge for small island countries. Even though it is widely acknowledged that incineration and landfill disposal have severely stressed environments and societies, and that investments in equipment to remove harmful elements from disposal processes have caused financial burdens, many developing countries follow the same approach in waste disposal as developed countries. They have then struggled with negative impacts on their land. In addition, people are exposed to air and water pollution. Unfortunately, in most cases the victims live in developing countries, because of their small capacities such as lack of financial capability and low technology. Therefore, many of these issues are becoming a reality in small island countries in the South Pacific.

Providing good solid waste management services while also ensuring the financial sustainability of the system continues to be a major challenge in cities of developing countries (Lohri, Camenzind, & Zurbrügg, 2014). It suggests that a key point to lead vulnerable societies in a direction of sustainability is economic incentives. Hence exploring of economic value of compost disposal is an important strategy, and leads a society to raise awareness of the role of composting in securing sustainable waste management as well as conserving natural environments.

These data provide the possibility of moving toward sustainable waste management in Fiji. This chapter has already described the benefits of composting, including financial benefits. It can be said that introduction of sustainable waste management based on composting disposal is a worthy challenge.

Chapter 3 : Study Area and Project Background

Introduction

This research is a part of the SCC Home Compost Bin Project, and was conducted with the project team in Suva. Chapter 3 provides a background to the study site including a waste problem that is defined at the end of this thesis, and explains in detail about the SCC Home Compost Bin Project. In addition, the garbage collection service managed by Suva City Council is described in relation to garbage trucks and challenges.

The Suva city area

Suva is the capital city of the Republic of Fiji, established in 1882. Suva succeeded the previous capital city, Levuka. Suva is located on the southeast coast of the main island, Viti Levu, on Suva Peninsula. Even though Fiji is an underdeveloped country, Fiji is one of the most developed island nations in the South Pacific and Suva City acts as the regional center under the authority of Suva City Council. As a result, Suva is experiencing both tradition and modernity. One of the most popular universities in the south Pacific, the University of the South Pacific (USP), was established in Suva in 1968 after its foundation by the 12 member countries. USP has established Suva as central to tertiary education in the South Pacific. Suva has a concentration of advanced information technologies and foreign aid agencies, which in turn attracts people in the education and business sectors, and creates a multi-ethnic society. According to the Housing Authority, the population of Suva is 84,178, and the number of households is 17,857 (figures provided by the Housing Authority, May, 2015). The two major ethnic groups are native Fijian called iTaukei and Fijian-Indian. Approximately 57 percent of the population of Fiji are Fijian; 38 percent are of Indian descent; and the remaining 5 percent are of other ethnic origin, primarily European, Chinese or other Pacific Islanders (Gubhaju, 2014). As a capital city, Suva is a business center, so there are also a variety of foreigners living in Suva such as Americans, Australians, New Zealanders and Asians.

Residential segregation in Suva has occurred between foreigners and native people. Squatter settlements are normally located on former mangrove swamps

(Gubhaju, 2014), because people rely heavily on natural resources; mangroves provide firewood, medicine and the marine foods necessary for local people. Recently, some mangrove forests along the Suva Peninsula seacoast were replaced by a public park; in addition, mangrove forests in Lami district (a town just outside Suva, which Suva relies on for landfill waste disposal) were removed to develop a landfill disposal site. Local environmental organizations warn of negative impacts of natural disasters and coastal erosion. In addition, the fact that local uneducated people throw their garbage bags into rivers impacts on the river system, reducing water quality and contributing to flooding. This is a serious issue for Suva City Council as well as for the Fiji government. Seawater surrounding the Suva Peninsula degrades the quality of the seawater of the wider area, with the result that despite Suva's position as a major south Pacific centre, there are no resort hotels with beautiful beaches available in Suva.

Suva's location at the southeast corner of the main island has completely different weather to that of Nadi town in the west (TALOIBURI, 2009). Nadi is a prosperous town based on tourism, and has typical tropical weather with little rain, located in a dry part of Fiji. In Suva, wet winds blowing from the southeast cause rain as they meet the mountains. Since almost every night and early morning brings rain, it is popularly said amongst foreigners living in Suva that you are lucky to see a sunset during your stay in Suva, because it is normally hidden by clouds. The usual precipitation type is a squall; sudden and heavy rain occurs in a small area and in a short time. Suva weather is tropical, which has its own advantages. The temperature is moderate and the humidity is bearable (World Weather Online, 2012). The time from May to November is the coolest and the months from December to April remain hotter, and are the cyclone season. January is the hottest month in Suva with a day/night average temperature of 26 degrees and the coldest is July at 23 degree (World Weather Online, 2012). The average daytime temperatures can be as high as 30 ℃ to 32 ℃ (Fiji Meteorological Service, 2006).

Suva City Council Home Compost Bin Project

"The Suva City Council hosted their official launching of the SCC Home Compost Bin Project at their Chambers on the 10th of December, 2012" (webmedia

Fiji, 2012). "The Council hopes to reduce operational costs and to maintain a clean City…" (webmedia Fiji, 2012). The SCC Home Compost Bin Project is funded by the United Nations Development Programme (UNDP), and supported by the Japan International Cooperation Agency (JICA). The project sells compost bins at a reasonable price, which is an incentive for people to use compost bins. The actual cost of one bin is FJ$90, the SCC and UNDP each provide a subsidy of FJ$30 for people purchasing a compost bin for their own composting activity in their back yard garden, the sale price therefore is FJ$30.

According to SCC, about 400 households used compost bins in May 2015. SCC often organizes promotions and demonstration events to encourage not only individuals but also apartments and schools to utilize compost bins.

In Fiji, thanks to a tropical climate, compost disposal does not need any external efforts or materials. It takes 10 ~ 12 weeks to produce organic fertilizer after filling a compost bin with food waste and leaves (see Table 2).

Table 2. Information on compost bins used by SCC

<table>
<tr><th colspan="2"><u>Compost bin details</u></th></tr>
<tr><td><u>Compost bin details:</u>

Dimension
✧ Height – 86 cm
✧ Top diameter – 42 cm
✧ Bottom diameter – 83 cm</td><td>

Photo 1: Image of Compost bins</td></tr>
<tr><td colspan="2">● 225 litre U.V. stabilized plastic moulded compost bin with twist lock lid
● Available in black or green (Note: black bin composts quicker as it attracts more heat)
● Made from polyethylene material
● Maximum seal to reduce nasty smells and keep away insects
● Lifetime warranty
Note: It normally takes about 12 weeks to fill one compost bin</td></tr>
</table>

Suva city solid waste collection services

The Suva City Council (SCC) has its own collection service, but relies on a private company to dispose of collected wastes at Naboro Landfill. The total quantity of waste for 2011 was 23,510,236 kg with a total disposal cost amounting to FJ$591,047. The total disposed wastes are gradually increasing from year to year, SCC paid FJ$ 646,811 for disposing of 25,728,350 kg wastes in 2014. The increased amount of waste from 2011 to 2014 is 2,218,114 kg, this corresponds to FJ$55,763.

Table 3. Total rubbish taken to Naboro landfill from Suva city

disposed wastes at Naboro landfill and costs	2011	2012	2013	2014
Total garbage (kg)	23,510,236	23,866,331	24,019,723	25,728,350
Total costs (FJ$)	591,047	599,999	603,855	646,810

Source: the Suva City Council

Samabula Depot is a waste collection center and office operating garbage collection services, which includes management of collection trucks. Normally six large trucks operate in the six districts respectively. The six districts are each further divided into two areas, in which the truck operates on alternate days. Their operations start from 7:00 am, and they return to the Depot in the afternoon between 2:30 pm or 4:00 pm depending on the amount of wastes and the size of the area.

Table 4. Engine size information for SCC rubbish trucks

Large Truck	Small Truck
Nissan: 6925 cc HINO: 7684 cc	HINO: 4009 cc

Table 5. Information on the SCC rubbish truck routes

Truck No.	Area name	Area A (Mon, Wed, Fri)	Area B (Tue, Thu, Sat)
Truck 1	Muanikau	Vatuwaqa	Nailuva
Truck 2	Rewa	Raiwaqa	Toorak
Truck 3	Central	Namadi Heights	Nasese
Truck 4	Samabula	C.B.D	C.B.D
Truck 5	Cunningham	Nabua	Cunningham
Truck 6	Tamavua	Tamavua	Rewa St.

Photo 2: NISSAN truck (left), HINO truck (right)

Challenges to composting in Suva city

Suva City Council is now faced with new challenges because of the changing character of the town, and for geographical reasons. Modern concrete buildings and reduced communication between citizens are all characteristics of a town that influence waste minimization. For example, people living in a town area do not have a gardening space, so they are not able to use a compost bin. In addition, the CBD area is a huge waste creator, producing large amounts of kitchen wastes in restaurants and office buildings. However, their characteristics make it difficult to separate raw garbage such as fish and meat which are not suitable for composting. In response, the SCC has designed a waste minimization system (not covered in this thesis). Kitchen wastes are gathered by many restaurants voluntarily and are reused by pig farmers. However not all restaurants have committed to this activity, a further challenge for SCC. A contributing factor is that a weak relationship between workers in a town weakens the frequency of sharing information. This may require regular events to share information and gain support from stakeholders.

Another challenge is the customer aftercare service. It is important to keep or build good relationships with composters, and this gives SCC an indication of what kinds of support or information they need. In fact, some compost bins are not yet in use, and some composters use it incorrectly, because they do not have a proper understanding. This creates problems such as producing unpleasant smells and attracting insect pests. Furthermore, an aftercare service is necessary to maintain the existing customer base and develop new customers. *Talanoa* (Fijian, meaning chat) between neighbors is a powerful tool to share information in a community. Neighbourhood evaluation of products as good or bad is seen as reliable, so convinces others and improves their community. In fact, composters in a community are often friends, neighbors or relatives who recommend or introduce good products to each other; so compost bins are quickly spread by *talanoa* into their group. Thus, the aftercare service provides a valuable insight into success, and it has the potential to encourage *talanoa* promoting compost bins in a community.

It is important to meet the needs of locals as well as enhancing sustainability. Composters' degree of satisfaction must be equated with the level of success of the project. Meeting these challenges is important to further reduce waste in Suva City.

Chapter 4 : Methods

Introduction

One hundred households with compost bins were chosen from the study area to gather primary data on the amount of organic wastes they were composting, the amount of recyclable solid wastes they generate, and their level of willingness to start solid waste (plastic bottles, aluminum cans, papers) recycling collection. These 100 composters were interviewed using a questionnaire to identify what kinds of kitchen waste they produce. From these primary data, the amount of organic fertilizer that would be produced by compost bins, and CO_2 and CH_4 that could be generated from incineration and landfill disposal were estimated.

This chapter explains the 6 methodological steps taken in this research:

1) Selection of participating households and questionnaire design
2) Estimation of amount of organic waste produced by participants
3) Calculation of amount of organic fertilizer produced by participants
4) Calculation of CO_2 and CH_4 emissions avoided by composting
5) Estimation of CO_2 emissions from rubbish trucks in Suva City
6) Estimation of amount of recyclable wastes and willingness to recycle

Selection of household participants and questionnaire design

Suva City Council divides Suva district into six geographic areas for collection of garbage. Hence there are 6 garbage collection trucks, one for each area.

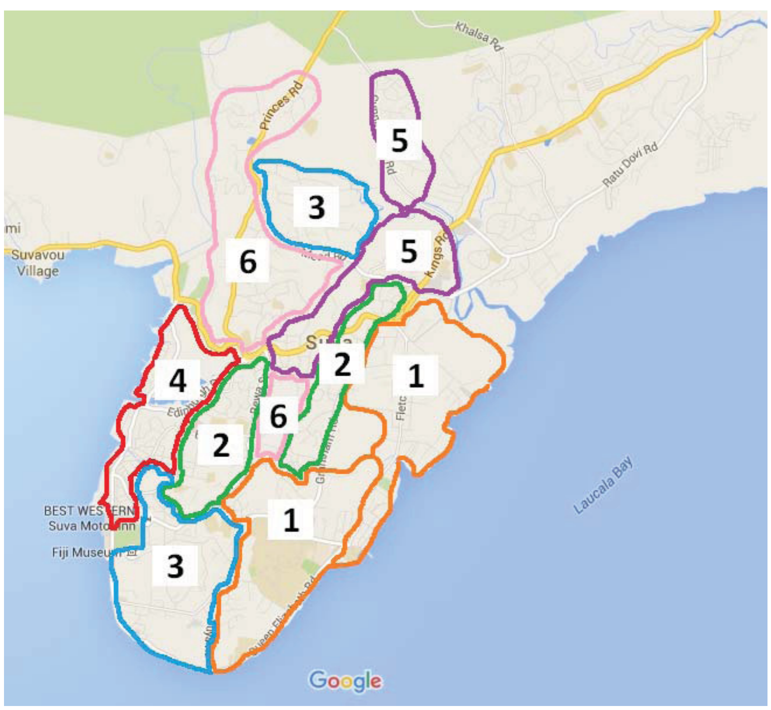
From these six areas, between 25 and 30 percent of households using compost bins (participating in the SCC project) were selected as participants. The number of composters (i.e. participants) in respective areas is variable: for example, the town area has a small number of composters, but residential areas have a larger number of composters due to land availability (i.e. larger lot sizes).

Area 1, 2, 3 and 6 have almost the same number of composters because their area characteristics are similar: middle to high-quality residential housing. Area 5 is also residential, but as most households are low-income only a few can afford a compost bin. Often in lower-income residential housing kitchen wastes are used to feed livestock, such as pigs and chickens. Area 4 is a town area with the lowest number of composters, because there is not enough space for composting or they are living in an apartment. Thus the one hundred interviewees were derived from the selected 25~30 percent of composters.

Table 6. Study area details and number of selected composters in each area

No (Colour)	Area	Details	The number of selected participants in each area
Area 1 (Orange)	Muanikau	Laucala Bay, Suva point	22
Area 2 (Green)	Rewa	Nailuva, CWM・Private Hospital	22
Area 3 (Blue)	Central	Namadi Height, Nasese, Domain	26
Area 4 (Red)	Samabula	Suva town, C.B.D	2
Area 5 (Purple)	Cunningham	Nabua, Cunningham	7
Area 6 (Pink)	Tamavua	Rewa, Samavula, Tamavua	21
TOTAL			100

Figure 1. Map of study area (Suva district) with area numbers



Source: https://www.google.co.jp/maps/@-18.1235341,178.4282865,13z

A questionnaire was designed to determine the amount of organic and recyclable wastes produced in each household. Another objective of the survey was to understand willingness to explore the possibility of recycling, so this was included in the questionnaire.

Three factors were used to identify interviewees; (1) address, (2) age and (3) ethnicity. Ethnicity included seven categories for nationalities or regions of origin: Native Fijian (iTaukei), Indian and Indo-Fijians, European, Australian, American, Asian and Others. Organic wastes were divided into four categories: (1) vegetable/fruit peelings, (2) food leftovers, (3) coffee grounds, teabags, stale bread, grains, etc. (4) grass/flowers, etc. Recyclable wastes were divided into three categories: (1) plastic bottles, (2) juice/soda cans, (3) paper (white paper and newspaper only).

Finally, the level of willingness for recycling was studied using a five-level measurement. Measurement levels are from 1 to 5; level 1 indicates that people do not desire to recycle at all, while level 5 indicates that people strongly wish to recycle wastes.

Estimation of amount of organic waste produced by participants

Interviewees were asked to record the quantity of wastes by measuring it using a 5 liter plastic shopping bag every day for one week. For instance, if the quantity of organic wastes was half of the 5 liter plastic bag, they record that amount as “1/2”, if a quarter, “1/4”. These amounts were converted into weight in grams based on the average weight of materials.

In order to find the average weights of the four types of waste, each type of the organic wastes prepared and selected by the survey team was measured using a kitchen scale by the principal researcher (see Table 7). The food leftovers represent the parts of the vegetables after removing the peelings.

Table 7. Converted weight of organic wastes

Amount of wastes (5ℓbag)	Food peelings (g)	Food leftovers (g)	Teabags (g)	Grass/flowers cuttings (g)
1	1752.45	997.96	-	748.08
1/2	876.23	498.98	-	374.04
1/3	584.15	332.65	-	-
1/4	438.11	249.49	-	-
1/5	350.49	199.59	-	-
1/6	292.08	166.33	-	-
1/7	250.35	142.57	-	-
1/8	219.06	124.75	-	-
1/9	194.72	110.88	-	-
1/10	175.25	99.80	52.83	-
1/15	116.83	66.53	39.62	-
1/20	87.62	49.90	26.42	-

The major vegetables potato, onion, carrot and egg plant, plus seasonal vegetables such as cabbage and native crops cassava and dalo, which are staple foods in Fiji, were chosen to estimate an average weight for food peelings.

The weight for vegetable peelings of half a 5-liter plastic bag was calculated at first, and then the full bag, and other amounts. Average weights, selected vegetables, and their size and number of pieces are as follows:

Table 8. Selected vegetables and their peeling weight

Vegetables peelings	Number of pieces (size)	Weight (g)	5 ℓ Bag	Weight (g)
Potato	3 (S) 1 (L)	53.57	1 bag	1404.7
Onion	3 (S)	36.44	1/2 bag	702.35
carrot	1 (L)	34.93	1/4 bag	351.18
Cabbage	3 leaves	102.71		
Egg plant	4 (S)	107.54		
Cassava	1 (M)	108.40		
Dalo	1 (M)	258.76		
Total (a half of 5ℓ bag)		702.35		

To estimate an average weight for food leftovers, the vegetables used for calculating vegetable peelings were reused after calculation of their weight. Cooked food such as fried cabbage and eggplants and boiled cassava, dalo and potato were measured and filled a quarter of the 5-liter plastic bag (see Table 9). They were fried with kitchen oil.

Table 9. Weight of food leftover

Food leftovers	Number of pieces (size)	Weight (g)	5 ℓ Bag	Weight (g)
Cabbage	3 leaves	-	1 bag	997.96
Eggplants	1 (S)	-	1/2 bag	498.98
Cassava	1/4 (M)	-	1/4 bag	249.49
Dalo	1/4 (M)	-		
Potato	1 (S)	-		
Total (a quarter of 5ℓ bag)		249.49		

For weight of fruit peelings, banana, pineapple, papaya and a native fruit, sosope, were selected. These are all seasonal fruits harvested around May in Fiji, so an average weight of fruit peelings can change seasonally. These fruit peelings filled three-quarters of the 5-liter plastic bag. Numbers of pieces, size and an average weight were as follows:

Table 10. Weight of fruit peeling

Fruit peelings	Number of pieces (size)	Weight (g)	5 ℓ Bag	Weight (g)
Banana	3 (M)	179.88	1 bag	2100.20
Pineapple	1 (M)	544.75	3/4 bag	1575.14
Papaya	1 (S)	164.14	1/2 bag	1050.10
Sosope	1 (L)	438.68	1/4 bag	525.05
Total (third quarter of 5ℓ bag)		1575.14		

Teabags were treated as representative for estimating an average weight of coffee grounds, teabags and stale bread. Six used teabags filled a tenth of a 5 liter plastic bag. Estimated weights in each amount are as follows:

Table 11. Weight of tea bag

Number of teabags	Weight (g)	5 ℓ Bag	Weight (g)
1	12.37	1/10 bag	52.83
2	19.40	1/15 bag	39.62
3	27.90	1/20 bag	26.42
4	36.55		
5	44.15		
6 (tenth of 5ℓ bag)	52.83		

Grass cuttings and flowers were collected at the Lower campus of USP and half-filled a 5-liter plastic bag. This was then used to calculate the weight of a full bag. It appeared that much of the moisture in the sample had evaporated, but it was not totally dry. Therefore the weight of materials may differ depending on their condition. Each weight was as follows:

Table 12. Weight of grass cuttings and flowers

5 ℓ Bag	Weight (g)
1 bag	748.08
1/2 bag	374.04

Calculation of organic fertilizer produced by participants

The amount of organic fertilizer produced by compost bins depends on how much organic wastes is added to the compost bin. According to the SCC Home Compost Bin Project, only 30 percent of wastes can be stayed and converted into fertilizer, as other 70 percent of wastes are decomposed by organisms. (SCC Home Compost Bin Project, Oct, 2013).

For example, the average amount of organic wastes produced in area 1

(Muanikau) is 4.94 kg per week for one household. This comes to 1.48 kg of organic fertilizer per week (30% of 4.94 kg). An example of the calculation for area 1 is as follows:

Table 13. Example of calculation (organic fertilizer)

Example of a calcuation	
Area 1 (Maunikau): The average household puts 4.94 kg in the compost bin in one week	
4.94 kg	Amount of biodegradable waste put in compost in one week
4.94 kg * 0.3 = 1.48 kg	Amount of organic fertilizer produced after 10 weeks from one week's waste
(10/1.48)*10 = 67 weeks	Number of weeks required to produce 10 kg of organic fertilizer

Calculation of CO_2 and CH_4 emissions avoided by composting

As noted previously in Chapter 2 the amount of CO_2 released from composting is considered to be less than the amount released when biodegradable wastes are taken to the landfill (Epstien, 1996). Also, because organic wastes buried in landfills produce more CH_4 because they are not able to receive oxygen underground. Thus, composting organic wastes instead disposing them in the landfill or incineration, results in a reduction of overall emission of CO_2 and CH_4. Based on calculations for estimating CO_2 and CH_4 emissions during the disposal process by landfill or incineration and calculations of the same during the process of composting, Ministry of the Environment in Japan (Ministry of the Environment, 2015) was able to determine how much CO_2 and CH_4 emissions are reduced by composting instead of disposing these wastes in the landfill or incinerating them.

Based on differences in the amount of CO_2 and CH_4 emitted through compositing as opposed to landfill or incineration, the Ministry of the Environment in Japan (Ministry of the Environment, 2015) derived coefficients that can be used to estimate the reduction of gas emission when composting. The coefficients are applied to the amount of organic waste measured in kilograms. These coefficients are presented in Table 14. Note there is no coefficient for CH_4 incineration because when wastes are incinerated, no CH_4 is produced.

Table 14. Formulas and emission coefficients

Type of disposal (animal and plant residues)	emission coefficient (CO_2) (tCO_2e/t)	emission coefficient (CH_4) (tCH_4/t)
Landfill	0.8460	0.0360
Incineration	0.0837	-

Source: the Ministry of the Environment in Japan

The average of organic wastes produced in area 1 (Muanikau) was 4.94 kg per week, or 21.03 kg per month, per household. After the quantity of waste calculated in kilograms is converted into tons, the result is multiplied by the emission coefficient: 0.846 for CO_2 emission, and 0.036 for CH_4 emission respectively (Ministry of the Environment, 2014). An example of a calculation to estimate CO_2 and CH_4 emissions from landfill disposal is as follows:

Table 15. Example of calculation (CO_2 and CH_4)

Example of a calculation	
Area 1 (Maunikau): The average household puts 4.94 kg in the compost bin in one week	
4.94 kg/7 days = 0.71*30days = 21.03 kg	Amount of organic waste produced per moth
21.03 kg = 0.0213 t	Convert kg to weight in tonnes
0.0213 * 0.846 = 0.0180198 t CO_2	Multiply by coefficient for CO_2
0.0180198*1000 = 18.02 kg CO_2	Multiply by 1000 to convert to weight in kg
0.0213 * 0.036 = 0.0007668 t CH_4	Multiply by coefficient for CH_4
0.0007668 *1000 = 0.7668 kg CH_4	Multiply by 1000 to convert to weight in kg

CO_2 emissions from rubbish collection trucks

As Suva district is divided into six areas, which are further subdivided into two for garbage collection, the total number of collection areas is twelve. Each of the six trucks operates in a subdivided area every other day. For example, truck 1 operates in half of area 1 on Monday, Wednesday and Friday, and operates in the other half on Tuesday, Thursday and Saturday. Therefore the operation of the garbage collection service takes six days.

The formula provided by the Ministry of the Environment in Japan (The

Ministry of Environment, 2016) was used to estimate the amount of carbon dioxide emissions produced by rubbish collection vehicles. That formula contains a number of factors that are necessary to estimate emissions, such as weight and size of the vehicle, fuel efficiency of the vehicle (mileage) and distance traveled. Table 16 presents the parameters and the formula

Table 16. Formula and parameters (CO_2)

Fuel	Maximum loading capacity (kg)	Efficiency[C] (km/l)	Heat value unit [A] (GJ/kl)	Emission coefficient [B] (tC/GJ)	Default basic unit of light diesel oil emission (tCO_2/kl) ①x②x44/12
Diesel	2,000~3,999	4.58	37.7	0.0187	2.585*
CO_2emission＝distance/(efficiency[C]×Heat value unit[A]×Emission coefficient[B]×44/12)					

Source: the Ministry of the Environment in Japan

Distance travelled and the amount of fuel consumed during collection services were obtained from a report book managed by SCC DEPO. The following is an example of the data:

Table 17. Distance in Area 1 (Muanikau)

Truck	Distance (km)						
	Mon	Wed	Fri	Tue	Thu	Sat	Total
Truck1 (NISSAN)	128	80	127	134	82	81	632

For example truck 1 operated from Monday 8th to Saturday 13th of June, travelling a total of 632 km in that week. Therefore according to the formulas applied to these data, Truck 1 generates an estimated 356.70 kg-CO_2 per week. An example of the calculation is as follows:

Table 18. Example of calculation (CO_2)

Example of Calculation	
Truck 1 (Area1:Muanikau) Total distance for one week 632 km	
632/(4.58*37.7*0.0187*(44/12)) = 356.70	Distance/(C*A*B*(44/12)) = Amount CO_2 in kg

Estimation of the amount of recyclable wastes and response on willingness to recycle

The amount of recyclable wastes generated by households was also estimated using a 5 liter plastic bag. In this survey, three recyclable wastes were studied: plastic PET bottles, aluminum cans and paper. The average weight of plastic PET bottles, cans and papers are based on actual weights. Estimated averages of weight are as follows:

Table 19. Average weight of recyclable wastes (plastic PET bottle, can and papers)

Number of Recyclable Materials (size)	Amount of wastes (5ℓbag)	Average (g)	Final Average (g)
Plastic PET bottle			
8~10(S)	1bag	232.74	235.20
4~6(L)		237.65	
4~5(S)	½ bag	116.37	117.60
2~3(L)		118.83	
Cans			
16~20(S)	1 bag	287.46	
8~10(S)	½ bag	143.73	
Papers			
10	1 bag	4018.50	
5	½ bag	2009.25	

The following is an actual weight of materials: Plastic PET bottle, cans and newspapers.

Table 20. Weight of recyclable wastes (plastic PET bottle, can and newspaper)

Materials	Size	Weight(g)	Average weight (g)
Plastic PET bottle	Small (S)	25.86	33.09
	Middle (M)	25.87	
	Large (L)	47.53	
Can	Can	15.97	15.97
Newspaper	Newspaper	401.85	401.85

Measuring willingness

Understanding the level of willingness of composters to start recycling wastes is an important aspect to consider before implementing this as a policy. A five-level measurement was used for people to indicate the level of their willingness to recycle their household waste.

Composters rate from 1 to 5, 1 being not at all interested and 5 being very willing to implement recycling household waste.

How interested are you in having SCC collect recyclable wastes from your home?
(Not at all) 1 • 2 • 3 • 4 • 5 (Very)

Chapter 5 : Results

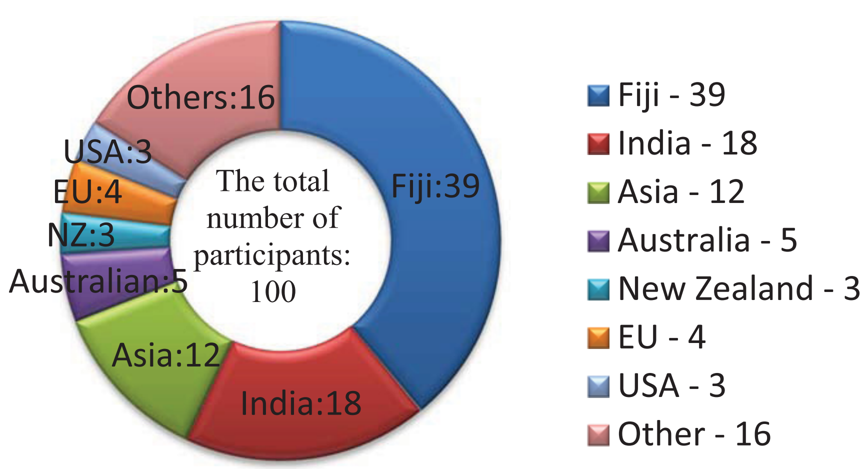
Introduction

This chapter is subdivided into the following topics: (1) organic wastes and organic fertilizer, and CO_2 and CH_4 gas emissions during waste disposal, (2) CO_2 emission from garbage trucks, (3) recyclable wastes and willingness to recycle.

The data gained through this survey - primary data gathered from one hundred participants with compost bins - are summarized in this chapter, and all data is presented in an appendix section (see Appendix 1).

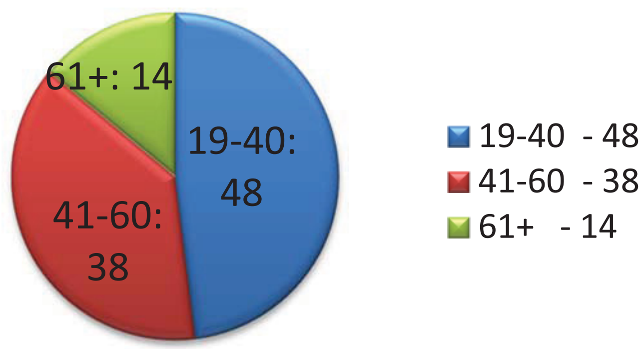
The one hundred participants include a variety of ethnicities: Native Fijian, Fijian of Indian decent, Asian, Australian, New Zealander, European, American and others including other south Pacific islanders. The largest proportion is Fijian-iTaukei (39 households) followed by Indian (18 households), others (16 households) and Asian (12 households). These included other Pacific islanders, such as Samoans, I-Kiribati, Tongans and so on. The smallest groups were Australians, New Zealanders, Europeans and Americans: 5 households, 3 households, 4 households and 3 households respectively.

Figure 2. Distribution of ethnicity in the survey



Age ranges of households were also collected. Age ranges are divided into three; 19-40, 41-60 and 61+. The largest group, almost half of the total number of households, belonged to the 19-40 range (48 households). The second largest group is 41-60 (38 households); followed by 61+ (14 households).

Figure 3. Distribution of different age ranges



This chapter presents the results of the data collection an analysis. It will do this by breaking down the estimates by each of the 6 Areas (Table 6; Figure 1). Specifically this chapter will present the:

1) Estimated organic wastes and organic fertilizer produced by participant households.
2) Estimated CO_2 and CH_4 from participant households avoided by composting.
3) Estimate of disposal cost savings city-wide by area.
4) Estimated CO_2 emission from rubbish collection trucks.
5) Estimated recyclables produced by participant households, and willingness to recycle.

Quantity of organic wastes produced by participant households

Table 21 represents the estimated total and average of the total weight of organic wastes generated by households, arranged by area. In other words, these data show the quantity of organic wastes disposed of using compost bins. These weights are estimated per day, week and month (30 days).

The weight of organic wastes produced by all one hundred participants per week is 622.29 kg. The estimated average weight per day, week and month for each household is 0.83 kg, 5.83 kg and 25.00 kg respectively (see Table 21).

The table also shows differences between each area in the weight of organic wastes per day, week and month. In area 6 (Tamavua) 21 households together produce the largest quantity of wastes: 1.06 kg per day, 7.44 kg per week and 31.80 kg per month. The next largest quantity of organic wastes produced per day, week and month is area 5 (Cunningham): 0.96 kg, 6.73 kg and 28.80 kg respectively; followed by area 2 (Rewa) and 3 (Central). Area 2 and 3 produce almost the same weight: 0.87 kg and 0.94 kg per day, 6.09 kg and 6.55 kg per week and 26.10 kg and 28.20 kg per month respectively. Area 4 (Samabula) produces a lower quantity of organic wastes: the weight per day, week and month is 0.46 kg, 3.24 kg and 13.80 respectively. The next lower quantity is produced by area 1 (Muanikau): the weight per day, week and month is 0.71 kg, 4.94 kg and 21.30 kg respectively.

Table 21. Quantity of organic waste produced by household (composters)

Area	Area name	Number of Composters	Total weight (kg/week)	Average (kg/day)	Average (kg/week)	Average (kg/month)
Area1	Muanikau	22	108.67	0.71	4.94	21.30
Area2	Rewa	23	139.98	0.87	6.09	26.10
Area3	Central	25	163.84	0.94	6.55	28.20
Area4	Samabula	2	6.47	0.46	3.24	13.80
Area5	Cunningham	7	47.09	0.96	6.73	28.80
Area6	Tamavua	21	156.24	1.06	7.44	31.80
Total		100	622.29	0.83	5.83	25.00

Table 22 gives the quantity of organic waste consumed by each household in different types: vegetable and fruit peelings, food leftovers, coffee grounds and teabags and grass and flowers. The largest quantity of waste is vegetable and fruit peelings; the average weight per week for one household is 4.56 kg. The next is grass and flowers; the average is 1.01 kg per week for one household. The quantity of food leftovers and coffee grounds and teabags are almost the same weight; the average is 0.16 kg and 0.12 kg respectively per week for one household.

Looking at total weight of each area, areas 6, 5, 2 and 3in descending order produce more than the average in vegetable and fruit peelings. The weights are 6.23 kg, 5.81 kg, 5.42 kg and 5.35 kg in order. Area 1 and 4 produce less than the average: 3.84 kg and 0.62 kg respectively. Even though grass cuttings and flowers are the next largest factor, the quantities are small. All areas except area 4 produce less than the average, with 0.43 kg, 0.55 kg, 0.71 kg, 0.75 kg and 1.00 kg in numerical order from area 1 to 6. Only area 4 produces more than the average: the weight is 2.62 kg. All areas except area 4 and 5 produce a small quantity of leftovers: the weights are 0.40 kg, 0.04 kg, 0.41 kg and 0.11 kg from area 1, 2, 3 and 6. Areas 4 and 5 do not produce any quantity, which may indicate that people living in these areas may not put leftovers into compost bins because they feed them to their dogs or cats. The quantity of coffee grounds and teabags is smaller than quantities of food leftovers: area 4 does not produce any quantity, and even area 1, producing the largest quantity, has only the weight of 0.28 kg per week. Other areas produce 0.07 kg, 0.09 kg, 0.17kg and 0.11 kg in numerical order from area 2 to 6.

Table 22. Average of each type of wastes per week for one household

Area	Name of area	Vege/Fruit peelings (kg/week)	Food leftovers (kg/week)	Coffee grounds, tea bags (kg/week)	Grass/Flowers, etc (kg/week)	Total weight (kg/week)
Area1	Muanikau	3.84	0.40	0.28	0.43	4.94
Area2	Rewa	5.42	0.04	0.07	0.55	6.09
Area3	Central	5.35	0.41	0.09	0.71	6.55
Area4	Samabula	0.62	0.00	0.00	2.62	3.24
Area5	Cunningham	5.81	0.00	0.17	0.75	6.73
Area6	Tamavua	6.23	0.11	0.11	1.00	7.44
Average		4.56	0.16	0.12	1.01	5.83

Table 23 shows the estimated quantity of organic fertilizer generated by composting activity. The weight was estimated based on the quantity of organic wastes calculated above. The result indicates a period needed to generate a total weight of 10 kg of organic fertilizers. The weight of fertilizers each household can gain is arranged weekly. All calculations are arranged in appendix 2.

The average period necessary for the whole area is 61 weeks, which is about fifteen months. Composters can gain an average of 1.75 kg of fertilizer per week based on 5.83 kg of organic wastes produced every week. Since the quantity of organic fertilizer depends on the source (the quantity of organic wastes), area 6 (Tamavua) gains the largest quantity of fertilizer. The average is 2.23 kg per week from 7.44 kg of organic wastes, taking 44 weeks. The next largest quantity of fertilizer is generated by areas 3 and 5, a total of 1.97 and 2.02 kg per week taking 50 and 49 weeks; this comes from 6.55 kg and 6.73 kg of organic wastes respectively. Area 2 follows generating 1.83 kg per week over 54 weeks from 6.09 kg of organic wastes. Area 4 generates the smallest quantity of fertilizer: 0.97 kg per week over 103 weeks from 3.24 kg of organic wastes. Finally, Area 1 generates 1.48 kg per week over 67 weeks from 4.94 kg of organic wastes.

Table 23. Estimated quantity of organic fertilizer and period needed

Area	Name of area	Average weight of organic wastes (kg/week)	Needed period for 10 kg fertilizer (no. of weeks)	Weight of organic fertilizer (kg/week)
Area1	Muanikau	4.94	67	1.48
Area2	Rewa	6.09	54	1.83
Area3	Central	6.55	50	1.97
Area4	Samabula	3.24	103	0.97
Area5	Cunningham	6.73	49	2.02
Area6	Tamavua	7.44	44	2.23
Average		5.83	61	1.75

Estimated CO_2 and CH_4 from participating households avoided by composting

Composting is not only a way to generate organic fertilizer, but also reduce amounts of carbon dioxide (CO_2) and methane (CH_4), as organic wastes generate greenhouse gases (GHG) when disposed of in landfill or by incineration. The data estimated above (the quantity of organic wastes produced by household) and formulas and coefficients (Table 14 and 15) allow us to find the amounts of GHG reduced by composting activity instead of disposing to landfill. All calculations are arranged in appendix 3.

Table 24 represents a hypothetical estimation of the average amount of CO_2 emission by incineration, and CO_2 and CH_4 emission by landfill per week. The weekly reduction of GHG emissions from the hundred households is an estimated weight of 52.09 kg-CO_2 by incineration and 526.46 kg-CO_2 and 22.40 kg-CH_4 by landfill, from 622.29 kg of organic wastes. The table also shows how much each household helps to mitigate GHG emissions: the average weight per week for one household is 0.52 kg-CO_2 for incineration, and 5.26 kg- CO_2 and 0.22 kg- CH_4 for landfill, from 6.22 kg of organic wastes.

Table 24. Estimated CO_2 and CH_4 generated by landfill and incineration

Area	Area name (Number of compost bins)	Weight of organic wastes (kg/week)	Average weight of organic wastes (kg/week)	incineration (kg/week)	Landfill (kg/week)	
				CO_2	CO_2	CH_4
Area1	Muanikau (22)	108.67	4.94	9.10	91.93	3.91
Area2	Rewa (23)	139.98	6.09	11.72	118.42	5.04
Area3	Central (25)	163.84	6.55	13.71	138.61	5.90
Area4	Samabula (2)	6.47	3.24	0.54	5.47	0.23
Area5	Cunningham (7)	47.09	6.73	3.94	39.84	1.70
Area6	Tamavua (21)	156.24	7.44	13.08	132.18	5.62
Total (per week)		622.29	5.83	52.09	526.46	22.40
Average (per week for one household)		5.83		0.52	5.26	0.22

Hypothetically extending composting to all of Suva city

The calculations in the previous two sections are based on the data collected from the participant households in this research. The calculations that follow are estimates of the possible effects of extending composting more widely throughout Suva City. A major limitation to doing this is that of the sample of participant households from this study is not necessarily represent all households in each area. In fact, because most of the participants in the SCC composting project are wealthy, they are not representative of many low and middle income households. Nevertheless, for illustrative purposes the results below will assume that the estimates generated from this survey are representative.

Estimate of CO_2 and CH_4 reduction and disposal cost savings city-wide by area

The calculation provides the potential to reduce greenhouse gases if all or half of households were involved in composting disposal. It also calculates the reduction in cost by these wastes not going to the landfill.

Table 25 represents the amount that CO_2, CH_4 and disposal costs can be reduced by using compost bins in all or half of the households. Area 6 (Tamavua), with the largest number of households (4,075) and the largest production of waste, has the potential to reduce organic wastes by 30,318 kg, CO_2 by 25,649 kg and CH_4 by 1,091 kg, saving FJ$762.19 per week if all households use composting disposal. The next largest area is area 5 (Cunningham). They can reduce organic wastes by 24,665 kg, CO_2 by 20,867 kg and CH_4 by 888 kg, saving FJ$620.08 per week. Other areas, area 2 (Rewa), 3 (Central), and 1 (Muanikau) in descending size order have almost an equal potential amount. Area 2 would contribute to reduction of organic wastes by 17,034 kg, CO_2 by 14,411 kg and CH_4 by 613 kg, saving FJ$428.23. Area 3 could reduce the amount of organic wastes by 14,790 kg, CO_2 by 12,512 kg and CH_4 by 532 kg, saving FJ$371.82. Area 1 can reduce organic wastes by 13,042 kg, CO_2 by 11,034 kg and CH_4 by 470 kg, saving FJ$327.88 per week. The smallest producer is area 4 (Samabula), which has the potential to reduce organic wastes by 7,823 kg , CO_2 by 6,618 kg and CH_4 by 282 kg, saving FJ$196.67 per week.

The reduction of the total amounts are; 107,672 kg of organic wastes, 91,091 kg-CO_2 and 3,876 kg-CH_4, saving FJ$2,706.87 per week. To find the reduction of the half of households can be half of the total amount (see Table 25).

Table 25. Potential amount if all or half household utilize a compost bin

Area	Area name	Weight of organic wastes (kg/week for one household)	All number of Household	Organic wastes (kg)	CO_2 (kg)	CH_4 (kg)	Costs (FJ$)
			Half	Half	Half	Half	Half
Area 1	Muanikau	4.94	2,640	13,042	11,034	470	327.88
			1,320	6,521	5,517	235	163.94
Area 2	Rewa	6.09	2,797	17,034	14,411	613	428.23
			1,399	8,520	7,208	307	214.19
Area 3	Central	6.55	2,258	14,790	12,512	532	371.82
			1,129	7,395	6,256	266	185.91
Area 4	Samabula	3.23	2,422	7,823	6,618	282	196.67
			1,211	3,912	3,310	141	98.35
Area 5	Cunningham	6.73	3,665	24,665	20,867	888	620.08
			1,833	12,336	10,436	444	310.13
Area 6	Tamavua	7.44	4,075	30,318	25,649	1,091	762.19
			2,038	15,163	12,828	546	381.20
Total			17,857	107,672	91,091	3,876	2706.87
			8,930	53,847	45,555	1,939	1353.72

Estimated CO_2 emission from garbage collection trucks

This section presents estimates of the amount of carbon dioxide emitted by garbage collection trucks during operations. Amount of CO_2 depend on distances travelled. Six trucks operate daily in Suva district, and most trucks travel between Suva district and Naboro landfill site twice every operation.

Table 26 displays information on all garbage trucks in detail. Suva district is divided into six areas, and then each area is subdivided into two: hence the total number of areas is twelve. There are 6 garbage collection trucks, each operating in one subdivided area every other day. For normal operation the large trucks are used, with small trucks assigned if the large trucks need repair or maintenance. For example, in area 3, a large truck needed to be rotated for regular maintenance, so a small truck was temporarily operating. However, the smaller truck is not sufficient to take all garbage, so truck number 4 (HE762) and 0 (ED751) partially helped collections.

These collection trucks are used for gathering garbage produced by the household sector only, not garbage produced by the business sector.

Table 26. Information for garbage collection trucks

Truck	Truck	Model	Size		Year	Subdivided area A	Subdivided area B
1 (Area1)	Nissan 4t	FL557	L	6925	2008	Vatuwaqa	Nailuva
2 (Area2)	Nissan 4t	FL556	L	6925	2008	Raiwaqa	Toorak
3 (Area3)	Hino 2t	HE763	S	4009	2013	Namadi Height	Nasese
4 (Area3)	Hino 4t	HE762	L	7684	2013		
0 (Area3)	Nissan 4t	ED751	L	6925	2003		
4 (Area4)	Hino 4t	HE762	L	7684	2013	C.B.D	C.B.D
5 (Area5)	Hino 4t	HQ568	L	7961	2014	Nabua	Cunningham
6 (Area6)	Nissan 4t	FC237	L	6925	2006	Tamavua	Rewa St.

Two types of truck are employed; Nissan and Hino. The large version of both trucks is a 4 t, with a 6925 cc engine in the Nissan, and 7684 cc or 7961 cc engine in the Hino. The Hino and the Nissan are relatively a new truck, bought within the last 2 years and the last 10 years respectively. In area 3, a small truck is operating which is a 2t, 4009cc Hino bought in 2013. Therefore they are operating with the most fuel efficient (gas mileage) vehicles.

Table 27 presents weights of CO_2 emissions. All trucks operate in area A on Monday, Wednesday and Friday, and operate in area B on Tuesday, Thursday and Saturday. Half of the week, trucks need a second circuit because of large amounts of garbage, so the distance travelled is doubled.

Table 27. Amount of emitted CO_2 and distance of garbage vehicles

Area Truck (ID)		Area A: Mon	Area A: Wed	Area A: Fri	Area B: Tue	Area B: Thu	Area B: Sat	Total
Area 1 Truck1 (FL557)	CO_2 Produced (kg)	72	45	72	76	46	46	357
	Distance (km)	128	80	127	134	82	81	632
Area 2 Truck2 (FL556)	CO_2 Produced (kg)	65	37	64	65	37	37	306
	Distance (km)	116	65	114	116	66	66	543
Area 3 Truck3 (HE763)	CO_2 Produced (kg)	71	65	-	66	72	45	318
	Distance (km)	125	116	-	117	127	79	564
Area 3 Truck4 (HE762)	CO_2 Produced (kg)	35	-	-	36	-	-	71
	Distance (km)	62	-	-	63	-	-	125
Area 3 Truck0 (ED751)	CO_2 Produced (kg)	-	-	71	-	-	-	71
	Distance (km)	-	-	126	-	-	-	126
Area 4 Truck4 (ED762)	CO_2 Produced (kg)	46	44	45	42	40	41	259
	Distance (km)	82	78	79	75	71	73	458
Area 5 Truck5 (HQ568)	CO_2 Produced (kg)	70	41	69	72	41	40	332
	Distance (km)	124	72	122	128	72	71	589
Area 6 Truck6 (FC237)	CO_2 Produced (kg)	72	42	68	71	54	45	352
	Distance (km)	127	74	121	126	95	80	623
Total	CO_2 Produced (kg)							2,066
	Distance (km)							3,660

Notes: The "-" signifies that the truck is not used for the specified day.

The total weight of CO_2 emission per week is 2066 kg, from 55 collection rounds. The total running distance is 3,660 km using 1,602 liters of fuel, 271,110 kg of garbage is brought to Naboro landfill, costing FJ$6,816. From this result, one circuit from Suva district to Naboro landfill, including an operation route in Suva district, is approximately 66.55 km (3,660 km / 55): producing 38 kg-CO_2. The distance from Suva district to Naboro landfill site is approximately 20 km.

The two top CO_2 producers excepting truck number 3 are truck 1 and 6.

Truck 1 produces 357 kg-CO_2 per week from a running distance of 632 km, using 274 liters of diesel to carry 46,630 kg of waste. Truck 6 produces 352 kg-CO_2 per week from a running distance of 623 km, using 240 liters of diesel to carry 46,160 kg of wastes. The next largest group is trucks 5 and 2. Truck 5 emits 332 kg-CO_2 per week from a running distance of 589 km, using 240 liters of diesel to carry 51,100 kg of waste: and truck 2 produces 306 kg-CO_2 per week from a running distance of 543 km, using 274 liters of diesel to carry 45,900 kg of wastes. The lowest producer is truck 4, producing 259 kg-CO_2 per week from a running distance of 458 km, using 240 liters of diesel to carry 33,960 kg of waste.

Table 28. Weight of garbage brought to the landfill

Area Truck ID	Area A			Area B			Total
	Mon	Wed	Fri	Tue	Thu	Sat	
	Garbage weight (kg)						
Area 1 Truck1(FL557)	11,600*	6,540	7,030*	10,080*	5,560	5,820	46,630
Area 2 Truck2(FL556)	12,540*	6,760	7,560*	8,780*	5,020	5,240	45,900
Area 3 Truck3(HE763)	6,120*	6,180*	-	8,920*	5,380*	5,180	31,780
Area 3 Truck4(HE762)	5,940	-	-	2,520	-	-	8,460
Area 3 Truck0(ED751)	-	-	7,120*	-	-	-	7,120
Area 4 Truck4(ED762)	6,440	5,440	6,380	5,420	4,920	5,360	33,960
Area 5 Truck5(HQ568)	11,580*	6,600	7,260*	12,300*	6,220	7,140	51,100
Area 6 Truck6(FC237)	11,800*	6,720	8,120*	8,820*	4,980	5,720	46,160
					Total	271,110	

Notes: * These trucks make two trips to the landfill per day. The "-" signifies that the truck is not used for the specified day.

Three trucks are operating in area 3; truck numbers 3, 4 and 0. Truck 4 temporarily helps operations in area 3. Truck 3 is a small vehicle and truck 0 is a large one. As a result the CO_2 emissions and distances are greater than in other areas. The total emitted weight is 460 kg-CO_2 per week from a running distance of 815 km, using 299 liters of fuel to carry 47,360 kg of waste.

All garbage pickup trucks, except those in area 3 and 4, make 9 rounds. Truck 4 needs less than other areas, making 6 rounds; and trucks operating in area 3 make

13 rounds temporarily. If the quantity of wastes could be reduced, garbage collection times could be reduced. SCC desires to reduce collections from three to two days per week. This may be possible, if the quantities of waste produced on Wednesday and Thursday could be reduced.

Table 28 expresses how a reduction of collection times from three to two days might be achieved, by showing the required reductions by weight; and also indicates challenges, and benefits including reductions of CO_2 emissions and landfill disposal costs. It would require reduction of refuse by a total weight of 38,240 kg on Wednesday and 32,080 kg on Thursday per week, saving 562 kg-CO_2 and FJ$1767.84. For example, in area 1 the weights of waste produced on Wednesday and Thursday are 6,540 kg and 5,560 kg respectively, saving 91 kg-CO_2 and FJ$304.19 per week. However, this is a great challenge, and it is seemingly not possible to reduce these amounts of wastes by only the implementation of composting disposal. This highlights the need to use recycling collection to achieve SCC's goals.

Table 29. Potential for reduction of garbage collections, CO_2 emissions and disposal cost

Area	Needed reduced weight of wastes on Wednesday (kg)	Needed reduced weight of wastes on Thursday (kg)	Potential for CO_2 reduction (kg)	Potential for costs reduction (FJ$/week)
Area 1	6,540	5,560	91	304.19
Area 2	6,760	5,020	74	296.15
Area 3	6,180	5,380	137	290.62
Area 4	5,440	4,920	84	260.45
Area 5	6,600	6,220	81	322.29
Area 6	6,720	4,980	95	294.14
Total	38,240	32,080	562	1767.84

Quantity of recyclables produced by participant household, and willingness to recycle

This section presents of the amount of recyclable waste, plastic PET bottles, cans, and newspaper including other white paper. From Table 30, it can be seen that the total average weight of plastic PET bottles discarded by one hundred households per week is 19.69 kg, each household producing average of 0.20 kg. Every week 6.47 kg of cans are discarded by one hundred households, an average of 0.06 kg per household. One hundred households discard 92.41 kg of newspaper or white paper per week with a household average of 0.92 kg.

Looking at each area, area 1 produces more plastic PET bottles per week than other areas, with an average weight per household of 0.37 kg. The next largest quantities are produced by areas 2 and 5, less than half that of area 1: both average 0.18 kg per household. Areas 3 and 6 produce a smaller quantity, 0.14 kg and 0.12 kg per week respectively. The lowest quantity is from area 4, which produces an average of 0.03 kg per week.

The amount of cans discarded by households is smaller than other two types of recyclable wastes. Area 1 produces the largest quantity; each household produces an average of 0.17 kg per week. Other areas are each nearly equal in quantity; areas 2, 4, 5, 3 and 6 in order from largest, produce averages of 0.05 kg, 0.04 kg, 0.04 kg, 0.03 kg and 0.01 kg per week respectively.

More newspaper (including white paper) is discarded than other types of recyclable wastes. Each household in area 1 produces more than other areas; the average is 1.55 kg per week, followed by area 3 which produces an average of 1.45 kg per week. Other areas produce smaller quantities: and areas 4 and 5 do not produce any papers. Areas 6 and 2 produce an average of 0.85 kg and 0.17 kg per week respectively.

The estimated quantities of recyclable wastes across the three types are smaller than expected, because the project team could collect data only on the quantity discarded in the public garbage collection. This does not include recyclable wastes given to others, such as housekeepers and villagers. It is difficult even for the households themselves to estimate a quantity for these. This is a typical example of the effects of research limitations on research quality. However this situation indicates where the team needs to alter their strategy in measuring recyclable wastes. This will be discussed in the next chapter.

Table 30. Quantity of recyclable wastes produced by household (composters)

Area No (Truck No)	Area name	Total weight PET bottle (kg/week) / Average per household	Total weight can (kg/week) / Average per household	Total weight Newspapers (kg/week) / Average per household
Area 1	Muanikau	8.07	3.83	34.16
		0.37	0.17	1.55
Area 2	Rewa	4.17	1.12	4.02
		0.18	0.05	0.17
Area 3	Central	3.55	0.86	36.37
		0.14	0.03	1.45
Area 4	Samabula	0.06	0.07	0
		0.03	0.04	0
Area 5	Cunningham	1.29	0.29	0
		0.18	0.04	0
Area 6	Tamavua	2.54	0.29	17.86
		0.12	0.01	0.85
Total average		19.69	6.47	92.41
		0.20	0.06	0.92

Willingness to start recycling collection

The result indicates that most composters are willing to participate in a recycling collection. Eighty-two households answered that they are highly motivated and willing, and six households were willing to recycle. Three households had no interest in recycling, but would follow a new collection system, if recycling collection starts. Only four households answered that they are not willing to start recycling.

Table 31. Level of willingness to start recycling collection

Level	Number of people
5	82
4	6
3	5
2	0
1	4
No answer	3

The main reason they do not want to help recycling is that they do not want to take the time, or because they are busy and they cannot see any benefits from recycling. One family provided an interesting answer: she sells plastic PET bottle and cans to Coca-Cola, and is worried that a new recycling system may disturb this activity.

Chapter 6 : Discussion

Introduction

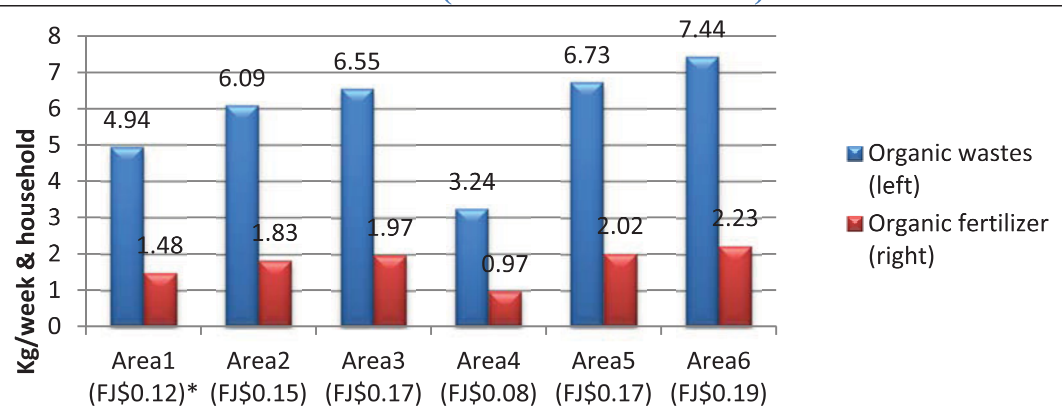
The main purpose of this chapter is to discuss the results and the data analysis in the previous chapter. Other objectives related to the study's purpose are to explore benefits, potential and challenges for reducing wastes and greenhouse gas emissions, and to define research limitations regarding data quality and accuracy found in the study.

Discussion of organic wastes and organic fertilizers

The objective of these calculations was to find how much organic waste is produced by each household. This calculation enables the study to identify how much organic fertilizer these quantities of organic wastes generate with the use of compost bins. These data were also used to derive the degree to which the use of compost bins contributes to reduction of greenhouse gases and disposal costs.

Each household is able to get about 1.75 kg of organic fertilizer per week. This is a small quantity; however, it can be said that it is sufficient for the space of just one house garden. Hence these contributions also produce a small benefit for SCC to save the landfill disposal cost at the Naboro landfill site.

Figure 4. Average weight of produced/reduced organic wastes and fertilizers (/week & household)



Note: * the landfill disposal cost saved by each house using compost disposal

However, there are invisible benefits which contribute to each household as well as to society. Saving the cost of buying chemical fertilizers from a shop is a small benefit; however actual benefits have greater value, such as costs of transportation and time needed for shopping. In this they also contribute to reduction of carbon dioxide emissions generated by their shopping; for example, in car transport and shopping bags. Furthermore, all chemical fertilizer in Fiji is imported from overseas, which produces a huge amount of carbon dioxide emissions from shipping which will have a serious impact on global warming and marine environments (Harrould-Kolieb, 2008). In addition, the Fiji government spends a lot of its budget to help consumers by keeping fertilizer prices low. If the government can utilize that budget to improve society in Fiji, composters will get more benefits through public services. The following is a list of benefits;

Composters:

- Saving costs to buy chemical fertilizers
- Saving transport costs and time needed for shopping

The Fiji Government:

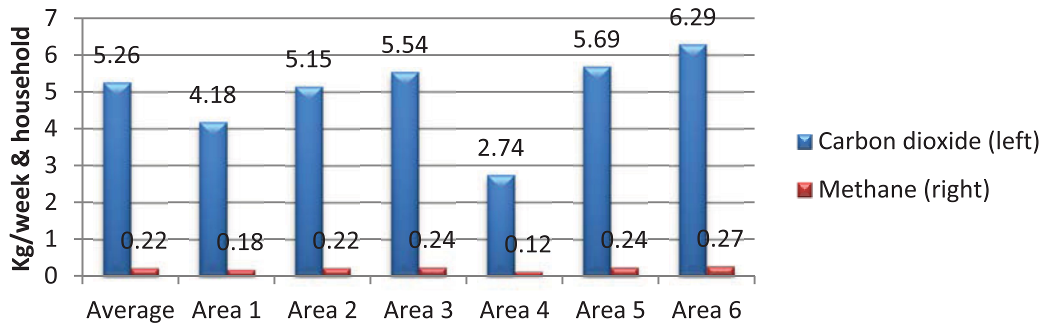
- Reducing carbon dioxide emissions from shopping and shipping
- Mitigation of serious impacts on marine environments
- Saving on budget for keeping fertilizers' costs low

More importantly, they contribute significantly to minimizing emissions of greenhouse gases that would be generated by landfill disposal, and are responsible for climate change.

Discussion on the amount of emissions reduced by recycling

Each composter reduces on average 5.26 kg-CO_2 and 0.22 kg-CH_4 every week (Figure 5). If 5.26 kg-CO_2 is expressed in two-liter plastic PET bottles, this corresponds to 1338.67 bottles as 1 kg-CO_2 equals 509 litres (Minnano chisiki iinkai, 2015). The amount of methane are smaller than CO_2, however the contribution of methane to global warming is far greater than carbon dioxide (Howarth et al. 2011). In addition, these amounts can help reduce carbon dioxide emissions during garbage collection and reduce environmental damages.

Figure 5. Average amount of reduced CO_2 and CH_4 compared to landfill disposal



The potential benefit derived from organic waste reductions by all or half households is the reduction of global warming gases: CO_2 by 91,091 kg and CH_4 by 3,876 kg based on 107,672 kg of organic wastes and 17,857 households. This provides a strong incentive for SCC, as it also saves FJ$2706.87 of disposal fees every week. Even if half of households were involved in composting, they would reduce CO_2 by 45,555 kg and CH_4 by 1,939 kg based on 53,847 kg of organic wastes and 8,930 households. However, different characteristics are apparent for middle to high-income and low-income people. It is difficult to force low-income people to set up compost bins, because they do not understand the importance of composting. Even if they agreed, they could not afford to pay FJ$30 for a compost bin. Hence SCC may need to consider providing free compost bins to the lesser educated.

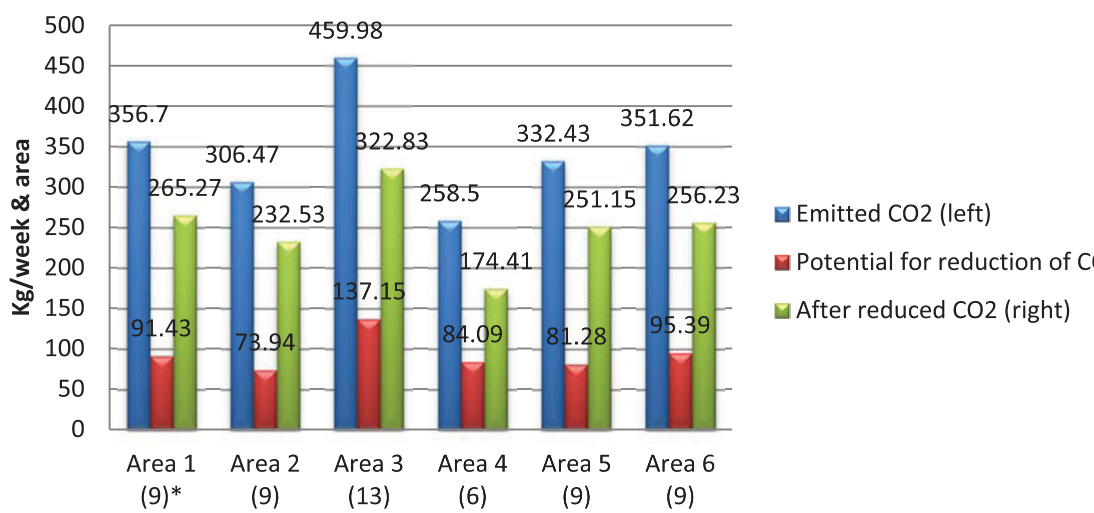
The area in which most gains could be expected is area 6 (Tamavua). A relatively large number of wealthy people live in that area, and they produce more organic wastes than others. They are familiar with how to manage kitchen and garden wastes in an environmentally friendly manner. Therefore residential composting could be acceptable to them. A key point here is that SCC should ensure equitable benefit distribution to all people. For example, SCC could use the saved disposal costs for new subsidies to improve their environment. This is a promising solution which would involve all people as much as possible.

Discussion of CO_2 emissions from garbage trucks

These calculations revealed how much carbon dioxide is generated by garbage collection trucks during garbage pickup services. Another purpose is to explore the potential for reduction of collections from three to two days per week which is a major aim of the SCC Home Compost Bin Project. This includes suggestions as to how much wastes need to be reduced for the project and discussion of challenges.

The amount of carbon dioxide generated by truck transportation is related to distances travelled. If the quantity of waste is more than the carrying capacity of the vehicles, garbage trucks need to travel many times between collection sites and the Naboro landfill. This truck round trip is a key to reduce transport carbon emissions.

Figure 6. Amount of CO_2 emissions during collection services and the potential for reduction of CO_2

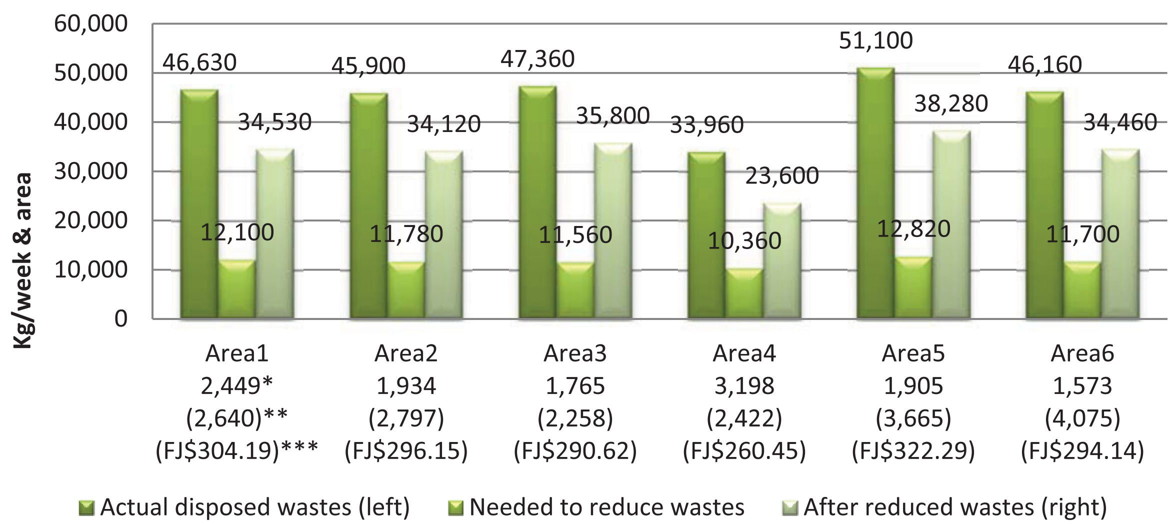


Note: * trucks' travel times between the collection sites and the landfill site.

Area 3 produces more transport carbon emissions than other areas because three trucks operate there temporarily, due to routine truck repair and maintenance. This causes an increase in travel times; the trucks travel to the landfill a total of thirteen times per week. This consumes more fossil diesel than normal operations. Thus from these observations, maintenance more during operational days and the need for unexpected repairs is a challenge. Closer examination to identify that issue revealed that carrying weights tends to be more than the recommended carrying capacity of the vehicles. All collection vehicles carry more than their stated limits; usually a 4 ton vehicle can carry a load of about 4 tons, and a 2 ton vehicle can carry a load of about 2 tons. Over-carrying wastes results in increased wear, which is associated with financial and environmental burdens.

The study estimates the degree to which wastes need to be reduced in order to decrease collection frequency from three to two days per week. All areas require a reduction of more than ten thousand kilograms per week. However, reduction by these amounts through deployment of compost bins in new target households is a significantly difficult goal. Even at the lower end, area 4 requires a reduction of 10,360 kg of wastes. These amounts are another challenge for SCC. This is not possible without a new policy or regulation requiring people to set up bins in every backyard.

Figure 7. Weight of disposed wastes and potential for reduction of trucks' travel times



Note: * Required number of compost bins, ** actual number of household, *** saving rates

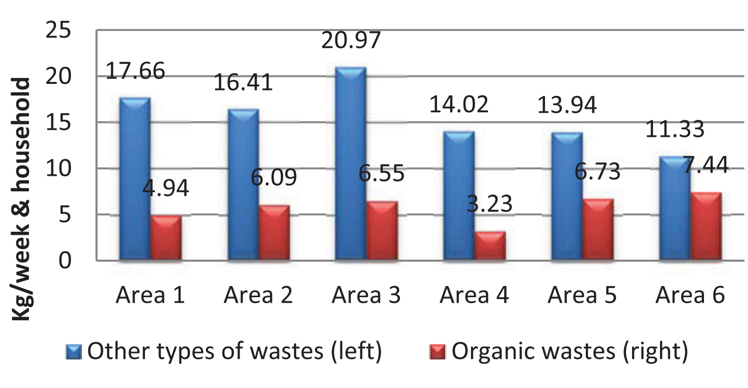
However, there is another possibility. These numbers are based on only the quantity of organic wastes, which are 23 ~ 66 percent of the total quantity of wastes sent to the landfill. If SCC could reduce other types of wastes, reduced landfill trips may be possible. The next section estimates on how much recyclable waste is produced by each household. The total quantity of both organic and recyclable wastes provides hope to reduce weekly collection days.

Discussion of recyclable wastes and willingness

The main purpose of these calculations is to discover the potential for starting a new recycling collection service, which is a next step SCC wishes to implement. Recycling may provide complementary assistance in reducing weekly collection days from three to two. Combining recycling with composting disposal is a sustainable approach to further reduce wastes. However, recycling is a controversial topic, because it requires a lot of energy, and consumes natural resources (Bribián et al. 2011). That may make it difficult to balance benefits and costs. Nevertheless, this study focuses on reduction of wastes rather than considering energy consumption, and so approaches recycling as a positive method to achieve this.

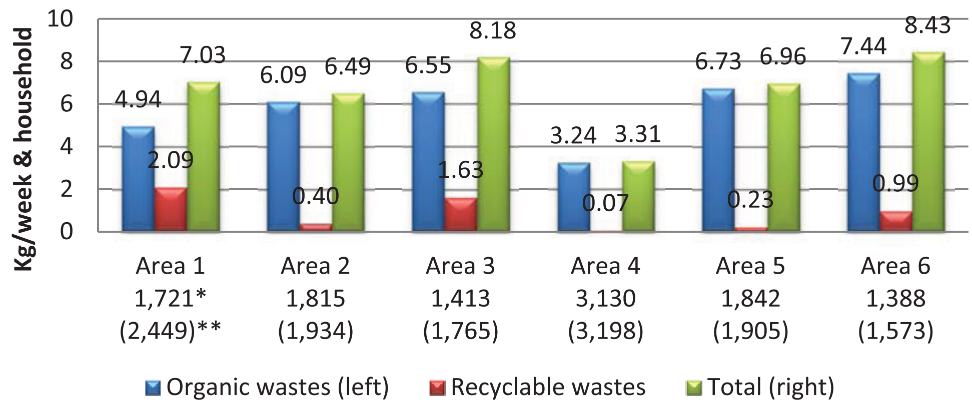
The total weight of wastes sent to the landfill is more than double or triple the weights of organic wastes disposed of by composting. For example, in area 3, the weight of waste disposed of in landfill is more than triple that of organic wastes disposed of in home composting. The amount of recyclable wastes is located somewhere between these points. However, the data obtained from the survey shows that the weight of recyclable wastes produced in each household is small.

Figure 8. Comparison between other types of wastes and organic wastes



Compared to the quantity of organic waste, each household produces a small amount of recyclable wastes. These quantities are not helpful to materially reduces waste. Even if both weights were combined, it comes to less than 10 kg per week. This result suggests that these quantities is not sufficient to introduce recycling in Suva, and recommends further study to find other ways for starting a new recycling operation.

Figure 9. The quantity of organic wastes and recyclable wastes



Note: * Required number of compost bins, ** previously required number of compost bins

These data reflect certain limitations. Most households reuse recyclable wastes in their home; newspapers may be given to a housekeeper, village or school or to relatives living in an isolated island, for cleaning, wrapping or educational purposes. Hence, these amounts are not included in the survey data. It is hard to assess these actual quantities and where they go. An interesting aspect is that these quantities do not come out to public garbage collection from their original location, but from the other areas where they were sent. Since they are sent to support low-income people, presumably their new location is in squatter residential areas. This suggests that squatter residential areas probably produce more recyclable wastes than other areas. Strong evidence supporting that hypothesis is that SCC pays more than twice as much for landfill disposal for waste produced in squatter residential areas. This reflects a flow of recyclable wastes that SCC needs to measure in planning for recycling.

Another place recyclable wastes are gathered is in town. People take recyclable wastes to their office, and dispose of it into recycling boxes or throw it into public garbage bins. Many international organizations and local companies employ recycling collection boxes in their office or building. For example, the University of the South Pacific (USP) has a contract with a paper recycling company. This company regularly collects any kind of papers from recycling boxes, and uses this as material for a new product. Some families bring PET bottles and cans to Coca-Cola to earn a small amount of money. In Fiji, there are two types of commercial recycling: PET bottles and cans, and papers. This is another possibility this study offers to further reduce wastes.

Recycling companies in Fiji

Two commercial recyclers are Coca-Cola Amatil (Fiji Limited) for plastic PET bottles and cans, and South Pacific Recyclers for papers. People can earn a few coins from Coca-Cola by selling empty plastic PET bottles and cans; but these are not recycled in Fiji. The paper recycling company mostly collects papers from private companies or organizations, not from individuals; however there is potential for individuals to take paper to this company for recycling.

Coca-Cola Amatil (Fiji) Limited

In Fiji, Coca-Cola Amatil (Fiji) Limited is the only company collecting and buying used plastic PET bottles and cans. The purchase price is F$1/kg for both PET bottles and cans. People who want to sell these recyclable wastes need remove the lid, but do not need to wash the bottle.

However, they need to take it to the company directly on specific days. Coca-Cola buys only PET bottles and cans of their own products, with a Coca-Cola label. There are several kinds of their products in Fiji. From their average weight, people need to collect at least about 30 PET bottles, or 62 cans to get F$1.

Table 32. Recycling in Coca-Cola Armatil (Fiji)

<table>
<tr><td colspan="2">Days of purchase</td><td>Purchase price</td></tr>
<tr><td colspan="2">Monday, Wednesday and Friday only</td><td>F$1/kg</td></tr>
<tr><td colspan="3">Weight of plastic PET bottle</td></tr>
<tr><td>Size</td><td>Weight</td><td>Types</td></tr>
<tr><td>Small (S)</td><td>25.86 g</td><td rowspan="4">
Photo 3: Coca-Cola products</td></tr>
<tr><td>Middle (M)</td><td>25.87 g</td></tr>
<tr><td>Large (L)</td><td>47.53 g</td></tr>
<tr><td>Average</td><td>33.086 g</td></tr>
</table>

The South Pacific Recyclers

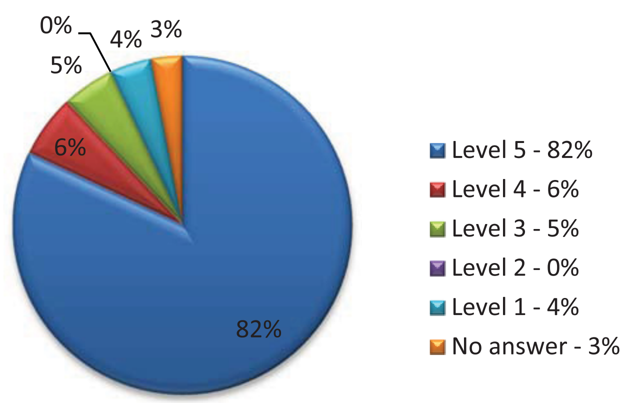
Two private companies are involved in recycling paper. This study introduces one of them, running their business at Laucala Beach in Suva. This company produces toilet paper using recycled paper, and sells it at a lower price than other toilet paper at local supermarkets. Producing these recycled white and pink toilet rolls also contributes to providing employment opportunities for locals. The company also produces even cheaper recycled toilet paper but only at their office because the size and the colour are not the same as normal toilet paper. This, however, does not mean that the recycled paper is damaged or of inferior quality. Their running capacity is 10 tons per day; however, at the moment the company manages only 7 tons of paper wastes as their source of material every day. Therefore they sometimes need to stop operations, if they could not obtain enough amount of paper wastes. Their business partners are the business sector and educational organizations, and do not include any individuals. Their next target is the household sector, and they are working on this through seeking collaboration with SCC. Their approach is a great opportunity and challenge to promote cooperation among government, industry and local people.

Willingness

Cooperation is the most powerful means to achieve a goal. The survey data shows a high level of willingness to start recycling collection. Eighty-eight percent of composters are willing to recycle their wastes.

They feel guilty about not being able to recycle wastes, which is a reason they are giving away recyclable wastes to low-income people or taking it to their office. That suggests that recycling has the potential to make all stakeholders happy, and this becomes an incentive to cope with the challenge in order to promote a new system of waste management through recycling.

Figure 10: Willingness for recycling



Chapter 7 : Conclusion

Introduction

This chapter concludes that composting is valuable economically, socially and environmentally, and proposes ways to achieve the goal. The research shows that the benefits of composting are more than just of a method of disposal; they include many other significant advantages. Generation of organic fertilizers and the reduction both of carbon dioxide and disposal costs are the most obvious benefits, but composting also has secondary benefits. However, the amount of waste potentially reduced by increased composting is not sufficient to reduce SCC's collection days from three to two days per week. Even when combined with the amount of recyclable wastes, cutting back on the frequency of SCC collecting wastage presents considerable difficulties. SCC needs to take account of the flow of recycling wastes. Moreover, action needs to be taken to recycle types of rubbish other than those considered in this research, and SCC needs to take account of the flow of recycling wastes through society.

The solution to this challenge is cooperation between the private sector, government and local people. Other stakeholders such as private companies with recycling operations, e.g. Coca-cola and the South Pacific Recyclers, provide potential to further reduce waste. Even if all households were to cooperate in utilizing compost bins, the reduction of trips by the collection trucks to the landfills would only decrease minimally. This, however, could reduce a certain amount of CO_2, CH_4 and disposal costs, which may become an incentive. In addition, the level of willingness to participate in recycling is high, which is another incentive for the project. This highlights that cooperation is a key point in effective coordination between local government and local people.

Conclusion of organic wastes and organic fertilizers

The results on the contribution of composting disposal show both visible benefits and invisible benefits. The quantity of organic wastes as converted into organic fertilizers is a visible benefit that composters can gain from their eco-actions. However, the invisible benefits are greater than these. A major contribution is that their actions reduce carbon dioxide and methane gas pollution by 5.26 kg-CO_2 and 0.22 kg-CH_4 on average per week per household, as these quantities were not added to landfill. The calculation explores the potential for CO_2 and CH_4 reductions and the potential benefits from these reductions.

Associated benefits by generation of organic wastes is variable, such as reduction of carbon dioxide emissions related to transport and shopping for purchase of fertilizers from a shop; what is even more noteworthy is the reduction of consumption of chemical fertilizers. All chemical fertilizers in Fiji are imported, causing a huge amount of greenhouse gas emissions from shipping, and marine pollution through oil spills into the sea. Considered at a national level, it eliminates the need for tax concessions for chemical fertilizers. Locally-generated fertilizer removes the need for the Fiji government to spend its budget to keep fertilizers at a reasonable price. Furthermore, it ensures the health of the land, as organic fertilizers protect the soil from erosion. This becomes a great incentive for all stakeholders. It is true that composting is beneficial in many ways (Epatein, 1996); it not only reduces a large amount of CO_2 and CH_4, but also assists local governments financially. If all people work together to reduce landfill disposal of organic wastes, this equals a saving of 91,091 kg-CO_2, 3,876 kg-CH_4 and FJ$2,706.87 per week. It has potential to provide even further value if local governments use this amount wisely to help the locals that responded to the incentives to use compost bins.

Conclusion of CO_2 emissions from garbage trucks

Greenhouse gas emissions from wastes are not only from the disposal process, but also from garbage collection trucks. The amount of carbon dioxide emissions generated by garbage pickup vehicles depend on the distances they travel. Clearly, the running distance of garbage trucks increases relatively to the quantity of wastes; by producing more wastes, the running distance for garbage vehicles will also increase. Even if all the households were to adopt using compost bins, the reduction in the wastage for collection would not be significant enough to reduce the frequency of collection. Even if there were no more organic waste to be collected, the fact is that this type of waste is only about 30% of the total waste that is being collected at present.

Although reducing the frequency of waste collection is problematic, it is nevertheless beneficial for households to adopt the use of compost bins to reduce the amount of waste to be collected as this will reduce the wear and tear to garbage vehicles. Normal operations in Suva district at present require collecting more waste matters than the vehicles' capacity, causing damage to the vehicles. This results in added costs to maintenance and repairs as well as the production of more CO_2 through the operation of additional backup trucks.

The calculation for organic wastes shows that composting disposal alone is not enough to sufficiently reduce the quantities. The calculation for recyclable wastes, in the next section, considers the effects of the combination of composting and recyclable wastes.

Conclusion of recyclable wastes and willingness

The calculation of how much recyclable waste is produced by each household reveals an interesting truth through investigation of a research problem. The quantity of recyclable wastes researched in the project was small, because households send it elsewhere to help low-income people, or recycle wastes at the office. Their support and recycling behavior create a flow pattern of recyclable wastes to squatter settlements and the business district. This provides information on where the project needs to take measures to recycle wastes. The project suggests further potential to reduce landfill by collecting other types of recyclable wastes not focused on by the project, such as milk cartons, snack boxes, egg cartons, and magazines. Another strong potential is the cooperation of two powerful helpers. Coco-Cola pays FJ$1/kg for collecting empty PET bottle and cans, and the paper recycling company is approaching SCC to gather waste paper from household sector.

Thus these become incentives and provide a strategy for establishing a new recycling system; recycling other types of recyclable wastes (milk cartons, snack boxes and etc…) for high-income residency, and recycling cans, plastic PET bottles and newspaper for squatter settlements and town area by supporting cooperation from recycling companies. This has potential to form a beneficial cycle from which all stakeholders can benefit.

Overall conclusion

As mentioned above, the project clarifies the necessary factors for it to succeed keeping all stakeholders satisfied and cooperating together. We now understand the type of areas in the city where the project needs to concentrate to be effective, and some of the expected challenges to make it work well. Importantly, the waste management system needs to include a variety of types of recyclable wastes. Energy and incentives as engines to start sustainable waste management are also highlighted. The clear support from 88 percent of composters reveals their high willingness to undertake recycling practices, and if all or even half the households endorse the composting project, positive results can be obtained. This is a strong impetus for the council to pursue the project. If the benefits of a waste cycle are clearly communicated to the people and the methods are also easily understood, all stakeholders will benefit through cooperatively planning the way forward to achieve the goals set out in this paper.

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Appendices

APPENDIX A

Appendix A: The survey results (100 participants)

No	Age	Ethnic	Vege/Fru peeling (Bag/kg)		Food leftovers (Bag/kg)		Coffe grounds, tea bags, stale bread, grains (Bag/kg)		Grass/Flowaers, etc (Bag/kg)		Total weight (kg)
Area 1 (Truck1)											
1	41-60	Fijian	7.5	12.32	0	0.00	5	2.64	0	0.00	14.96
2	41-60	Fijian	4	6.57	1	1.00	0.05	0.02	2	1.50	9.09
3	41-60	Fijian	2	3.29	1	1.00	0.04	0.02	1	0.75	5.05
4	19-40	Australian	1.75	2.88	1.75	1.75	0.25	0.13	0	0.00	4.75
5	41-60	Other	2	3.29	0	0.00	0	0.00	0	0.00	3.29
6	19-40	Fijian	0.75	1.23	0	0.00	0.1	0.05	0	0.00	1.29
7	41-60	Indian	1.48	2.43	0.35	0.35	0.76	0.40	0	0.00	3.18
8	41-60	Other	0.75	1.23	0.75	0.75	0.5	0.26	0	0.00	2.24
9	41-60	Other	0.5	0.82	0.63	0.62	0.7	0.37	0	0.00	1.82
10	41-60	Indian	0.53	0.86	0.7	0.70	0.7	0.37	0.5	0.37	2.30
11	41-60	Indian	0.80	1.31	1.75	1.75	0.7	0.37	0	0.00	3.42
12	41-60	EU	2	3.29	0.88	0.87	0.7	0.37	0	0.00	4.53
13	19-40	Fijian	1.70	2.78	0	0.00	0.7	0.37	0	0.00	3.15
14	41-60	Asia	0.2	0.33	0	0.00	0.05	0.03	0	0.00	0.36
15	19-40	Asia	1.63	2.67	0	0.00	0.46	0.24	0.25	0.19	3.10
16	19-40	Indian	2.22	3.65	0	0.00	0	0.00	0	0.00	3.65
17	41-60	Fijian	3.5	5.75	0	0.00	0.35	0.18	1	0.75	6.68
18	41-60	Fijian	6	9.86	0	0.00	0.35	0.18	1.25	0.94	10.98
19	41-60	Fijian	3	4.93	0	0.00	0	0.00	0.75	0.56	5.49
20	61+	Fijian	6.5	10.68	0	0.00	0.07	0.03	2.5	1.87	12.58
21	41-60	Indian	1.75	2.88	0	0.00	0	0.00	2	1.50	4.37
22	19-40	Indian	0.88	1.44	0	0.00	0	0.00	1.25	0.94	2.37
Area 2 (Truck2)											
23	41-60	Other	4.75	7.80	0	0.00	0	0.00	1	0.75	8.55
24	61+	Other	9	14.79	0	0.00	0	0.00	0	0.00	14.79
25	19-40	Other	11.75	19.31	0	0.00	0	0.00	0	0.00	19.31
26	41-60	Other	1.25	2.05	0	0.00	0	0.00	0	0.00	2.05
27	19-40	Asia	1.75	2.88	0.17	0.16	0.25	0.13	0	0.00	3.17
28	19-40	Asia	1.75	2.88	0	0.00	0.04	0.02	0	0.00	2.89
29	19-40	Australia	1.57	2.58	0.5	0.50	0.04	0.02	0	0.00	3.10
30	19-40	other	1.88	3.08	0	0.00	0	0.00	0	0.00	3.08
31	19-40	Asia	1.85	3.04	0	0.00	0.7	0.37	0	0.00	3.41
32	19-40	USA	2.9	4.76	0	0.00	0	0.00	3	2.24	7.01
33	41-60	Asia	5.25	8.63	0	0.00	0	0.00	0.33	0.25	8.87
34	41-60	NZ	4.33	7.11	0.1	0.10	0.04	0.02	1	0.75	7.98
35	19-40	NZ	1.63	2.67	0	0.00	0	0.00	1	0.75	3.42
36	41-60	Australia	1.61	2.65	0	0.00	0.15	0.08	0	0.00	2.72
37	19-40	Australia	1.15	1.89	0	0.00	0.35	0.18	0	0.00	2.07
38	19-40	Australia	1.75	2.88	0	0.00	0.35	0.18	1.5	1.12	4.18
39	19-40	Other	2.65	4.35	0	0.00	0.35	0.18	0.5	0.37	4.91

40	19-40	Fijian	4.15	6.82	0	0.00	0.04	0.02	1	0.75	7.59
41	41-60	Fijian	2.5	4.11	0.25	0.25	0.35	0.18	0.42	0.31	4.85
42	41-60	Indian	1.88	3.08	0	0.00	0	0.00	1.5	1.12	4.20
43	19-40	Fijian	7	11.50	0	0.00	0.35	0.18	0.6	0.45	12.13
44	19-40	USA	1.75	2.88	0	0.00	0	0.00	5	3.74	6.62
45	19-40	Asia	1.8	2.96	0	0.00	0.21	0.11	0	0.00	3.07
Area 3 (Truck3)											
46	41-60	Other	1.5	2.46	1.5	1.50	0.035	0.02	1.5	1.12	5.10
47	41-60	Other	7	11.50	0	0.00	0	0.00	0.5	0.37	11.88
48	41-60	Fijian	8	13.14	0	0.00	0	0.00	2.5	1.87	15.01
49	61+	Fijian	3.5	5.75	0	0.00	0	0.00	0.5	0.37	6.12
50	41-60	Asia	3.5	5.75	0	0.00	0.04	0.02	1.5	1.12	6.89
51	61+	Fijian	3.59	5.90	0.875	0.87	0.04	0.02	1	0.75	7.54
52	41-60	Indian	4.47	7.34	0	0.00	0.04	0.02	2.5	1.87	9.22
53	41-60	Fijian	2.73	4.49	0	0.00	0	0.00	2.5	1.87	6.36
54	41-60	Other	1.5	2.46	0.5	0.50	0.32	0.17	0	0.00	3.13
55	41-60	EU	0.76	1.24	0.01	0.01	0.71	0.38	0	0.00	1.63
56	19-40	Asia	1	1.64	0.05	0.05	0.05	0.03	0	0.00	1.72
57	61+	Fijian	2.75	4.52	0	0.00	0.04	0.02	0.5	0.37	4.91
58	19-40	Other	4.06	6.67	0.25	0.25	0.04	0.02	1	0.75	7.69
59	19-40	Other	2	3.29	0	0.00	0	0.00	0	0.00	3.29
60	19-40	Asia	2.46	4.04	0	0.00	0.35	0.18	1	0.75	4.97
61	61+	Fijian	3.25	5.34	0	0.00	0.35	0.18	1	0.75	6.27
62	41-60	EU	2.33	3.83	5	4.99	0	0.00	1.25	0.94	9.75
63	19-40	Fijian	3.5	5.75	0	0.00	0.35	0.18	0.5	0.37	6.31
64	19-40	Fijian	2	3.29	0	0.00	0.46	0.24	0	0.00	3.53
65	19-40	Fijian	9.5	15.61	0	0.00	0.5	0.26	1	0.75	16.62
66	41-60	Fijian	3.15	5.18	0	0.00	0.35	0.18	2.5	1.87	7.23
67	19-40	Other	0.61	1.00	0.25	0.25	0.14	0.07	0	0.00	1.33
68	41-60	Fijian	1.86	3.06	0.5	0.50	0.14	0.07	1	0.75	4.38
69	19-40	Fijian	4.83	7.94	0	0.00	0.14	0.07	1.5	1.12	9.14
70	19-40	Fijian	1.5	2.46	1.25	1.25	0.14	0.07	0.06	0.04	3.83
Area 4 (Truck4)											
71	19-40	Asia	0.75	1.23	0	0.00	0	0.00	0	0.00	1.23
72	19-40	Indian	0	0.00	0	0.00	0	0.00	7	5.24	5.24
Area 5 (Truck5)											
73	61+	Indian	3.5	5.75	0	0.00	0	0.00	0.5	0.37	6.12
74	19-40	Fijian	8.25	13.55	0	0.00	0.5	0.26	3	2.24	16.06
75	19-40	Indian	5	8.22	0	0.00	0.5	0.26	0	0.00	8.48
76	19-40	Indian	1.65	2.71	0	0.00	0.35	0.18	0	0.00	2.90
77	19-40	Indian	1.15	1.89	0	0.00	0.35	0.18	0	0.00	2.07
78	61+	Fijian	3.4	5.59	0	0.00	0.35	0.18	3.5	2.62	8.39
79	61+	Indian	1.8	2.96	0	0.00	0.2	0.11	0	0.00	3.06
Area 6 (Truck6)											
80	61+	Indian	1.84	3.02	0	0.00	0.04	0.02	0	0.00	3.04
81	61+	EU	2.25	3.70	0	0.00	0	0.00	0	0.00	3.70
82	41-60	Indian	1.83	3.01	0.4	0.40	0.2	0.11	0.24	0.18	3.69
83	19-40	Fijian	3.25	5.34	0.13	0.12	0	0.00	1	0.75	6.21
84	41-60	Fijian	3.13	5.13	0	0.00	0	0.00	0	0.00	5.13
85	41-60	Asia	1.85	3.04	1	1.00	0	0.00	0.04	0.03	4.07
86	19-40	Indian	4	6.57	0	0.00	0.35	0.18	3	2.24	9.00

87	41-60	Fijian	3.25	5.34	0	0.00	0.35	0.18	0.75	0.56	6.09
88	19-40	Other	5.9	9.69	0	0.00	0.35	0.18	3	2.24	12.12
89	19-40	Fijian	3	4.93	0	0.00	0.23	0.12	2.25	1.68	6.73
90	19-40	Fijian	9	14.79	0	0.00	0	0.00	0	0.00	14.79
91	19-40	Fijian	4.33	7.12	0	0.00	0	0.00	0	0.00	7.12
92	41-60	USA	1	1.64	0	0.00	0	0.00	3	2.24	3.89
93	19-40	Indian	1.13	1.85	0	0.00	0.35	0.18	0	0.00	2.03
94	61+	Fijian	1.75	2.88	0	0.00	0.35	0.18	1	0.75	3.81
95	19-40	Fijian	4.2	6.90	0	0.00	0.35	0.18	1	0.75	7.83
96	61+	Fijian	4.5	7.39	0	0.00	0	0.00	0	0.00	7.39
97	61+	Fijian	0.7	1.15	0.74	0.73	0.61	0.32	6.25	4.68	6.88
98	19-40	Fijian	5.4	8.87	0	0.00	0.35	0.18	1	0.75	9.81
99	19-40	NZ	5.65	9.28	0	0.00	0.35	0.18	2.5	1.87	11.34
100	19-40	Fijian	11.65	19.14	0	0.00	0.35	0.18	3	2.24	21.57

APPENDIX B

Appendix B: Calculation for amount of organic fertilizer

Area	Calculation	Category
Area 1	4.94kg	Amount of biodegradable waste put in compost in one week
	4.94kg * 0.3 = 1.48kg	Amount of organic fertilizer produced after 10 weeks from one week's waste
	(10/1.48) * 10 = 67weeks	Number of weeks required to produce 10 kg of organic fertilizer
Area 2	6.09kg	Amount of biodegradable waste put in compost in one week
	6.09kg * 0.3 = 1.83kg	Amount of organic fertilizer produced after 10 weeks from one week's waste
	(10/1.83) * 10 = 54weeks	Number of weeks required to produce 10 kg of organic fertilizer
Area 3	6.55kg	Amount of biodegradable waste put in compost in one week
	6.55kg * 0.3 = 1.97kg	Amount of organic fertilizer produced after 10 weeks from one week's waste
	(10/1.97) * 10 = 50weeks	Number of weeks required to produce 10 kg of organic fertilizer
Area 4	3.24kg	Amount of biodegradable waste put in compost in one week
	3.24kg * 0.3 = 0.97kg	Amount of organic fertilizer produced after 10 weeks from one week's waste
	(10/0.97) *10 = 103weeks	Number of weeks required to produce 10 kg of organic fertilizer
Area 5	6.73kg	Amount of biodegradable waste put in compost in one week
	6.73kg * 0.3 = 2.02kg	Amount of organic fertilizer produced after 10 weeks from one week's waste
	(10/2.02) * 10 = 49 weeks	Number of weeks required to produce 10 kg of organic fertilizer
Area 6	7.44kg	Amount of biodegradable waste put in compost in one week
	7.44kg * 0.3 = 2.23kg	Amount of organic fertilizer produced after 10 weeks from one week's waste
	(10/2.23) * 10 = 44 weeks	Number of weeks required to produce 10 kg of organic fertilizer

APPENDIX C

Appendix C: Calculation for amount of CO_2 and CH_4 hypothetically generated by landfill and incineration disposal

Area	Calculation	Category
Area 1	108.67 kg = 0.10867 t	Amount of organic waste produced per moth Convert kg to weight in tones
	0.10867 * 0.846 = 0.09193482 t CO_2	Multiply by coefficient for CO_2 (landfill)
	0.09193482*1000 = 91.93 kg CO_2	Multiply by 1000 to convert to weight in kg
	0.10867 * 0.036 = 0.00391212 t CH_4	Multiply by coefficient for CH_4 (landfill)
	0.00391212 *1000 = 3.91 kg CH_4	Multiply by 1000 to convert to weight in kg
	0.10867 * 0.0837 = 0.009095679 t CO_2	Multiply by coefficient for CO_2 (incineration)
	0.009095679 * 1000= 9.10 kg CO_2	Multiply by 1000 to convert to weight in kg
Area 2	139.98 kg = 0.13998 t	Amount of organic waste produced per moth Convert kg to weight in tones
	0.13998 * 0.846 = 0.11842308 t CO_2	Multiply by coefficient for CO_2 (landfill)
	0.11842308 *1000 =118.42 kg CO_2	Multiply by 1000 to convert to weight in kg
	0.13998 * 0.036 = 0.00503928 t CH_4	Multiply by coefficient for CH_4 (landfill)
	0.00503928 *1000 = 5.04 kg CH_4	Multiply by 1000 to convert to weight in kg
	0.13998 * 0.0837 = 0.011716326 t CO_2	Multiply by coefficient for CO_2 (incineration)
	0.011716326 *1000 = 11.72 kg CO_2	Multiply by 1000 to convert to weight in kg
Area 3	163.84 kg = 0.16384 t	Amount of organic waste produced per moth Convert kg to weight in tones
	0.16384 * 0.846 = 0.13860864 t CO_2	Multiply by coefficient for CO_2 (landfill)
	0.13860864 *1000 = 138.61 kg CO_2	Multiply by 1000 to convert to weight in kg
	0.16384 * 0.036 = 0.00589824 t CH_4	Multiply by coefficient for CH_4 (landfill)
	0.00589824 *1000 = 5.90 kg CH_4	Multiply by 1000 to convert to weight in kg
	0.16384 * 0.0837 = 0.013713408 t CO_2	Multiply by coefficient for CO_2 (incineration)
	0.013713408 *1000 = 13.71 kg CO_2	Multiply by 1000 to convert to weight in kg

Area	Calculation	Category
Area 4	6.47 kg = 0.00647 t	Amount of organic waste produced per moth Convert kg to weight in tones
	0.00647 * 0.846 = 0.00547362 t CO_2	Multiply by coefficient for CO_2 (landfill)
	0.00547362 *1000 = 5.47 kg CO_2	Multiply by 1000 to convert to weight in kg
	0.00647 * 0.036 = 0.00023292 t CH_4	Multiply by coefficient for CH_4 (landfill)
	0.00023292 *1000 = 0.23 kg CH_4	Multiply by 1000 to convert to weight in kg
	0.00647 * 0.0837 = 0.000541539 t CO_2	Multiply by coefficient for CO_2 (incineration)
	0.000541539 *1000 = 0.54 kg CO_2	Multiply by 1000 to convert to weight in kg
Area 5	47.09 kg = 0.04709 t	Amount of organic waste produced per moth Convert kg to weight in tones
	0.04709 * 0.846 = 0.03983814 t CO_2	Multiply by coefficient for CO_2 (landfill)
	0.03983814 *1000 = 39.84 kg CO_2	Multiply by 1000 to convert to weight in kg
	0.04709 * 0.036 = 0.00169524 t CH_4	Multiply by coefficient for CH_4 (landfill)
	0.00169524 *1000 = 1.70 kg CH_4	Multiply by 1000 to convert to weight in kg
	0.04709 * 0.0837 = 0.003941433 t CO_2	Multiply by coefficient for CO_2 (incineration)
	0.003941433 *1000 = 3.94 kg CO_2	Multiply by 1000 to convert to weight in kg
Area 6	156.24 kg = 0.15624 t	Amount of organic waste produced per moth Convert kg to weight in tones
	0.15624 * 0.846 = 0.13217904 t CO_2	Multiply by coefficient for CO_2 (landfill)
	0.13217904 *1000 = 132.18 kg CO_2	Multiply by 1000 to convert to weight in kg
	0.15624 * 0.036 = 0.00562464 t CH_4	Multiply by coefficient for CH_4 (landfill)
	0.00562464 *1000 = 5.62 kg CH_4	Multiply by 1000 to convert to weight in kg
	0.15624 * 0.0837 = 0.013077288 t CO_2	Multiply by coefficient for CO_2 (incineration)
	0.013077288 *1000 = 13.08 kg CO_2	Multiply by 1000 to convert to weight in kg

APPENDIX D

Appendix D: Calculation for amount of CO_2 hypothetically generated by garbage collection trucks

Area	Calculation	Category
Area 1	Total distance for one week 632 km	
	632/(4.58*37.7*0.0187*(44/12)) = 356.70	Distance/(C*A*B*(44/12)) = Amount CO_2 in kg
Area 2	Total distance for one week 543 km	
	543/(4.58*37.7*0.0187*(44/12)) = 306.47	Distance/(C*A*B*(44/12)) = Amount CO_2 in kg
Area 3	Total distance for one week 815 km	
	815/(4.58*37.7*0.0187*(44/12)) = 459.99	Distance/(C*A*B*(44/12)) = Amount CO_2 in kg
Area 4	Total distance for one week 458 km	
	458/(4.58*37.7*0.0187*(44/12)) = 258.50	Distance/(C*A*B*(44/12)) = Amount CO_2 in kg
Area 5	Total distance for one week 589 km	
	589/(4.58*37.7*0.0187*(44/12)) = 332.43	Distance/(C*A*B*(44/12)) = Amount CO_2 in kg
Area 6	Total distance for one week 623 km	
	623/(4.58*37.7*0.0187*(44/12)) = 351.62	Distance/(C*A*B*(44/12)) = Amount CO_2 in kg

Appendix E: Survey questionnaire

Area:	Address (St, Rd, House No): Ethnic	
GPS record No:	Questionee Age: 0 – 18 · 19 – 40 · 41 – 60 · 61 +	Questionee Ethnic: Fijian · Indian EU · Australia · USA · Asia

How interested are you in having SCC collect recyclable wastes from your home? (Not at all) 1 - 2 - 3 - 4 - 5 (Very)

Week 1 (Date:)

	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.
Organic wastes – How many 5 ℓ plastic bags did you use? (may be a fraction, e.g. ½ , ¼ ,etc.)							
Vegetable/fruit peelings							
Food leftovers							
Coffee grounds, tea bags, stale bread, grains, etc.							
Grass/flowers, etc.							
Recyclable wastes – How many 5 ℓ plastic bags did you use? (e.g. ½ , ¼ ,etc.)							
Plastic bottle (PET)							
Juice/soda cans (Aluminum cans)							
Paper (white paper & newspaper)							

APPENDIX F

Appendix F: The SCC House Composting Project pamphlet

BROUGHT TO YOU BY THE SCC HEALTH EDUCATION TEAM

Waste Minimization Tips

1. Save your time and effort, compost all your green waste and kitchen waste in your own backyard.
2. It is not necessary to use compost bins only. You can also use timber, tree trunks, concrete blocks etc to make your compost pile as long as it is properly sheltered from rain.
3. For large tree trunks and branches, call SCC for collection at a cheap rate of $15 per cubic metre.
4. Call your waste recycling companies for all your old automotive parts, waste papers, PET bottles, aluminium materials, copper wiring etc and other metallic materials.

Waste Recycler's Contact:

- Pacific Scrap Buyers - 336 4757 / 933 0575 (Lami Street)
Email: pacific_scrap@yahoo.com
- Waste Recyclers (Fiji) Ltd - 336 1055 / 992 1056 (Lot 26 Wailada Subdivision, Lami)
Email: wasterec@connect.com.fj
- South Pacific Waste Recyclers - 334 1115 (Bulei Rd, Laucala B Estate)
Email: spwr@cjsgroup.com.fj (Waste Paper only)

All Residents are kindly reminded to keep our streets clean by strictly adhering to their current greenwaste collection schedule which is once a month and garbage collection schedule which is three days a week.

A Suva City Council Project
Proudly sponsored by UNDP

YOUR GUIDE TO GREEN GOLD

SUVA CITY

WHY WASTE IT? GAIN FROM IT

HOME COMPOSTING

Your little positive actions can add up to assist the Council in keeping your City "Clean & Green"

WASTE MINIMIZATION INITIATIVES

City residents are encouraged to exercise environment stewardship in minimizing waste by practicing the popular 3R concepts (reduce, reuse, recycle). One simple process is turning waste into useful compost through "Home based composting". Composting is recycling naturally by biological process that turns organic waste from your kitchen, yard clipping and green waste into soil-enriching humus (compost) which can be used in your backyard gardens to improve the soil fertility thereby increasing agricultural productivity, improved soil bio-diversity and reduced ecological risks and a better environment. Composting reduces the volume of generated wastes that would have to be transported and disposed of at Landfills thereby reducing disposal costs.

In our support to promote composting, Council is selling "Home Compost Bins" to our residents at a subsidized rate of only $30.00/bin. Please enquire at Council's Health Department for your compost bin and composting tips.

CB1 CB5

SCC Waste Minimization Project In Partnership with UNDP

TRY HOMECOMPOSTING TODAY

IT is easy to set up
is safe to keep
is fast and matures in 3 month's time
is very economical

FOR COMPOSTING IT'S SIMPLE - JUST FOLLOW THESE FEW STEPS NOW AND YOU'LL BE ON YOUR WAY

STEP 1: SELECTION OF A SUITABLE SITE ON YOUR PROPERTY.

STEP 2: SETTING UP OF COMPOST BINS OR COMPOST PIT

STEP 3: PLACE GREEN WASTE AND KITCHEN WASTE INTO COMPOST BINS OR COMPOST PIT

STEP 4: MIX CONTENTS PROPERLY IN YOUR COMPOST BINS OR COMPOST PIT

STEP 5: COVER COMPOST BINS AND COMPOST PIT

STEP 6: MAINTAIN COMPOST PROCESS BY REGULARLY REPEATING STEPS 3 - 5 ACCORDINGLY UNTIL MATURITY

For further enquiries and suggestions, please do not hesitate to call the address below

Health Services Department
1st Floor Civic Administration Building
196 Victoria Parade
P.O. BOX 176, SUVA
Phone: 331 3433 ext 402 / 406
Fax: 330 8434
E-Mail: enquiries@scc.org.fj