

**EFFECTIVENESS OF SOLID WASTE MANAGEMENT IN THE  
MALDIVES: A CASE STUDY FROM UKULHAS**

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A Master's Thesis submitted in partial fulfilment of the requirements for the  
degree of Master of Research Studies

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## DECLARATION

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I, Fathmath Shadiya, hereby declare that this Master's Thesis, entitled "Effectiveness of Solid Waste Management in the Maldives: A Case Study from Ukulhas" is the result of my own work, except for quotations and summaries which have been duly acknowledged. I have completed this study under the supervision of Dr. Ali Fawaz Shareef. I also declare that the research undertaken for this thesis has not been submitted for the award of any degree, diploma, fellowship or other similar title to any Institution / University.

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# ABSTRACT

**EFFECTIVENESS OF SOLID WASTE MANAGEMENT IN THE MALDIVES: A CASE  
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February 2016  
ABSTRACT**

Waste management in preindustrial times was simple because most of the waste comprised of organic materials which decompose naturally. However with the introduction of non- biodegradable synthetic materials such as plastic, waste treatment and waste disposal have become a pressing concern in the Maldives due to limited financial and human resources available in the country. This research tries to identify factors that can influence the long term sustainability of Community Based Solid Waste Management Systems from social, economic and environmental perspectives, and to suggest recommendations for areas that need further improvement and development in the system. A quantitative approach was used as the research methodology. The survey questionnaire was a close ended questionnaire. Data were collected by conducting social survey and secondary data sources. Data analysis for the social survey was carried out using SPSS. Analysis of results showed Ukulhas waste management Centre utilizes 79.2% of organic waste brought to the waste management Centre to make compost. Spearman's rank order showed there was no association between respondent's satisfaction level and their willingness to pay for waste collection service. Kruskal Wallis test showed there was a significance difference in satisfaction level towards waste management system across different age groups, and Chi-Square test showed there was no association between respondent's attitude towards plastic and their willingness to use recyclable shopping bags. The findings were analyzed using DPSIR framework.

**Keywords:** Sustainability, Community Based Solid Waste Management System, DPSIR framework.

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## LIST OF ABBREVIATIONS

SIDS:	Small Island Developing States.
IWMC:	Island Waste Management Centre.
ISWM:	Integrated Solid Waste Management.
ISWMS:	Integrated Solid Waste Management System.
UNCED:	United Nation Conference on Environment and Development.
CBSWMS:	Community Based Solid Waste Management System.
CBSWMM:	Community Based Solid Waste Management Model.

# CHAPTER 1

## INTRODUCTION

### 1.2 Background of the study

Maldives is a Small Island Developing State characterized by low lying coral islands with white sandy beaches and crystal clear blue lagoons. There are 1190 islands geographically spread across an area of 90,000 sq.km in the Maldives. (Ministry of Tourism, 2015). Compared to vast ocean surrounding the nation, only 1% of land mass accounts for the country's territory. Maldives has a tropical monsoon climate characterized by sunny days and warm nights. The monsoon seasons alternate between Northeast monsoon and Southwest monsoon. Northeast monsoon lasts from December to March, while Southeast monsoon lasts from May to November. National Census 2014 showed the country has a total population of 341,256 people. While 133,019 people reside in the capital city Male', 194,595 people lives in the atolls. (National Bureau of Statistics, 2014). Tropical climate and pristine nature of the Maldivian islands make Maldives one of the leading tourist destinations in the Indian Ocean.

Small Islands Developing States also known as SIDS like Maldives faces unique set of challenges very different from larger countries. These challenges were first recognized in United Nation Conference on Trade and Development (UNCTAD) held in the UN during 1972. By 1990, UN fully recognized SIDS face different kinds of environmental, social and economic challenges compared to challenges found in larger countries. During 1994, in Barbados Program of Action, (BPOA) organized by UN, a vulnerability index for SIDS was recommended by the

participants of the conference. BPOA was a policy document that thoroughly addresses economic, social and environmental vulnerabilities specific to SIDS such as small size, insignificant domestic market, heavy dependency on export market, limited natural resources, geographic isolation, remoteness and vulnerability to natural disasters. (Briguglio, L, 1995). Over the years BPOA was considered as an important reference document when addressing issues related to SIDS.

Maldives being a Small Island Nation also faces similar challenges mentioned in BPOA such as geographic isolation of islands, scarcity of land, small scale economy, insufficient financial and human resources. (Eckelman et al., 2014). Despite numerous challenges Maldives face as a Small Island State, over the last few decades, Maldives has experienced rapid economic growth due to a fast growing tourism industry. Today, tourism contributes about 30.2 % of GDP of the country. (Ministry of Tourism, 2015). Increase in economic prosperity has unlocked various foreign investment opportunities in the country, especially in the tourism sector investors have contributed significantly for economic development of the country. However, Maldives being a Small Island Nation is very susceptible to developmental challenges that come with economic prosperity. One such challenge is the issue of solid waste management. Mismanaged Solid waste is, one of the leading concerns that need an urgent solution in the Maldives today.

In recent years, the situation of waste management worsened due to population growth, change in consumption pattern of people, expansion of tourism industry, lack of an organized transport system and lack of awareness about good waste

management practices among the public. (Environmental Protection Agency, 2011) Population growth coupled with increase in economic prosperity has become the main drivers of solid waste generation in the Maldives. Inadequacy in the waste management system not only harms the environment, but also have become a barrier for economic development. The paradox surrounding development is, while on one hand development brings economic prosperity, on the other hand development also brings new environmental challenges to the country. The situation of solid waste will worsen unless urgent measures are taken to address current issue of mismanaged waste within the country.

According to (Ministry of Tourism, 2015) on average 860 metric tons of solid waste is discarded in the Maldives every day, with a prediction of 30% increase of solid waste over the next five years. This quantity of waste generation is alarming because currently, the amount of waste generated in the Maldives exceeds the capacity of the only operational landfill known as Thilafushi. In the absence of a proper solid waste management system, discarded solid waste such as plastic wrappings, empty plastic water bottles, and kitchen wastes can be seen piling up in pristine lagoons and white sandy beaches tourists enjoy in the Maldives. If these natural resources get polluted, the tourism industry will be unfavourably affected. Tourism heavily depends on the pristine nature of our beaches and marine environment. Therefore proper solid waste management is extremely important for the sustenance of the tourism industry in the future.

Present centralized waste management system established in Thilafushi is very much ineffective in dealing with issues related to solid waste management in the Maldives. Thilafushi is an island built from garbage to solve the problems of

mismanaged waste in the central region of the Maldives. (Ministry of Tourism, 2015). Wastes from the capital city, resorts and islands are brought to Thilafushi for segregation, incineration, recycling and open burning. But due to great remoteness between Thilafushi and islands in the northern and southern region of the Maldives, transport cost is very expensive. Therefore it is nearly impossible to transfer solid waste on a daily basis from islands to central region. Paying expensive fees for waste transfer is a liability for most islanders therefore most inhabitants practiced their own system of waste management. According to Malatesta, Friedberg, Pecorelli, Pietro, & Cajiao, (2015), waste management in the islands are carried out in a totally different manner compared to the central region. Table1 shows four categories of waste management practiced in the Maldives. According to table 1, in majority of inhabited islands waste is managed by dumpsite and open air burning. Onsite incineration is carried out in a planned manner in urban settlements and in resorts only, while in inhabited islands very few instances onsite incineration is carried out. Waste treatment is hardly carried out in the Maldives, but in very few occasions, waste treatment is carried out in some inhabited islands and in urban settlements. Though waste re-use or recycling is carried out in most of the inhabited islands and resorts, in urban settlements hardly any waste is re-used or recycled. Nevertheless, most of the recyclable materials generated in urban settlements are shipped to Thilafushi or shipped abroad to regional recycling companies. Even though a large percentage of organic waste can be converted into compost, Table 1.1 shows' dumping of organic waste into the ocean was practiced across the four categories of islands listed in table 1.1. Organic waste such as kitchen waste are biodegradable, even

so, many times they get washed into the beaches of islands and resorts, spoiling the pristine nature of white sandy beaches tourists enjoy.

**Table 1.1: Solid waste management systems and practices related to four categories of islands. (Source: Malatesta, Friedberg, Pecorelli, Pietro, & Cajiao, 2015),**

Dumpsite and open air burning.	Majority	No	Yes	No
Onsite incinerator	Few cases	Planned	No	Yes
Waste treatment	Few cases	Few cases	No	Yes
Waste reuse or recycle	Majority	Few cases	No	Yes
Shipping to central or regional sites	Very few cases	Yes	Yes	Yes
Organic fraction dumped in the sea.	Majority	Yes	Yes	Yes.

Building regional waste management facilities in every atoll appears to be a very attractive solution to solve the current crisis of solid waste management in the Maldives, but , due to land scarcity, converting at least one island in every atoll into a landfill, will be a challenge for the government, because in a country like Maldives where the percentage of landmass within the territory of the country is less than 1% and within this 1% land has to be shared for other economic activities such as agriculture, tourism and urbanization. (Environmental Protection Agency, 2011). Due to the complexity of the waste management problem in the Maldives, the government of Maldives has started to explore new options to solve the issue

of waste management by experimenting with innovative approaches that fits into the local context.

In one such attempt, Maldivian government in association with European Union implemented a pilot project called Maldives Ari Atoll Solid Waste Management Project in Dec 2012. Primary aim of the project was to introduce a low cost model of a Community Based Solid Waste Management System (CBSWMS) that was easy to implement and at the same time, reduces majority of solid waste that needs to be transported to Thilafushi. Selected islands for this pilot project were Ukulhas, Thoddoo, Dhigurah, Fenfushi and Dhangethi. (World Bank, 2015)

Reducing bulk of waste at island level is essential because transport of waste from Ari atoll to Thilafushi is costly and time consuming and due to these constraints many islanders prefer to practice open burning and dumping of wastes to lagoons and beaches as a more convenient way to get rid of waste. Preliminary assessment reports before the implementation of the pilot project showed all the islands in Ari Atoll practiced open burning, dumping of kitchen wastes to sea and in some instances disposal of unsegregated wastes to lagoons. (Environment Protection Agency, 2011). Ukulhas was the first island that was able to successfully implement a working model of a Community Based Solid Waste Management System (CBSWMS) during project phase in a formal fashion while Fenfushi and Digurah were able to replicate the same system to some extent during the project phase. The project ended on 30<sup>th</sup> November 2014 with a total cost of USD\$ 1.326 million. By the end of the project, Ukulhas council had trained 30 councillors from different islands to replicate the CBSWMS established in the island. (World Bank, 2015).

## 1.1 Problem Statement

Waste management in preindustrial times was simple because most of the waste comprised of organic materials which decompose naturally. (Owens, Zhang, & Mihelcic, 2011). However with the introduction of non- biodegradable synthetic materials such as plastic, waste treatment and waste disposal have become a pressing concern in the Maldives due to limited financial and human resources available in the country. According to (Ministry of Tourism, 2015) an estimated 860 metric tons of solid waste is discarded in the Maldives every day. Annually this amount is estimated to be about 312,075 metric tons per year. Proper disposal of large quantities of waste is a challenge in the Maldives because of lack of landfills and geographic isolation of Maldivian islands. On the other hand, construction of new landfills is not an easy option in a small island State like Maldives because of land scarcity. According to Eckelman et al., (2014) the competition of land for economic activities such as tourism and agriculture makes it difficult to allocate land to construct new landfills. Another factor that contributes to this challenge is “not- in my backyard attitude” which means communities do not prefer to have landfills near their place of residence. In cases where landfills are constructed within the close proximity of residential areas, emission from open burning can affect air quality of residential areas. (Eckelman et al., 2014). This is very much evident in Maldives, when solid wastes in Thilafushi are burned, smoke from Thilafushi reach capital city Male’ and a nearby island called Villingili, affecting air quality of these two residential islands.

Current waste management practices in the Maldives can be grouped into three categories. In most islands open burning is practiced while in the central region where the capital city is located, waste is taken to Thilafushi. In some resorts and some islands of Ari atoll wastes management is carried out using a hybrid method where organic kitchen waste were composted, treated or segregated before final disposal to Thilafushi. (Malatesta, Friedberg, Pecorelli, Pietro, & Cajiao, 2015). Many islands in the Maldives

lack an organized solid waste management system. Therefore the need for a good waste management system is very much evident in the country as the country's poor waste management strategies are not only destroying the environment but are also threatening health and wellbeing of the local communities. When solid wastes such as discarded tires, cans and bottles were not properly disposed, they become breeding grounds for disease transmitting vectors such as Aedes mosquitoes which spread Dengue fever. (Ministry of Health, 2013).

Dengue is an endemic vector born disease commonly found during rainy season of South East Asia. According to (Ministry of Health, 2013), dengue fever is a very common disease in the Maldives and dengue cases can be seen throughout the year. Table 1.2 shows dengue cases recorded from 2007 to 2012. Mismanaged waste is one of the leading causes of dengue fever in the Maldives. (Ministry of Health, 2013). Safe disposal of solid waste is essential for the wellbeing of the public. The cases of dengue fever are most widespread during the month of June to August as shown in the graph 1. This is because, during rainy seasons, water collected in discarded bottles, cans, tires and plastic bags becomes breeding grounds for mosquitos that spread dengue fever. (WHO, 2011).

Table 1.2

Cases of Dengue fever by month from 2007 to 2012. Source: (Ministry of Health, 2013)

Month/Year	2007	2008	2009	2010	2011	2012
January	276	99	105	52	180	57
February	91	74	55	29	151	46
March	25	94	38	40	164	58
April	38	133	52	40	177	84
May	97	220	60	87	224	64
June	187	304	68	101	359	37
July	239	185	95	115	595	150
August	143	125	96	90	147	147
September	114	135	43	61	165	89
October	130	73	59	33	134	92
November	83	94	47	31	61	88
December	69	81	56	73	72	46
<b>TOTAL</b>	<b>1492</b>	<b>1617</b>	<b>774</b>	<b>752</b>	<b>2429</b>	<b>958</b>

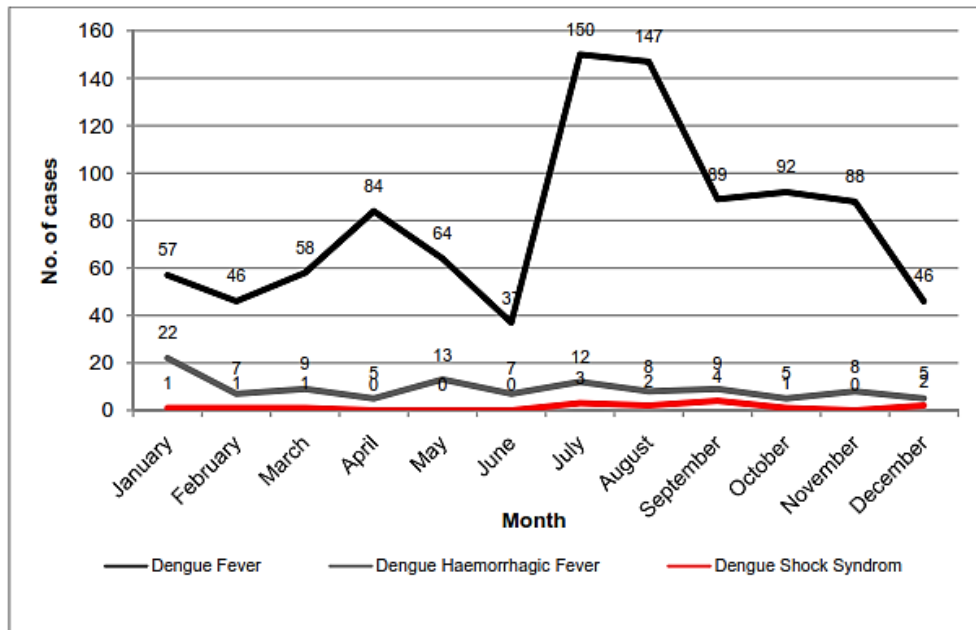


Figure 1.1: Number of dengue fever, dengue haemorrhagic fever and dengue shock syndrome cases in 2012. Source: (Ministry of Health, 2013.)

Community Based Solid Waste Management System (CBSWMS) proposed by Ari Atoll pilot project offers some relief to the problem of waste management in the Maldives. The project aims to introduce a low cost integrated solid waste management system (ISWMS) where, waste is recycled, reused and reduced. The new model also provides opportunities

for islanders to earn income through selling compost and recyclable materials such as glass, iron and aluminum. For long term sustainability of small scale waste management systems, a source of income is vital to cover the operational cost of the system. (Falzon, 2012).

Solid waste management in the Maldives was practiced traditionally in a very informal manner. It is through Ari Atoll solid waste management pilot project, that the concept of a formal waste management system was introduced to the Maldives. Yet, effectiveness of the newly introduced system in Ari Atoll is not known due to limited research available in the field. Even though Ukulhas was the first island that was able to implement a formal CBSWMS in Ari Atoll, long term sustainability of such programs cannot be predicted due to limitations such as, lack of available physical space, lack of financial resources, vulnerability to extreme events due to climate change, small market size and diseconomies of scale. Market size plays an important role in small island context because, most companies involved in the business of buying recyclables materials such as glass, aluminium and iron demand larger quantities of recyclable goods to be supplied, but, in the case of Maldives, recyclable goods sold to overseas companies is less in number, therefore the smaller quantity exported may not satisfy the demand of international commercial recycling companies. Successful solid waste management program that fits in to the island nature of the Maldives is a challenge. Nevertheless, innovative projects like Ari Atoll solid waste management project may offer promising solutions to current problems of solid waste management in the Maldives.

## 1.2 Objectives of the study

### **RESEARCH QUESTION AND RESEARCH HYPOTHESIS.**

For the purpose of this research, “**An Effective Community Based Solid Waste Management System**” was defined as:

*“A cost-effective system that has the capacity to minimize more than 50% of solid waste generated at island level, while at the same time providing economic, social and environmental benefits to the community without any social exclusion”.*

Based on this definition, the following research questions and hypotheses were developed.

- 1) How much organic waste generated in Ukulus was utilized by waste management center?
- 2) Is there a demand for compost produced in Ukulhas?
- 3) Is there a difference in the spread of dengue fever and diarrhoea before and after implementing CBSWMS in the island?
- 4) Is there an association between community satisfaction level and their willingness to pay for the sustenance of the CBSWMS?
- 5) Is there a difference in satisfaction level with the waste management system across different age groups?
- 6) Is there an association between people who think plastic is harmful and their willingness to use recyclable shopping bags?

Research question one, two and three were descriptive research questions. Variable under study for research question one was “**percentage of organic waste utilized by Ukulhas waste management Centre**”. Variables under

study for second research question was “**Demand for compost**” and variables under study for third research question was “**spread of Dengue and Diarrhea cases**” Questions four , five and six involve relationship between two or more variables, therefore to answer these questions, following hypotheses were developed.

### **Hypothesis 1**

There is an association between community satisfaction level and their willingness to pay for the sustenance of the Community Based Solid Waste Management System.

**Independent variable:** Community satisfaction level.

**Dependent variable:** Willingness to pay.

### **Null Hypothesis**

There is no association between community satisfaction level and their willingness to pay for the sustenance of the Community Based Solid Waste Management System.

### **Hypothesis 2**

There is a difference in satisfaction level with the waste management system across different age groups.

**Independent variable:** Age

**Dependent variable:** Satisfaction level around waste management system.

### **Null Hypothesis**

There is no difference in the satisfaction level with the waste management system across different age groups.

### **Hypothesis 3**

There is an association between people who think plastic is harmful and their willingness to use recyclable shopping bag.

**Independent variable:** Attitude towards plastic

**Dependent variable:** Willingness to use recyclable shopping bag.

### **Null Hypothesis**

There is no association between people who think plastic is harmful and their willingness to use recyclable shopping bag.

## 1.3 Significance of the study

Maldives being a small islands state do not have the technology, financial and human resources, to adopt sophisticated waste management systems implemented in the developed world. Nevertheless, Maldives Ari Atoll solid waste management project offers some hope to solve current issues of solid waste management in the Maldives with an innovative approach that fits into the native context. Yet, little is known about effectiveness of the system as the system is very young and availability of research findings on such a system in the local context is limited. Even though CBSWMS may appear to be successful during project life time, their effectiveness and long term impact on the community cannot be known unless influencing factors that can impact long term sustainability of such a program is investigated thoroughly.

Success of solid waste management programs will not only benefit the implementing islands, but also will bring some relief to the negative impacts of mismanaged waste across the country. By investigating effectiveness of such programs, there lies the opportunity to learn and understand aspects that contributes to the long term sustainability of small scale solid waste management programs in the Maldives. Efficiency and effectiveness of small scale waste management systems implemented in the islands can only be confirmed if the existing systems were studied in depth. However this can only be done through detailed research in this field. Current literature available is not enough and more research is needed to predict influencing factors that will affects future sustainability of CBSWMS in the Maldives so that successful systems can be replicated in more islands in the future. Therefore it is hoped, through this research to identify factors that can influence the long term sustainability of CBSWMS from social, economic and environmental perspectives and to suggest recommendations for areas that need further improvement and development of the system. In addition, findings of the research can also be used to enhance understanding of various aspects of CBSWMS that work and does not work in the local context.

#### 1.4 Research scope

The main focus of the research was to measure effectiveness of Community Based Solid Waste Management system established in Ukulhas. The unit of analysis of the case study was Ukulhas waste management system. In order to measure effectiveness of the waste management system, elements shown in DPSIR framework shown in figure 3 was considered as the key areas of focus. However,

due to time constraints and limited financial resources, only three elements from DPSIR framework, Impact, Response and Drivers related to case study was studied in depth.

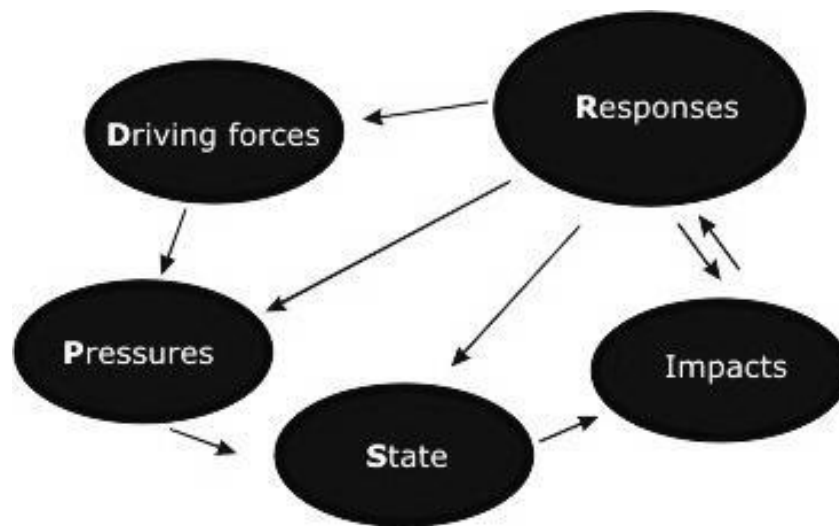


Figure 1.2: DPSIR framework developed by European Environmental Agency in 1999.

Table 1.3

Indicators develop to measure the effectiveness of the Ukulus waste management system based on DPSIR framework.

Areas of focus from DPSIR framework.	Thematic areas of focus
1) Responses.	<ul style="list-style-type: none"> <li>• Rate of organic waste utilization by waste management Centre.</li> </ul>
2) Drivers	<ul style="list-style-type: none"> <li>• Consumption pattern of plastic by consumers.</li> </ul>
3) Impact.	<ul style="list-style-type: none"> <li>• Community wellbeing.</li> <li>• Socio economic impacts.</li> </ul>

Table 1.3 shows Response, Drivers and Impact as the main elements under investigation from DPSIR framework. The element “Response” was again further specified into thematic area of “organic waste utilization rates” whiles the element “Driver” was specified into the theme “consumption pattern of plastic by

consumers”. The third element “Impact” was detailed into “community wellbeing and socio economic impacts” related to solid waste management. Research boundary lies within these three elements and their thematic specific areas shown in table 1.3. In addition findings of the research will be limited to the context of Ukulhas only.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Chapter summary

This chapter will first look at issues and problems of solid waste management from a small island context. At present, UN identifies 52 island nations and territories as SIDS. The countries, all share common issues such as small population size, land scarcity, geographic isolation of land and small economies of scale, weak institutional capacity, and vulnerability to climate change. Next the chapter will look at problems of marine pollution on small island states. The aesthetic beauty and the vast ocean surrounding SIDS make SIDS idyllic places for tourism and fisheries development. But today oceans are threatened by oceanic acidification, coral bleaching, nutrient over loading, and fisheries depletion making tourism and fisheries very vulnerable industries in SIDS. As food waste is a leading driver of marine pollution, next the chapter will look at effect of marine pollution on SIDS economy, followed by a brief look at food waste and consumer lifestyle. Food waste is a leading concern in Small Island States, because majority of packaging or wrapping that comes with packaged foods end up in the ocean. Next the chapter will introduce as a policy recommendation tool the concept of Integrated Solid Waste Management (ISWM). Integrated Solid Waste Management (ISWM) tries to address issues related to solid waste management by taking into account, the social, economic and environmental dimensions. Finally Community Based Solid Waste Management System will be looked at before closing the chapter with an overview of DPSIR framework.

DPSIR framework was the analytical tool used in this thesis to examine the case of Ukulhas solid waste management system.

## 2.2 Solid waste management in Small Island Developing States. (SIDS).

In 1992, for the first time, at the United Nation Conference on Environment and Development held in Rio de Janeiro, the UN identified a group of Small Island Nations in need of urgent attention about distinctive developmental challenges specific to these island nations that needs to be addressed globally. (UN, 2011). According to Fry (2005) all Small Island Developing States (SIDS) share similar challenges that needs global attention such as small population size, land scarcity, geographic isolation of land and small economies of scale, weak institutional capacity, and vulnerability to climate change. At present, UN identifies 52 island nations and territories as SIDS. The countries are located in the Pacific, Caribbean, Atlantic, Mediterranean, South East China Sea and Indian Ocean. (UN, 2011).

One common feature shared by all SIDS is small size. Small size is economically disadvantageous because small size means limited natural resources, which restricts SIDS ability to produce and export a wide range of products. Therefore to diversify the products available in the local markets of SIDS, a large proportion of goods are imported from overseas market to SIDS. (Briguglio, 1998). While international imports increases the variety of goods available in the local markets, the shortcoming of this dependency is, SIDS do not have any control over the types of goods they import. As more products are imported, the quantity of waste generation also increases. Since SIDS lack proper solid waste management

system, management of solid waste has become one of the key environmental issues that need an urgent response.

Apart from imported goods, tourism industry also contributes to waste generation. According to Willmott & Graci (2012) the global tourism industry is responsible for production of 35 million tons of solid waste annually in SIDS. Waste generated from tourism industry accounts for nearly twice the rate of local waste generation. (Shamshiry et al., 2011). The figure is alarming as most SIDS do not have the capacity to deal with vast quantities of solid waste generated in the islands. Poor waste management often leads to environmental degradation and aesthetic pollution. Cleaning coastal litter is costly and time consuming because floating litters keeps washing up on beaches even though the beaches were cleaned regularly. The complex relationship between tourism and natural resource management puts SIDS in a vulnerable position because tourism depends on the health of natural resources such as beauty of the coastal habitats and the pristine nature of the marine environment, but at the same time, tourism also generates solid waste that pollutes the very same natural resources tourism depends on. (Shamshiry et al., 2011).

### 2.3 Marine pollution and Solid Waste Management.

Oceans support great diversity of life and are important regulators of weather and climate. But today oceans are threatened by marine pollution. Marine pollution, have steered oceanic acidification, coral bleaching, nutrient over loading, and fisheries depletion. (CBD, 2012). Much of the problem of marine pollution lies with marine debris. (CBD, 2012) defines marine debris as “Any persistent, manufactured or processed solid materials discarded, disposed of or abandoned in

the marine and coastal environment.” Marine debris are formed from plastic, glass and metals fragments that get split while floating in the ocean as they drift away from one continent to another. Marine species such as sea turtles, marine mammals and sea birds mistake floating debris less than 5 mm in diameter as food. Many marine organisms have died due to indigestion of marine debris. Once marine debris gets into the digestive tract of the organisms, they stay in the digestive tract without being digested or egested. (CBD, 2012). There are two main sources of marine debris. They are land base sources and ship bases sources. Most of the land base source of marine debris comes from coastal litter. Owens, Zhang, & Mihelcic (2011) reports coastal litter accumulation rate around coastal habitats range from 6.4 to 7 billion metric tons per year. Out of this marine litter, 80% comes from land based sources, while 20% of marine litter comes from ocean based sources. According to (CBD, 2012) at a global scale, plastic rank as the most abundant form of marine debris followed by metal and glass particles.

Hazardous waste dumped into the ocean by a large percentage of boats and ships that pass through SIDS while transiting between boarders, is another concerning Trans -boundary issue faced by SIDS (UN, 1994). SIDS heavily depends on marine environment for food and livelihood activities. Next to tourism fisheries industry is the second dominant industry that contributes to the economic development of SIDS, thus SIDS have a very close relationship with the marine environmental for development.

The aesthetic beauty and the vast ocean surrounding SIDS make SIDS idyllic places for tourism and fisheries development .But on the hand, the close relationship SIDS have with the marine environment for tourism and fisheries

activities make SIDS very vulnerable to impacts of marine pollution. (UN, 2014) reports that extensive loss of marine species due to marine pollution will have a detrimental effect on people's livelihood especially for people of SIDS where jobs are inadequate due to limited industries. The over specialization of SIDS to one particular industry such as tourism industry or fisheries industry is risky because majority of local people will be employed only in those industries. Suppose if marine pollution impends tourism and fisheries, livelihood of vast number of people who depend on tourism and fisheries will be affected negatively, especially the poor people with limited job opportunities. Finding new jobs for these vulnerable groups of people will be very difficult due to limited job market in SIDS.

SIDS lack land for construction of new landfills and have limited budget for proper method of incinerations to minimize waste. Waste recycling is a better option for SIDS because reducing bulk of solid waste through recycling activities will reduce the pressure felt on landfills in accommodating large quantity of wastes that comes from various islands. In addition, recycling activities also will reduce marine and coastal pollution. Waste minimization strategies such as recycling will be useful to a country like Maldives where there is only one operational land fill to cater for all the islands and resort within the country. Despite the challenges SIDS face as a Small Island Nations, (Eckelman et al., 2014) points out that the very same constraints faced by SIDS also gives opportunities for SIDS to create alternative strategies for waste management practices distinct to SIDS. Such opportunities provide windows for innovative ways of managing solid waste that is more appropriate for small island context.

## 2.4 Food waste and consumer life style.

In recent years the issue of food waste has become a trending topic in global forums. (High Level Panel of Experts, 2014) defines food waste as “food suitable for human consumption being discarded at consumer level that was originally intended for human intake, regardless of the cause”. Food waste is very common in high mass consumption societies where lifestyle encourages people to use packaged food to suit their busy schedule. FAO statistics as of 2014 showed 1.3 billion tons per year is either lost or wasted globally as food waste. Food waste is a leading concern in Small Island States because majority of packaging or wrapping that comes with packaged foods end up in the ocean. (High Level Panel of Experts, 2014) estimates, there are 1000 million tons of floating garbage drifting in the oceans around the world.

During last 50 years, many developed countries have become “consumer societies” in which consumption of goods and services have become a dominant part of their economy. (Crane, 2010). Lifestyles in urban cities play a vital role in the consumption pattern of individuals. Consumer behaviour can be classified as passive, autonomous and political. (Crane, 2010). While it is difficult to blame the economy for consumer’s choice of the products available in the market, Crane, (2010), explain that the main problem is not growth of economy but the philosophy behind economic growth and consumption. The idea of self-indulgent consumer is seen as the promoter of economic growth and with this approach, over consumption of goods was encouraged in consumer societies as the main driver to expand the market. According to (High level Panel of Experts, 2014) one

third to one half of waste that goes to landfills come from the food sector in consumer societies.

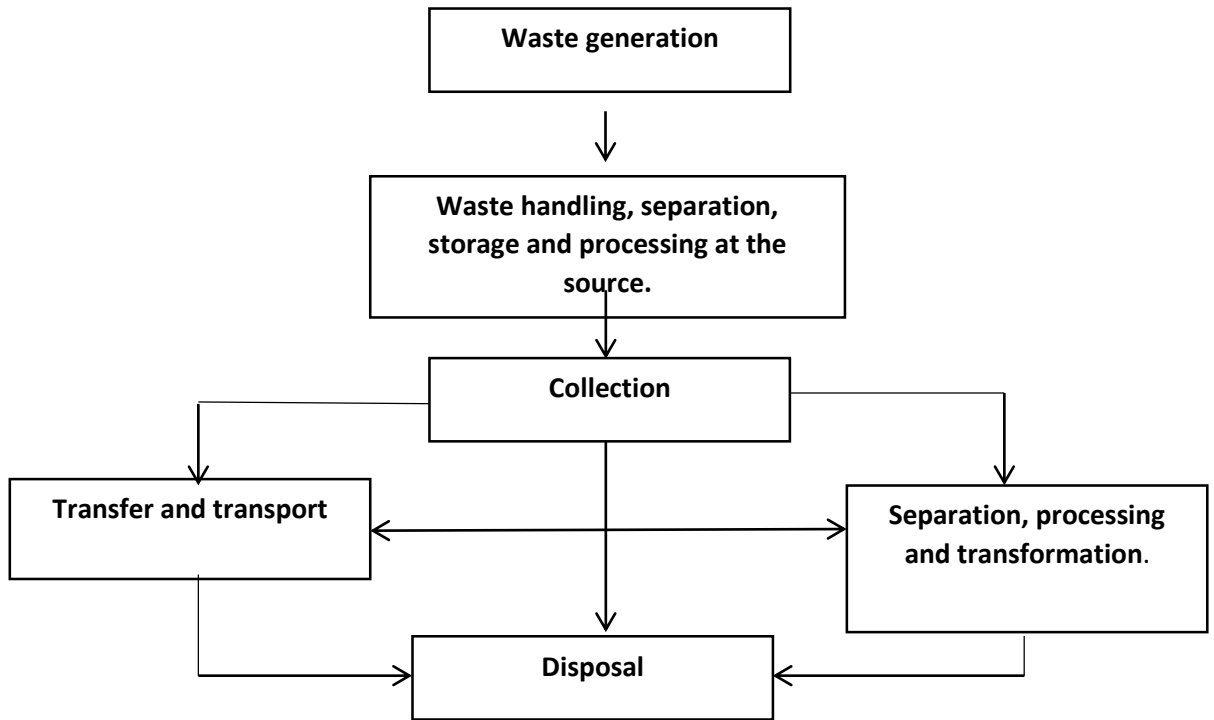
A similar trend can be observed in the Maldives too, in recent years with economic prosperity, the capital city has become a high mass consumption society where majority of the waste generated in the city is result of change in life style of the urban population. While all kinds of waste are generated in the capital city, the story is quite different in rural islands and resorts. In a study done by (Peterson, 2013) he explained that 70% of waste composition in the islands and 89% of waste discarded in resorts are organic waste. Even though organic waste can be recycled into products such as compost, most of the organic waste generated in the islands and in resorts are dumped into the ocean which leads to coastal and marine pollution. Food wastage is a significant problem found in the Maldives. While it is true that Maldives lack sophisticated waste management systems to handle all the waste generated in the country, Maldives still can explore options where organic waste can be utilized to form new products such as compost, fish meal or tuna oil as seen in countries like Thailand. (High Level Panel of Experts, 2014).

Maldives being a Small Island State do not have the mechanism to cater for large number of waste generated within the country. Therefore efforts are needed to create awareness among Maldivians on how their lifestyle is impacting the environment. However awareness and education alone does not promote environmental friendly behaviour. In a study done by Crane, (2010) he found that concerns about the environment do not necessarily lead to specific behaviour that protect the environment. A person may be very concerned about pollution and environmental degradation, yet the very same person might not engage in green

consumer behaviour such as usage of green products to save the environment. Crane, (2010) explains consumer attitudes can only be understood in relation to their conception of self-identities they form with themselves in different social settings

## 2.5 An Integrated Solid Waste Management (ISWM) approach for SIDS.

Solid waste management is a complex issue that involves social, economic and environmental dimensions. Unless solid waste management is not addressed holistically, waste cannot be managed properly. The concept of Integrated Solid Waste Management (ISWM) tries to address issues related to solid waste management by taking into account, the social, economic and environmental dimensions. Squires (2006) defines solid waste management as the systematic administration of activities that provides services to source separation, storage, collection, transfer, transport, and disposal of solid waste in a manner that is safe to the public. ISWM tries to combine the six elements of waste management in to one approach where these elements are addressed in depth as a one system. In typical waste management system, waste management elements are categorized as 1) waste generation 2) waste handling, sorting, storage and processing where waste is generated, 3) waste collection 4) separation, processing 5) waste transfer and 6) disposal of waste. (Kadafa, Abd Manaf, Sulaiman & Abdullah, 2014). When all six functional elements of solid waste management are linked, an ISWMS is formed as shown in figure 2.4.



*Figure 2.51: Interrelationships between elements of waste management system. Source: (Kadafa, Abd Manaf, Sulaiman & Abdullah, 2014).*

ISWMS is based on the principles of waste management hierarchy which is a policy recommendation tool consisting of four alternatives as shown by figure 2.51. They are 1) Source Reduction, 2) Recycling, 3) Waste Transformation 4) and landfilling. (Tchobanoglous, Theisen & Vigil, 1993). According to figure 2.51, the most preferred option shown by waste management hierarchy is source reduction. Source reduction can be achieved through designing phase by the manufactures. If manufactures pack their products with minimum materials, source reduction can be achieved at production level, if household member were willing to use reusable products for their everyday activities source reduction can be achieved at household level. Source reduction is attractive because this technique has the potential to conserve resources, reduce pollution and decrease greenhouse emissions. While source reduction is the most preferred option,

recycling is considered as the second best alternative. (Tchobanoglous, Theisen & Vigil, 1993).

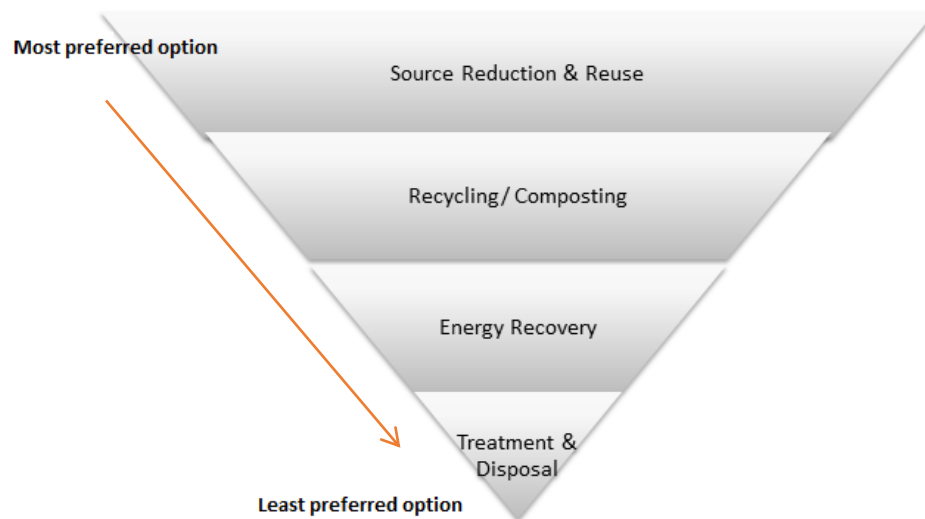


Figure 2.52: Waste management hierarchy ((Samah, Abd Hamid, & Ishak, 2015)

Recycling involves activities such as separation and collection of waste materials, reprocessing and manufacturing of new materials by applying methods such as composting. Composting is a common strategy applied by many waste management Centres to minimize organic waste. Composting can be defined as a natural process where micro-organisms such as bacteria, actinomycetes and fungi decompose organic matter into carbon dioxide, water, minerals and humus and plant nutrients. (Temporal-Lara, Gomez, Navarro-Pedre~no & Raya, 2015).

During composting process, moisture and carbon dioxide are lost from the organic waste, this in turn reduces the total volume of organic waste. Reduction of volume is advantageous from waste management perspective because cost of storing and handling of wastes will be cheaper if volume get reduced. (Renkow& Rubin, 1998). Composting involves several phases. The first phase involves degradation of freshly compiled organic waste by mesophilic bacteria, actinomycetes, fungi,

and protozoa. This process occurs between temperatures of 10 and 45 degree Celsius. As the degradation starts to continue pH starts to increase due to acid build-up. The second stage of composting is referred as thermophilic phase which can last for several weeks. It is during the thermophilic phase most of the organic matter is degraded. The optimum temperature for this process is 40–50 degree Celsius. After the thermophilic phase, then comes cooling phase where microbial activity decreases as the temperature falls. Next comes maturation phase where temperature falls to room temperature and mesophilic bacteria slowly degrade complex organic compounds such as lignin to humus. This last phase is important because humus-like substances are produced in this phase to form mature compost. (Gajalakshmi & Abbas, 2008)

The three common types of composting carried out are windrow, aerated static pile and in vessel composting. In the Maldives windrow composting is carried out in Ukulhas. In windrow composting the organic wastes are placed out in parallel rows, two to three meters high and three to four meters across. The process of composting is increased by regular turning of the windrow piles. The piles completely turned into compost within three to four weeks. While windrow composting is an easy low cost efficient way to decompose organic waste, there are some drawbacks such as requiring large space, spread of odour when decomposition process is not going well, and likely chance of spread of bioaerosols such as fungal spores. Due to these reasons, for safety purposes a very large space is required for windrow composting. (Gajalakshmi & Abbas, 2008). Even so, windrow composting is popular among waste management Centres due to low cost and simple operational procedures involved.

According to (Eglė Zuokaitė, & Aušra, 2013) compost has numerous benefits such as solid conditioning, prevention of leaching of nutrient during heavy rain and reducing bulk of organic waste. Compost is a very good soil conditioner where nutrients such as nitrates, phosphates are added to the soil. From an economic perspective composting has two advantages such as job creation and earning income by selling compost. According to (Eglė Zuokaitė, & Aušra, 2013) composting creates and sustains five times more jobs when compared to jobs created in landfills.

The benefits of recycling activities such as composting involves conservation of natural resources, space recovery of landfills and recovery of economically useful products. (Tchobanoglous, Theisen & Vigil, 1993). In addition to composting, in many developed countries sophisticated landfills have the technology to recover energy. Energy recovery is referred to as the “heat or electricity” obtained through burning of waste that cannot be reused or recycled. Energy can also be recovered by collection of biogas produced by anaerobic digestion of organic wastes. (Shumais, 2014). Unlike windrow composting, installing a good quality incineration and maintaining operational cost of such a system is expensive therefore it is very difficult to establish such sophisticated systems in SIDS. In addition to the maintenance cost, collection and distribution of biogas can be a challenge in a country like Maldives where land is geographically isolated and transport cost is expensive. (Shumais, 2014).

The least preferred option according to waste management hierarchy shown by figure 2.52 was waste disposal to landfills. Even though landfills are least preferred option according to waste management hierarchy shown by figure 2.52,

they are important component of waste management system as landfills are needed to bury non-recyclable and non-combustible wastes. Modern landfills are engineered sites with well-maintained leachate, storm water, landfill gas control and environmental monitoring systems. (UNEP, 2005). Construction and maintenance of modern landfills will be very costly for SIDS as SIDS do not have the finances, human resources and technology to invest in large scale projects like that, however, Maldives is trying to establish a modern landfill in Raa.Vandhoo from the climate change trust fund administered by the International Bank for Reconstruction and Development (IBRD). (Ministry of Environment & energy, 2015). Funds from donor agencies is one way SIDS can establish modern landfills, still the maintenances and operational cost and limited human resources are challenges that has to be overcome.

## 2.6 Community Based Solid Waste Management System.

There is a distinguishing difference between the concept of Sustainable Solid Waste Management and Integrated Solid Waste Management. Sustainability measures the appropriateness of the system to the local conditions from social, environmental, economic, technical and institutional perspectives and capability of the system to maintain itself over a long period of time, while an ISWMS measures the interactions that occur between relevant stakeholders involved in the waste management system from household level to policy level. (Klundert, 1999). Achieving sustainability is time consuming and difficult as solid waste management systems are complex systems which involve integration of various stakeholders. The success of a fully integrated solid waste management system will depend on how positively various stakeholders involved in the system

cooperate with each other. The concept of Sustainable Integrated Solid Waste Management System (SISWMS) recognizes this complex nature of various roles of stakeholders involved in the system. Sustainability is very much concerned with the long term achievement of the system. Governments can spend large amounts of money in producing a very good ISWMS. However, the long term sustainability of such a system maybe at question, if the social, economic or political dimensions have clashes with each other. This is very much evident in developing countries where poor governance and political instability often leads to conflict between social, economic and environmental aspects surrounding solid waste management systems. In the case of SIDS similar scenarios can be seen. Success of any development projects depends on the roles and responsibilities taken by relevant stakeholders. Bottom up development Projects that are owned by communities have a better success rate than projects that do not involve community participation. (Squires, 2006). Community ownership is essential for successful implementation of a community based solid waste management system. Therefore the planning phase of an effective solid waste management system requires understanding of the needs and preferences of relevant stakeholders involved in the system.

The most important aspect for a planner in the field of Solid Waste Management is the feedback mechanism regarding the established system. Feedback such as community perception on fee collection services, community satisfaction and community awareness about the waste management system will give planners enough information on how to improve the system in the future. In a bottom up approach such as Community Based Solid Waste Management System, households play an important role in facilitating the running of the system.

Household roles such as managing and segregating waste at household level will lessen the load on the staff in the waste collection service as they do not have to segregate household waste from the waste management Centre and valuable time of the staffs in the waste management Centre can be allocated to carry out other activities in the Centre. In addition, when communities clean their houses the neighbourhood will look hygienic and the city council will not have to hire people to clean roads and public places, which will reduce the cost the council has to spend on cleaning roads and public areas. Community participation is the sociological process where the community members organize themselves and become actively involved to improve their living conditions.

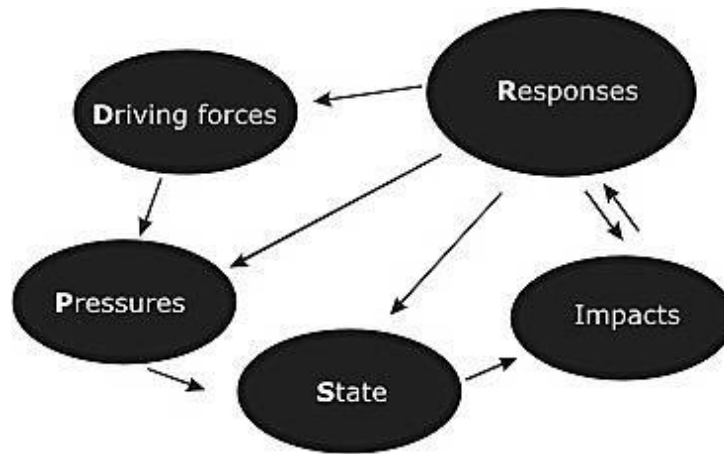
Successes of community based models are based on four core values. They are 1) Equity, 2) Integrity, 3) Openness and 4) Accountability. (Squires, 2006). According to Squires (2006) equity means all the stakeholders should be given the opportunity to make decisions for them. Integrity means decision makers should act in the best interest of the people and their actions must be transparent. Openness refers to the provision of information in the most transparent way and accountability means the degree to which public involvement affect the decision making process. However application of these four core values to a CBSWMS is a challenging task as communities are not homogenous, but are made from a complex layer of people with varied responsibilities and diverse roles to play in the society.

According to Zahra, Majeed, Mahmood, & Asad (2012) success of CBSWMS is based on the level of participation by the community with the waste management system. Public participation is a very complex process by nature as participation involves people from different backgrounds with different viewpoints. As a result,

participation of the community members in CBWMS becomes very complex and unless, there is coordination among the community members, full cooperation from the community might not be achieved. If there was lack of community participation, CBSWMS may fail to carry out effectively. Through education and awareness, public participation may increase if the community is made to realize they have a responsible role to play in waste management system implemented in the island. When communities are made to be actively involved in the waste management system, they get to feel a sense of accountability to the waste they generate and as a result, there is a demand to reduce the amount of waste they produce. Community accountability to the waste they generate is one of the strengths of CBSWMS. (Zahra, Majeed, Mahmood, & Asad, 2012).

CBSWMS is a new approach that is gaining popularity in SIDS as this approach makes communities more accountable for the waste they generate. Even though community participation has lot of benefits to the society, participation is not a homogenous term. (Bernstein, 2004) explains Participation will depend on the level of inclusiveness stakeholders are given from design, planning and implementation phase of any project. Degree and Level of participation will be different for different stakeholders as their roles are different within the society, nevertheless community involvement at different level will be important in a bottom up approach. Success of bottom up approach lies when communities are given opportunities to voice out their expectation and concerns regularly. Participation also means analysis of new strategies with the communities before their implementations. (Bernstein, 2004).

## 2.7 Driver, Pressure, State, Impact, Response framework.



*Figure 2.71: DPSIR Assessment framework developed by European Environmental Agency in 1999.*

It is vital to assess waste management systems systematically to measure their performance so that necessary improvements can be brought to improve weak areas in the system. Efficiency and effectiveness of waste management facilities can be evaluated by using system assessment tools such as Scenario Development, Material Flow Analysis, Life Cycle Assessment, Risk Assessment, Environmental Impact Assessment, Strategic Environmental Assessment, Socio Economic Assessment, and Sustainable Assessment Tools such as DPSIR framework. (Zurbrügg, Caniato, & Vaccari, 2014). Since waste management system selected for this research is a Community Based Solid Waste Management System, it is essential to use a system assessment tool that can capture the interactions of community members with the waste management system in a holistic manner.

Kristensen (2004,) explains that DPSIR framework shown in figure 2.71 as a very good framework in describing cause effect relationships between the environment and the society. Khajuria & Ravindranath, (2012) further describes DPSIR framework can capture the interaction between society and the environment by explaining how the DPSIR framework elements interact with each other. For

example DPSIR framework can be used to explain how drivers of environmental degradation such as developmental activities affect the state of the environment and as a result the impacts they have on people and ecosystem. For example, DPSIR framework can be used to explain how societies respond to impacts from environmental pressures such as water pollution. According to Skondras & Karavitis (2015) one of the biggest advantages of using DPSIR framework is its ability to give clarity and valuable information about the relationship between the origins and the consequences of environmental problems which impact the society.

DPSIR framework was originally built from Pressure – State –Response (PSR) framework developed by Organization of Economic Cooperation and Development (OECD, 1994). However due to limitations of PSR framework, the UN commission on sustainable development during 1997, developed a new framework called Driving –Force- State -Response, (DSR) framework. Neither PSR nor DSR framework addresses the motivational facts behind responses in the changes of the environment, therefore in 1999, a new framework called DPSIR framework was developed by European Environmental Agency (EEA). (Carr et al., 2007)

DPSIR framework is based on four elements as shown by figure 2.71. They are Drivers, Pressures, State, Impacts and Responses. According to (Kristensen, 2004) and (Carr et al., 2007), **driving** force is a need that arise from social demographic and economic developmental activities that corresponds to life style changes of the people. For an individual the driving force could be the need for

shelter or food. From an industrial perspective driving forces can be the need to earn a profit.

**Pressure** refers to specific human activities that result from driving forces which impact the environment. (Maxim, Spangenberg, & O'Connor, 2009) explains pressure as anthropogenic activities that induce environmental change. Usually the changes are seen as environmental damage or degradation. Pressure is caused by unsustainable use of natural resources by human activities such as over exploitation of natural resources. **State** refers to the quality of the environment due to pressure. The state of the environment can be measured by purely ecological or from socio-economic perspective.

**Impacts** mean the negative effect on the biotic and abiotic component of living and non-living environment due to pressure. (Maxim, Spangenberg, & O'Connor, 2009) explain some of these pressures that can impact an ecosystem will be genetic modifications of organisms, changes that occur to the chemical composition of air or water due to pollution. In addition impact can also be described from socio-economic perspective such as the effect of pollution on physical and mental health and the consequence on social cohesion within the society. Due to negative impacts, the result is **Responses**. (Carr et al., 2007) explains response as the decisions made by groups or governments to address changes in the state of the environment. Usually responses involve measures taken to protect or conserve natural resources by groups or government.

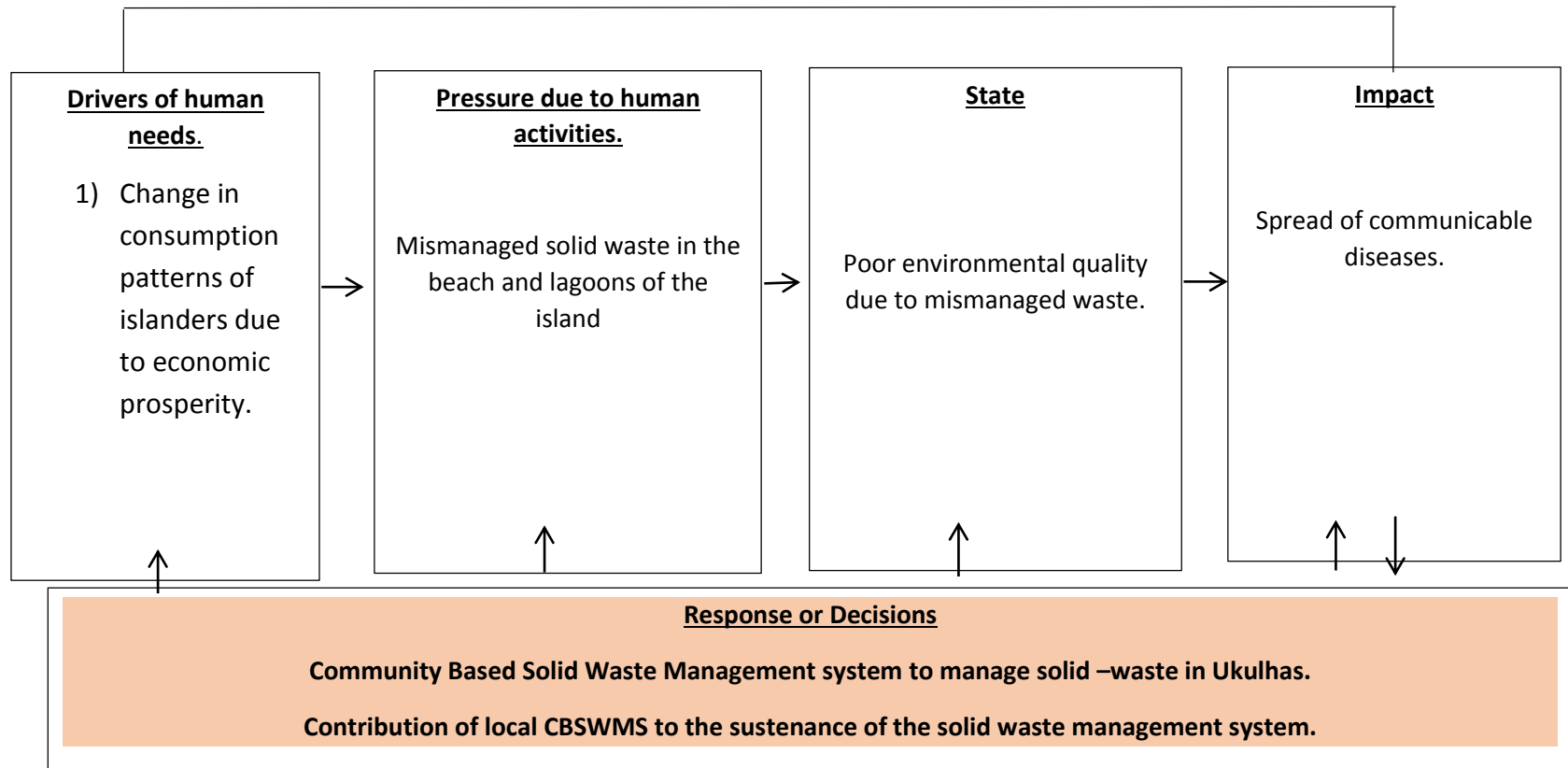
However, DPSIR framework also comes with some limitations. Some of the limitation explained by (Skondras & Karavitis, 2015) and (Atkins, Burdon & Elliot, 2011 and Carr et al., 2007) were the framework's inability to suggest non

linear relationships, inability to take into account natural drivers of environmental changes such as climate change, volcanic eruptions, natural disasters such as flood and storms, and failure to explain new developments or trending progresses except by recapitulating the study of the identical indicators at consistent intervals. DPSIR framework cannot fully describe the inherent complexity and uncertainties that lies beneath the causal relationships between Drivers, Pressure, State, Impact and Responses that makes the framework. (Kristensen, 2004).

Despite these limitations, DPSIR framework still manages to capture key relations between issues in the society and the environment in a simplistic framework that is easy to understand by everyone, and because of this reason, DPSIR framework was chosen as the Theoretical framework for this research. In order to conceptualize the case of solid waste management system in Ukulhas, the situation was assessed by identifying elements that can be fit into DPSIR framework and based on DPSIR framework, a new conceptual framework was developed to understand the causal relationship that exist between Ukulhas waste management system and Ukulhas community. The conceptual framework shown in figure 8 was developed by first identifying circumstances in the island, prior to establishment of waste management system and grouping them into the elements such as pressure, state, impact and responses. Because of its simplicity and its ability to take into account the social economic and environmental factors, DPSIR framework was found to be a useful system assessment tool to analyze environmental situation in Ukulhas.

DPSIR allows researchers the flexibility to categorize situations into their underlying causes, impacts and responses in a simplistic outline. In the case of

Ukulhas, as shown by figure 8, the main driver of waste generation was the change in the consumption patterns of the island community due to economic development in the island. In the absence of a proper waste management system and due to lack of awareness, most of the islanders throw their waste to the beach or the lagoon of the island. The result of this mismanaged waste was coastal and marine pollution. As situations of coastal and marine pollution got sever, the resulting impact was environmental degradation and spread of diseases such as dengue fever among the local community. In reaction to this state of poor health and environment quality in the island, the response by the island council was the establishment of CBSWMS as shown by figure 8.



*Figure 8 shows the conceptual framework developed from DPSIR framework.*

# CHAPTER 3

## METHODOLOGY

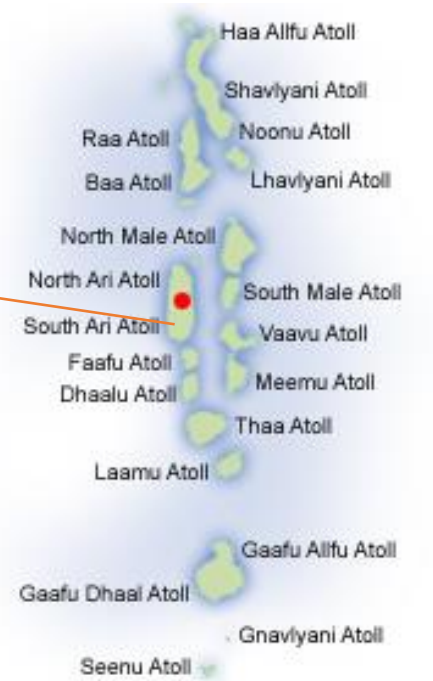
### 3.1 Introduction

This chapter details out the research methodology adopted for the present study. The chapter begins by explaining the study site with demographic information about the community under investigation. Next the chapter will look at the main objectives and the research questions of the study. Descriptive statistics will be presented in this section to define respondents demographic and socio economic status. Next, instrument design, data collection and data analysis will be presented followed by limitations.

### 3.2 Study site



*Ariel view of Ukulus. Source: Google Image.*



Alif Alif Ukulhas is an island located approximately 44 miles from the capital city Male'. Total population of the island is 1005 with 534 males and 471 females. (National Bureau of Statistics, 2014). Ukulhas is famous for good waste management practices and is considered

as the first island in the Maldives systematically to manage their waste. (UNDP, 2012). Today every household in the island is required to separate waste into three major groups, recyclable items, kitchen waste and leaf litter. Except for Friday, waste from each household is collected by the island council for a fee of MVR 100. Currently three methods are used for waste disposal. They are recycling, pyrolysis and composting. Recyclable items such as Aluminium cans, copper wires, steel and old furniture, glass bottles and PET bottles are sold every six months. Organic wastes such as kitchen wastes are decomposed to make compost which is sold to farmers in the island and nearby islands. Pyrolysis is carried in decomposition chambers established in the waste management facility where plant materials, cardboards and used papers are burned. Figure 3.1 shows a schematic representation of CBSWMS practiced in Ukulhas.

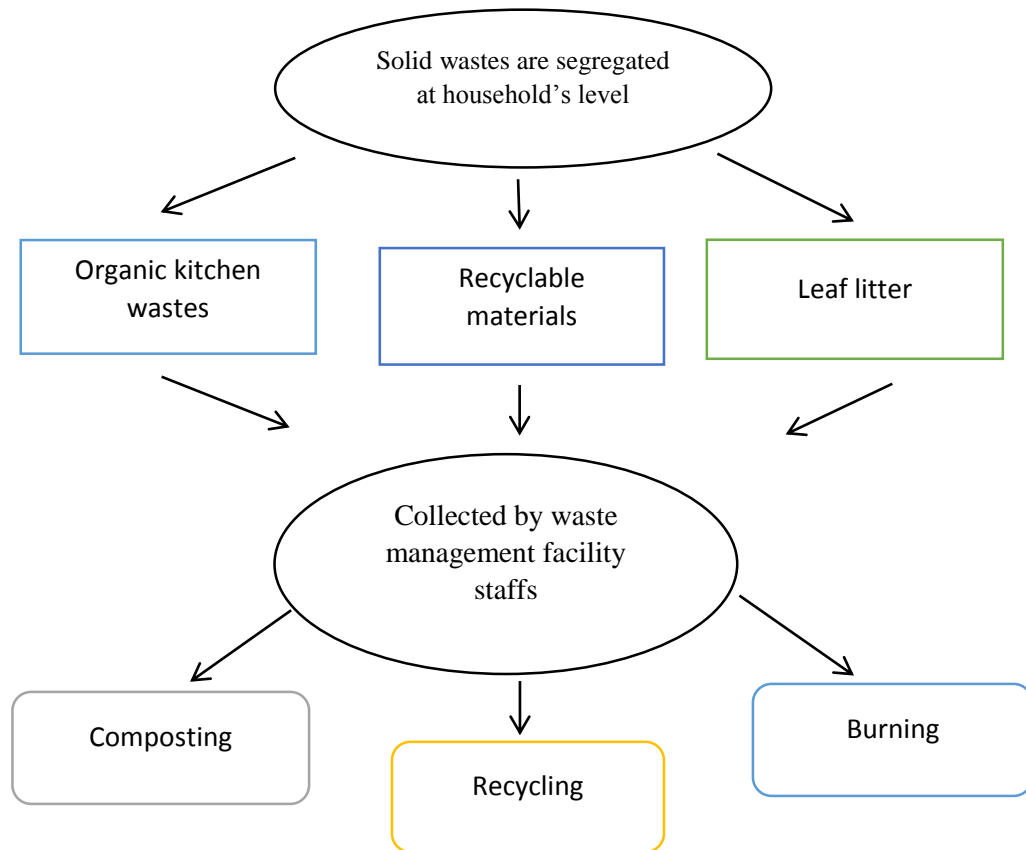
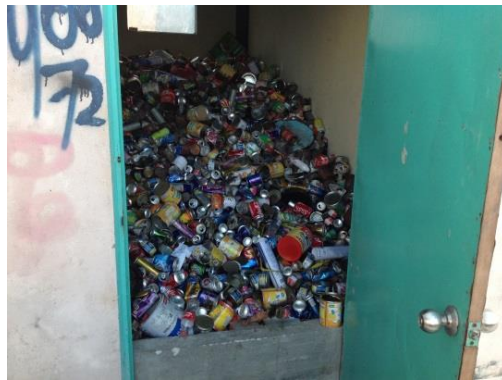


Figure 3.1 shows a schematic representation of CBSWMS practiced in Ukulus.



*Figure 3.2: household waste collected by waste management facility staffs.*



*Figure 3.3: Recyclables wastes such as aluminum cans collected for selling.*



*Figure 3.4: organic wastes decaying to form compost.*

### 3.5 Research methodology

For this study a quantitative approach was adopted to test the assumption effectiveness of Ukulhas waste management system. The operational definition used to define effectiveness was as follows.

*“A cost-effective system that has the capacity to minimize more than 50% of solid waste generated at island level, while at the same time providing economic, social and environmental benefits to the community without any social exclusion”.*

The operational definition “effectiveness” was categorized into three main groups. They were “rate of waste reduction”, “economic, social and environmental benefits” and “social inclusiveness of the community”. In this context, the rate of waste reduction was quantified by calculating how much organic solid waste generated in the island was utilized for composting. Economic benefits were measured by investigating if there was any demand for compost made by the waste management Centre. Social and environmental benefits were measured by comparing the number of dengue and diarrhea cases before and after implementation of the waste management Centre. Social inclusivity and equity was measured by investigating community satisfaction towards the waste management Centre and their willingness to contribute to the sustenance of the waste management Centre.

Based on the operational definition of effectiveness, a quantitative approach was selected because it was believed a quantitative approach provides the best approach to represent the waste management system using statistical analysis methods. Statistical analysis methods provide the opportunity for the researcher to generalize

the findings of the research to the whole community. Generalization is important for this study because the waste management system under study was a community based system, therefore an approach that represent the whole community's views, has to be taken into account as the nature of the research involve the attitude and perception of the whole community.

### 3.6 Sampling

The purpose of the cross –sectional social survey was to find answers to research questions about the relationship between community satisfaction level and their willingness to pay for the sustenance of the CBSWMS, community satisfaction level with the waste management system across different age groups and degree of association between community attitudes towards plastic and their willingness to use recyclable shopping bags. Random sampling was applied to carry out social survey. Random sampling was chosen for this study because it was the best sampling method to obtain a representative sample from Ukulhas community. Even though random sampling does not guarantee 100 % accuracy, in random sampling there is a higher probability of representing all the individuals in the community.

The total population registered for waste management service was 137 household. The sample size for sampling was calculated using Rao soft sample size calculator. The calculated sample size was 102 household, with 5% margin error, at 95% confidence level. To ensure randomness during data collection, a list of registered households for waste collection service was obtained from island council. In the list each household was numbered from 1 to 137. Out of 137 household, 102 households were randomly selected for the social survey using a random number generator

available from internet. From each household, the person in charge of handling waste was questioned during the survey.

### 3.7 Socio economic characteristics of respondents who participated in the social survey.

*Table 3.7*

*Age and Gender.*

		Gender	
		male	female
		Count	Count
Age	18-24	1	9
	25-35	2	36
	35-44	3	31
	45-54	1	14
	55+	0	5

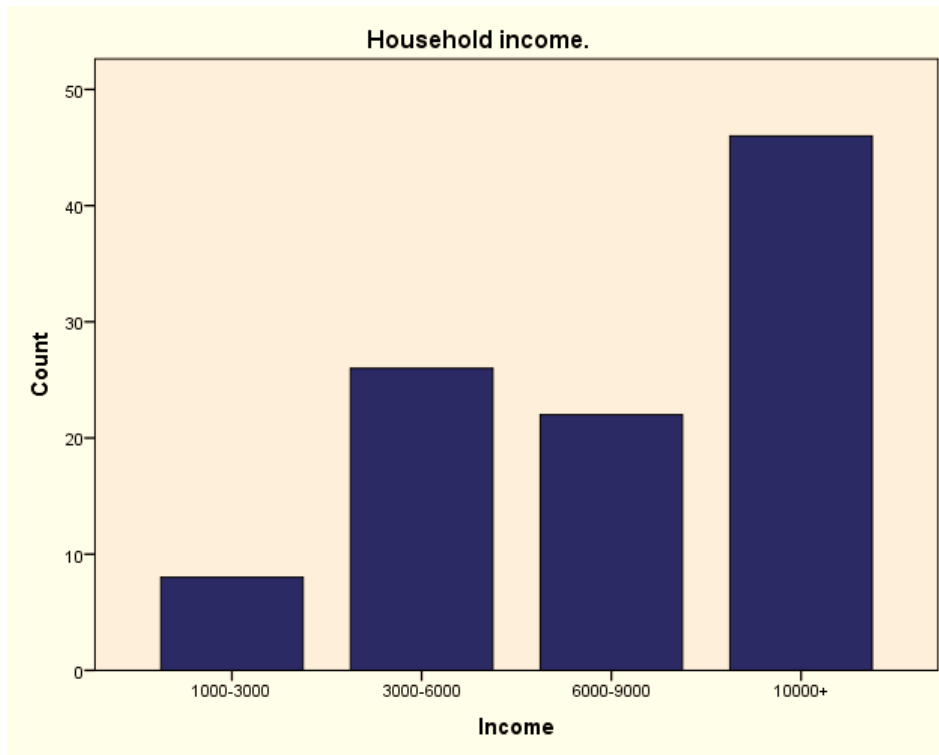
Table 3.7 shows the respondents gender and age group. In the age category 18 to 24 there were only 1 male and 9 female in charge of handling waste at home. Age group 25 to 35 only 2 males' handled household waste while 36 women handled waste at household level. Age group 35 to 44 there were 3 males and 31 females who handled waste at household level. Age group 45 to 54 only 1 male handled waste at household level while 14 females handled waste at household level. Age group 55 and above, only 5 females handled waste at household level.

Table 3.8

*Respondents Education level.*

		Age				
		18-24	25-35	35-44	45-54	55+
		Count	Count	Count	Count	Count
Edu level	Basic literacy level	0	2	15	14	5
	Primary education	1	12	14	0	0
	Secondary education	6	16	4	0	0
	A'level	2	0	0	0	0
	Diploma	0	6	0	1	0
	Degree	1	2	0	0	0
	Masters	0	0	1	0	0
	Phd	0	0	0	0	0

Table 3.8 shows respondent's education level across different age groups. In the age group 18 to 24, there were only 1 respondent with primary education level, 6 respondents have secondary education level, while two respondents have advanced level education and only 1 respondents have degree level qualification. Age group 25 to 35, there were 2 respondents with basic literacy level, while 12 respondents had primary education, 16 respondents had secondary education, and 6 respondents had diploma level qualification, while only two respondents had degree level qualification. Age group 35 to 44, there were 15 respondents with basic literacy level, 14 respondents with primary education, 4 respondents with secondary education and only 1 respondents with master's level education. Age group 45 to 54, 14 respondents had basic literacy level qualification, whole only 1 respondent had diploma level qualification. Age group 55 and above 5 respondents had basic literacy level qualification. There were no other qualification in this category.



*Figure 3.9: Household income levels.*

Figure 3.52 shows that 45% of the households surveyed received an income above MVR 10,000 per month; while 21% of household's receive an income between of MVR 6000 to 9000, 25% of the households receive an income of MVR between 3000-6000. Only 7% of the households receive an income between MVR 1000-3000.

### 3.10 Respondent's opinion about taking a fee for waste collection service.

From each household a fee of MVR 100 is taken by the island council for waste collection service. This service is provided for every day for registered households.

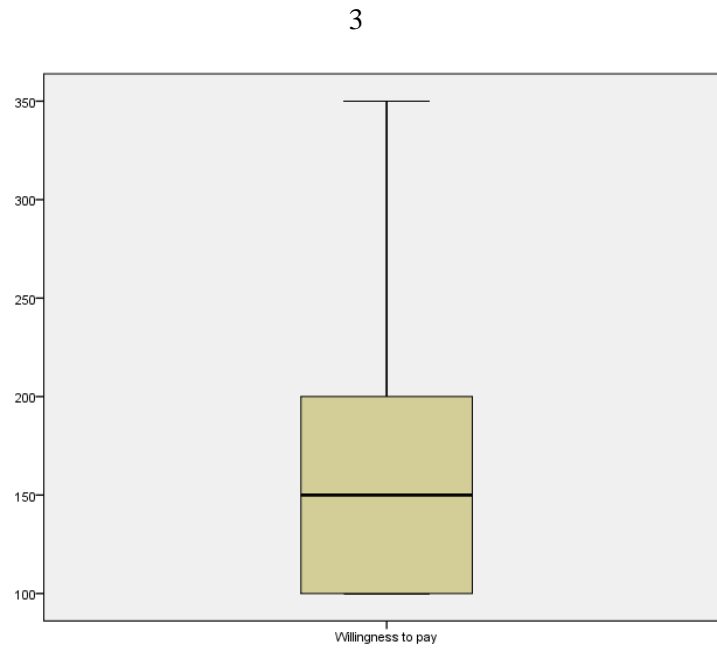
*Table 3.10*

*Respondent's opinion about charging a fee for waste collection service provided by the island council.*

		<b>Opinion about fee</b>			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	1	1.0	1.0	1.0
	disagree	2	2.0	2.0	2.9
	agree	34	33.3	33.3	36.3
	strongly agree	65	63.7	63.7	100.0
	Total	102	100.0	100.0	

Table 3.10 shows 97% of people agreed that a fee must be taken for waste collection services provided by the island council. Only 3% of people disagreed to take a fee for waste collection services.

### 3.11 Respondent's willingness to pay a fee for waste collection service.



*Figure 3.11: boxplot representing amount of money willing to pay for the waste collecting service by the respondents.*

figure 3.11 shows how much respondents were willing to pay for waste collection service provided by island council. Respondent's willingness to pay falls between MVR 100 to 200, with majority preferring to pay a value of MVR 150.

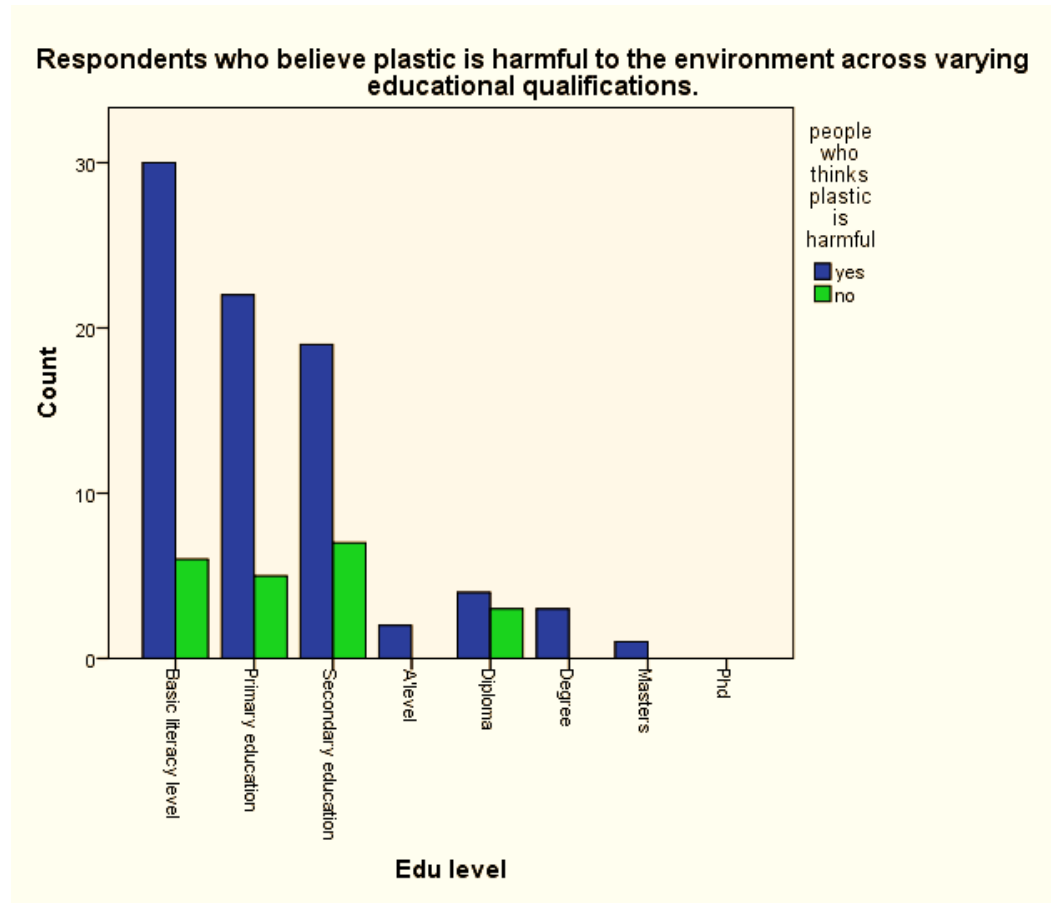


Figure 3.12: Respondent's belief about plastic across varying educational qualifications.

figure3. 12 shows respondents who believe that plastic is harmful to the environment is more across various educational qualifications. From the respondents who had basic literacy education level, 30 respondents believe that plastic is harmful, while, 6 respondents believe that plastic is not harmful. From the respondents who had primary educational level, 22 believe respondents believe that plastic is harmful, while 5 respondents believe that plastic is not harmful. From secondary education qualification, 19 said respondent believe that plastic is harmful to the environment while, 7 respondents believe that plastic is not harmful to the environment. Two respondent had A' level qualification and they all believe that plastic is harmful to the environment, while respondents with diploma, 4 believe that plastic is harmful to the environment, while 3 respondent believe that plastic is not harmful to the environment.

Respondent with degree and master’s qualification all believe that plastic is harmful to the environment.

### 3.13 Respondent’s attitude towards plastic and their willingness to use own recyclable shopping bag.

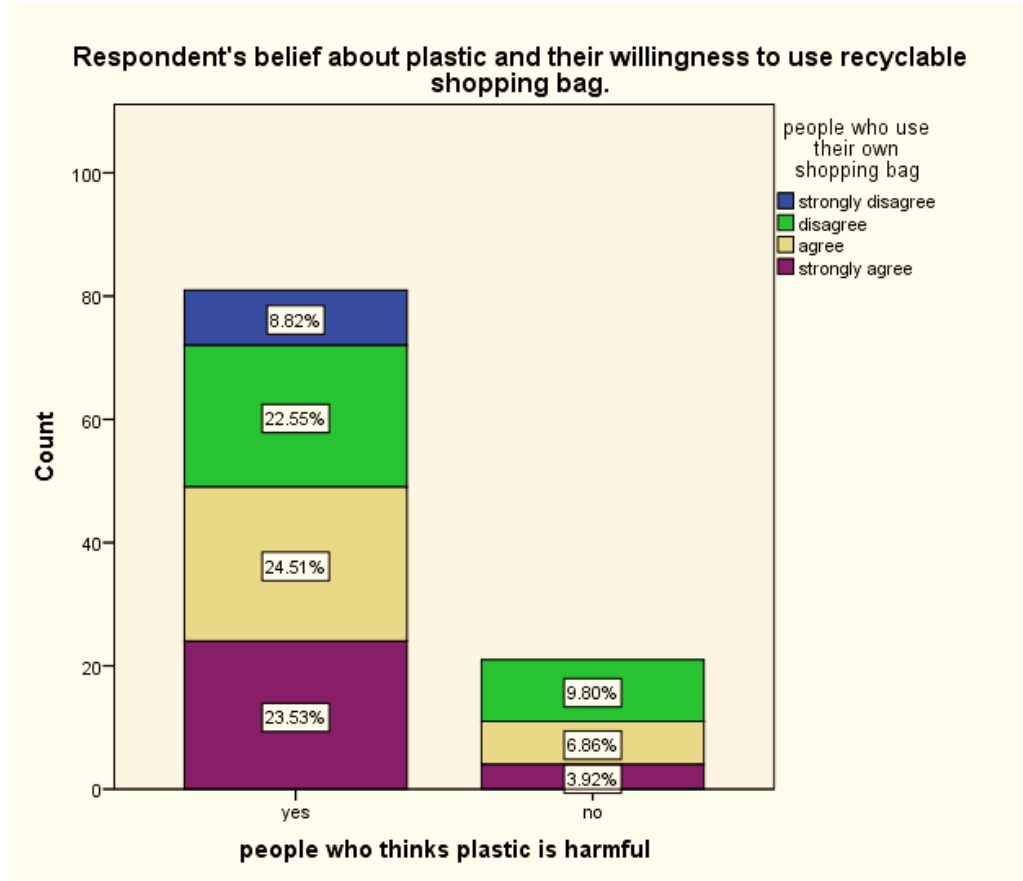


Figure 3.13: Respondents who believe plastic is harmful and their willingness to use their own recyclable shopping bag.

figure 3.13 shows that 79.4% of respondents believe that plastic is harmful to the environment, however, from this 79.4%, of respondents, 48.08% of people are willing to use their own recyclable shopping bag, while 31.37% of people disagree to use their own recyclable shopping bag. On the other hand 20.6% of respondents believe that plastic is

harmful to the environment, but out of this 20.6% respondents, 3.92% of respondents were willing to use their own recyclable shopping bag.

### 3.14 Instrumentation.

The survey instrument was a close ended questionnaire. This particular instrument was chosen for the study because it was easy and efficient tool for data collection. The questions were formulated based on the research objectives and hypothesis. A cover letter was attached with the questionnaire explaining the nature, objectives of the research and to seek consent from respondents to take part in the research. The questionnaire was designed to collect respondent's demographic, socio economic characteristics, their willingness to pay and their satisfaction level towards the waste management system, and to find their attitude towards composting. Question 1 to 7 addressed respondent's demographic information and their socio- economic characteristics. Questions 8 to 10 addressed how much respondents pay for the service and how much they were willing to pay in future. Questions 11 to 21 was related to find out respondent's attitude towards plastic and their willingness to use recyclable shopping bag. Question 22 to 23 asks about respondent's perception and their sense of belonging around waste management system. And question 24 to 26 address community attitude towards buying compost. Appendix one shows the sample questionnaire developed for data collection.

### 3.14 Measurement procedures.

Nominal, ordinal, and Interval measurement was used in the questionnaire. To measure respondent's age, dichotomous scale consisting of a simple "yes" or "no" was used. To measure community satisfaction level numerical scale was given in which the respondents has to rate their satisfaction level from 1 to 5, where 5 being the strongest. Respondent's

willingness to pay was measured using multiple choice single response scale. Respondents attitude towards plastic was measured using dichotomous scale with a simple “yes” or “no”. Respondent’s willingness to use recyclable bag was measured using Likert scale. And finally to study the demand for the compost, a dichotomous scale was used.

### 3.16 Data collection methods.

Data collection was carried out in three separate methods. The first method involved data collection using survey method. Survey was carried from Nov 26<sup>th</sup> 2015 to Nov 29<sup>th</sup> 2015. For the social survey, 6 enumerators were trained. The enumerators’ were advised to administer questionnaire only to the person who handled waste from each household.

The second method was obtaining secondary data from island health Centre and island council. Letters were sent to the health Centre requesting to give information about number of dengue and diarrhea cases since 2011 to 2015 December. Similarly letters were sent to the island council requesting to give information about how much income the council receive from selling compost.

Third method was using mathematical calculation to calculate the rate of organic waste utilization by the waste management Centre. For this calculation, total amount of kitchen waste and organic waste brought to the waste management Centre was recorded for a seven day period as shown by table 3.11

Table 3.11

Organic waste produced in one week

day	kitchen waste in kg	leaf litter in kg	total Kg.
1			
2			
3			
4			
5			
6			
7			
<b>Total in kg</b>			

### 3.17 Data analysis

Data analysis for the social was carried out using SPSS. The statistical analysis consists of descriptive statistics, and non-parametric tests. To find out if there was any association between community satisfaction level and their willingness to pay, non-parametric test Spearman's rank order correlation was run on SPSS to determine the relationship. To find if there was any association between respondents who think plastic is harmful to the environment and their willingness to use recyclable shopping bag across varying educational level; Chi-square test was run on SPSS. To determine respondent's satisfaction level around waste management system across different age groups Kruskal-Wallis test was run on SPSS.

To calculate rate of organic waste utilization rate, the following formula was used.

$$R = X/Y * 100$$

Where:

R= Organic waste utilization rate for one week

X = Organic waste utilized for composting in one week

Y= Total organic waste generated within one week

### 3.18 Limitations.

Cross sectional survey was carried out to collect information about community members. Therefore results of the research will be valid for the time frame in which survey was carried out. The questions on the questionnaire were close ended questions therefore some of the crucial information about waste management system might be missed. To measure rate of organic waste utilization rate, data was collected only for a 7 day period. There might be weeks where the total weight of organic waste might be different due to difference in waste generation rate within that week.

# CHAPTER 4

## DATA ANALYSIS

### 4.1 Introduction

This chapter explains findings of the research study. The chapter is divided into two sections, section A and section B. Section A will look into waste management system's ability to reduce organic kitchen waste produced from households. Section B will look at empirical findings of the research questions.

### SECTION A

#### 4.2 Waste reduction rate.

Every household in Ukulhas registered for the waste management service is expected to segregate waste at household level. As a result, households keep organic wastes separate from other types of waste. Every day the council pickup will carry the organic waste from households to the waste management Centre. On average about 548kg of organic waste is transported to the waste management Centre. Table 4.1 shows that for one week period, a total of 3834 kg of organic waste was generated in Ukulhas. From this organic waste, 2737 kg wastes were generated from households as kitchen waste, while 1097 kg of leaf litter was collected as green waste for the same duration.

Table 4.1

Organic waste produced in one week

day	kitchen waste in kg	leaf litter in kg	total Kg.
1	425	212	637
2	372	180	552
3	390	175	565
4	410	195	605
5	340	160	500
6	380	175	555
7	420	0	420
<b>Total in kg</b>	<b>2737</b>	<b>1097</b>	<b>3834</b>

According to island council, to make one pile of windrow compost, 380 kg of kitchen waste is added to 1140 kg of leaf litter to make a pile of 1520 kg of organic waste. On average, the waste management centre utilizes 3040 kg of organic waste for composting. To answer the first research question “How much organic waste generated within one week is utilized by Ukulhas waste management centre? Following equation was used.

$$R=X/Y*100$$

Where:

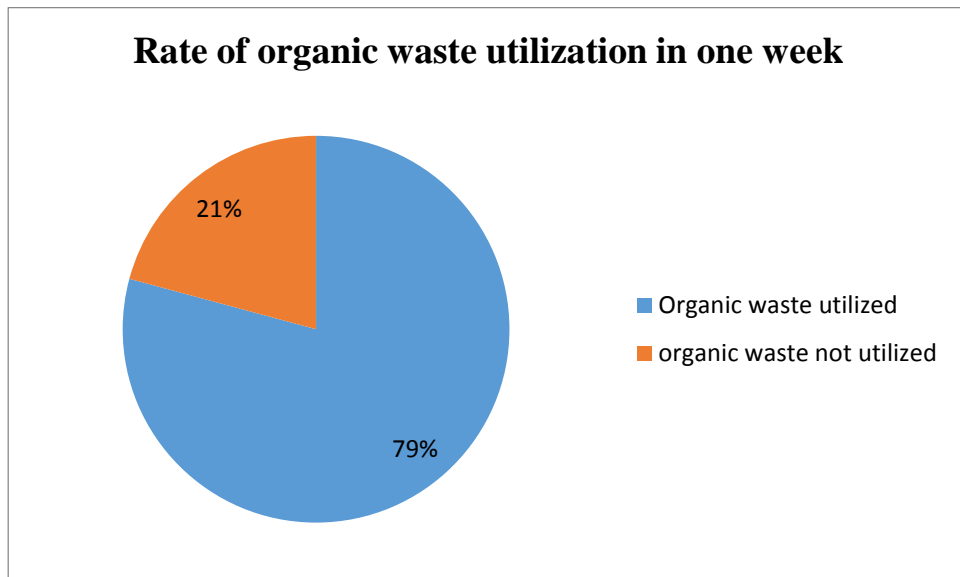
R= Organic waste utilization rate for one week

X = Organic waste utilized for composting in one week

Y= Total organic waste generated within one week

$$R = X/Y * 100$$
$$R = 3040/3834 * 100$$
$$= 79.2\%$$

The result shows 79%. Of organic waste brought to the waste management center is utilized by waste management Centre every week to make compost.



*Figure 4.2: Rate of organic waste utilized to make compost in one week.*

Figure 4.2 shows that while 79% of organic waste brought to the waste management Centre is utilized for composting, only 21% of organic waste is left unutilized.

#### 4.3 Monthly income from composting.

*Table 4.3*

*Monthly income generated by composting.*

Details	Quantity in tons	Monthly average	Amount in MVR
<b>Compost sold to locals who practiced home gardening and farmers from nearby islands.</b>	1	10000kg	5000
<b>Compost sold to resort.</b>	2	2000kg	10,000
<b>Total</b>	3	3000kg	15,000

Table 4.3 shows Ukulhas island council receives a monthly income of MVR 15000 by selling compost to local farmers and resorts. 1000 kg of compost was sold to local farmers while 2000kg of compost was sold to resort. From the income earn by the island council, it can be said there was a demand for compost made by Ukulhas waste management facility by local gardeners and resorts. Table 4.3 shows that 49% of respondents practiced home gardening while 51% of respondents do not practice home gardening. From the 49% of respondents who practice home gardening 48% do not use compost or fertilizers on their plants. While 39% of people use compost, only 14% of people use imported fertilizers in their home gardens.

Table 4.4:

Respondents who practiced home gardening.

**Home gardening or farming practices**

	Frequency	Percent	Valid Percent	Cumulative Percent
home gardening	50	49.0	49.0	49.0
Valid neither	52	51.0	51.0	100.0
Total	102	100.0	100.0	

Table 4.3 shows 49% of people in Ukulhas practice home gardening, while, 51% of people in Ukulhas do not practice home gardening or any farming activities

Table 4.5:

Respondents who buy compost from waste management Centre.

**People who buy compost**

	Frequency	Percent	Valid Percent	Cumulative Percent
do not buy compost or fertilizers	49	48.0	48.0	48.0
Valid compost	39	38.2	38.2	86.3
imported fertilizers	14	13.7	13.7	100.0
Total	102	100.0	100.0	

Table 4.5 shows from the people who practice home gardening 38.2 % of people buy compost from the waste management center, while 48% of people do not buy compost or any fertilizers from the island. Only 13.7% of home gardeners use imported fertilizers.

Table 4.6

*Respondent's motives for buying compost.*

Motives for buying compost	% Frequency
Cheaper	8
Gives a better yield	58
Safer to health	29
Easily available	5
Total	100

Table 4.6 shows that the main motive for buying compost was because it gives a better yield. 58% of people buy compost because it gives better yield. 29% of people said they buy compost because it was safer to health and 8% of people said they buy compost because it was cheaper. Only 5% of people said they buy compost because it was easily available.

#### 4.7 Spread of dengue and diarrhoea cases before and after implementing waste management facility.

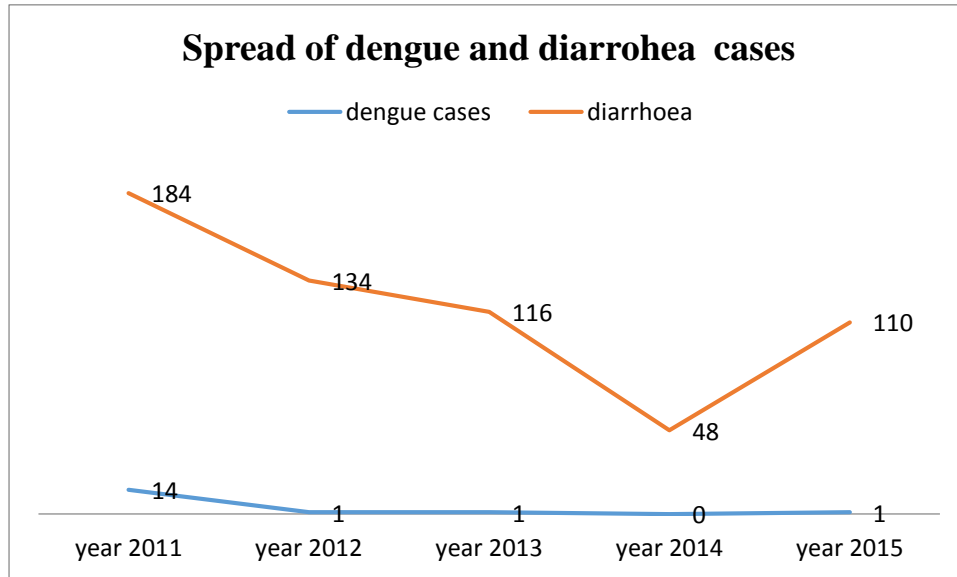


Figure 4.7: Spread of dengue fever and diarrhoea. (Source: Uklulhas health centre)

Figure 4.7 shows before waste management system was implemented, in 2011, there were 14 cases of dengue fever and 184 cases of diarrhoea. In 2012, there was only one case of dengue fever but 134 cases of diarrhoea. The total cases of dengue in 2011 and 2012 were 15, while total cases of diarrhoea within this period were 318. The number of cases of dengue fever after waste management system implementation in 2013 was one, in 2014 no dengue cases were reported and in 2015 one case was again reported. For diarrhoea cases within this period, 116 cases were reported in 2013, 48 cases were reported in 2014 and 110 cases were reported in 2015. When the total cases of dengue and diarrhoea were compared before and after implementing waste management system it can be seen that, before implementation of waste management system from 2011 and 2012, there were 15 cases of dengue and 318 cases of diarrhoea, while after waste management system implementation from 2013 to 2015, there was a decrease in spread of dengue fever from 15 cases to 2 cases, while Diarrhoea cases

dropped from 318 to 274. The data suggests, there was a decrease in the spread of Dengue and Diarrhoea cases since 2012.

## **SECTION B**

4.8 Association between respondent's satisfaction level and their willingness to pay a fee for waste collection service.

Research question to be answered:

Is there an association between community satisfaction level and their willingness to pay for the sustenance of the CBSWMS?

**The hypothesis for this research question is:**

**Hypothesis:** There is relationship between community satisfaction level and their willingness to pay for the sustenance of waste management system.

**Null Hypothesis:** There is no relationship between community satisfaction level and their willingness to pay for the sustenance of waste management system.

**Independent variable:** satisfaction level.

**Dependent variable:** willingness to pay.

Graph 4.81 and table 4.82 shows the results of the normality test for the variable “respondents willingness to pay” for Waste collection service.

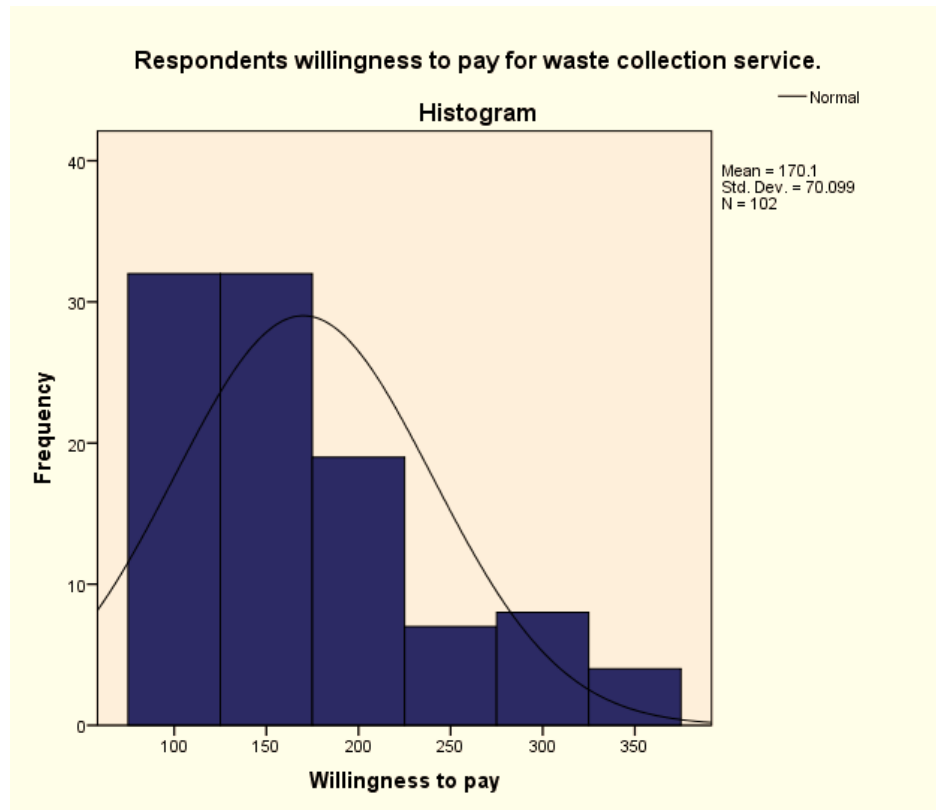


Figure 4.81: Histogram showing distribution of values respondents' willingness to pay for waste collection service.

The values range from 100 to 350, with a mean value of 170 with a standard deviation of 70.09 for 102 cases. The graph is positively skewed with majority of the scores leaning to left of the histogram. The Shapiro-Wilk assesses the normality of the distribution of the values. Shapiro-Wilk results show a significant value of 0.00, which is less than 0.05. Therefore the values are not normally distributed.

Table 4.82

Normality test result table for respondent's willingness to pay.

	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Willingness to pay	.240	102	.000	.846	102	.000

a. Lilliefors Significance Correction

#### 4.83 Respondent's satisfaction level with Community Based Solid Waste Management System implemented in Ukulhas

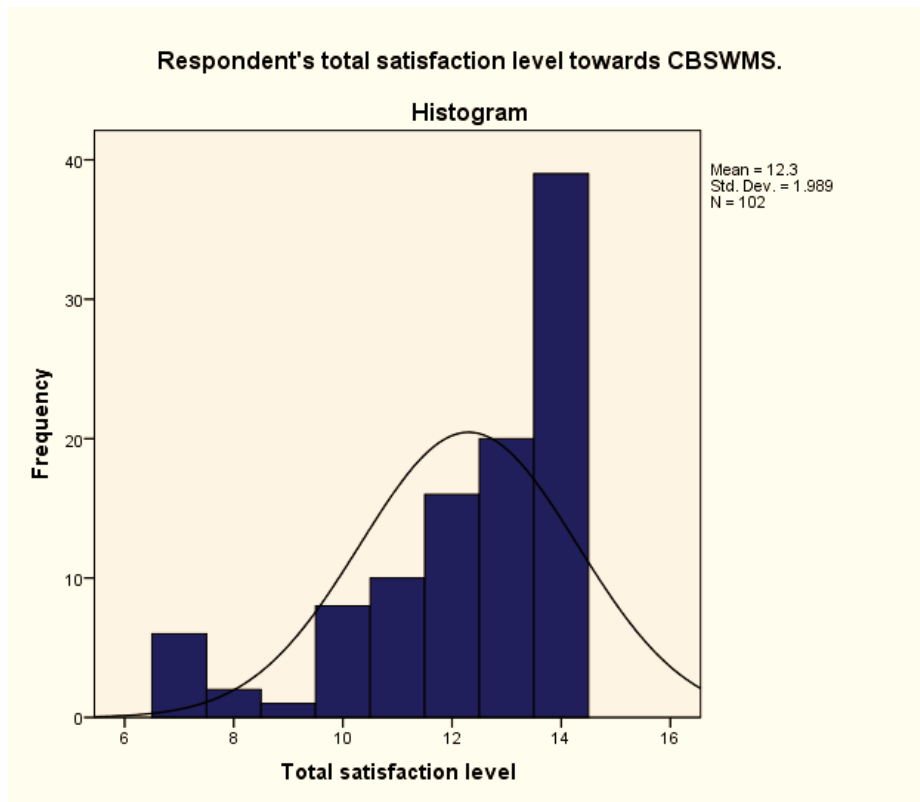


Figure 4.83 Respondents satisfaction level towards waste management system.

According to graph 4.83 Satisfaction score ranges between 7 and 14. Within this range, 39 respondents (38.2%) gave a score of 14, while 20 people out of 102 respondents, (19.6%) gave a score of 13. Most scores lies between 14 and 10. Only 6 respondents (5.9%) gave the lowest score of 7 to the CBSWMS. The mean score was 12.3 with a standard deviation of 1.98. The distribution of scores is skewed to the right with a peaked distribution of scores. To answer the research question “Is there a relationship between satisfaction level and willingness to pay’ a scatterplot was run in SPSS. The resulting graph was shown in graph 4.84.



Figure 4.84: Relationship between respondent’s satisfaction level and their willingness to pay for waste collection service provided by the island council.

From the eyeball judgment on graph 4.84, there seems to be no relationship between respondent’s satisfaction level and their willingness to pay for waste collection services.

Table 4.85

Association between respondent's satisfaction level and their willingness to pay.

		Willingness to pay	Total satisfaction level
Spearman's rho	Correlation Coefficient	1.000	.165
	Willingness to pay Sig. (2-tailed)	.	.098
	N	102	102
	Correlation Coefficient	.165	1.000
	Total satisfaction level Sig. (2-tailed)	.098	.
	N	102	102

A Spearman's rank-order correlation was run to determine the relationship between 102 respondents satisfaction level and their willingness to pay for waste collection service. The results show that Spearman's correlation coefficient is 0.165, since the significance value is above 0.05, there no association between respondent's satisfaction level and their willingness to pay more for waste collection service Therefore the null hypothesis is accepted and alternative hypothesis is rejected.

#### 4.9 Respondent's satisfaction level with waste management system across different age groups.

To answer the research question: "Is there a difference in satisfaction level around waste management system across different age groups?" A kruskal-Wallis test was run in SPSS.

**Hypothesis:** There is a difference in satisfaction level around waste management system across different age groups.

**Null hypothesis:** There is no difference in satisfaction level around waste management system across different age groups.

**Independent variable:** Age

**Dependent variable:** Satisfaction level.

*Table: 4.91*

*Rank score of between different age groups.*

<b>Ranks</b>			
	Age	N	Mean Rank
Total satisfaction level	18-24	10	32.80
	25-35	38	53.24
	35-44	34	55.75
	45-54	15	42.60
	55+	5	73.50
	Total	102	

Table 4.92

Kruskal Wallis Test result table.

Test Statistics<sup>a,b</sup>

	Total satisfaction level
Chi-Square	9.609
df	4
Asymp. Sig.	.048

a. Kruskal Wallis Test

b. Grouping Variable: Age

Table 4.92 shows there is a difference with the satisfaction level with waste management system across different age groups. Inspection of the mean ranks as shown in table 4.91 for the age groups suggests that the age group 35 to 44 had the highest rank scores for satisfaction, while the younger group between ages 18 to 24 had the lowest scores. The p value shown in table 5.2 was 0.04, which was less than 0.05. Since p value was lower than 0.05, the null hypothesis was rejected and the alternative hypothesis was accepted. Therefore it can be concluded there was a significant difference in satisfaction level across different age groups.

4.10 Respondent’s attitude towards plastic and their willingness to use recyclable shopping bag.

To answer researches question “Is there an association between people who think plastic is harmful and their willingness to use recyclable shopping bag?” a Chi-Square test was performed on SPSS.

**Hypothesis:** There is an association between people who think plastic is harmful and their willingness to use recyclable shopping bag.

**Null hypothesis:** There is no association between people who think plastic is harmful and their willingness to use recyclable shopping bag.

**Independent variable:** people who think plastic is harmful.

**Dependent variable:** willingness to use recyclable shopping bag.

Table 4.10

*Cross tabulation between respondents who think plastic is harmful and respondent’s willingness to use recyclable shopping bag.*

		people who use their own shopping bag		Total
		disagree	agree	
people who thinks plastic is harmful	no	10	11	21
	yes	31	50	81
Total		41	61	102

Table 4.10 shows that 81 respondents think plastic is harmful to the environment, 21 respondent think plastic is not harmful to the environment. From the 81 respondents who think plastic is harmful to the environment, 50 respondents were willing to use recyclable shopping bag while 31 respondents were not willing to use recyclable shopping bag. On the other hand, from the 21 respondents who thought plastic is not harmful to the environment, 11 respondents were willing to use recyclable shopping bag, while 10 respondents were not willing to use recyclable bags.

*Table 4.11*

*Result of Chi-square test to see if there was any significant association between respondents who think plastic is harmful and their willingness to use recyclable bag*

**Chi-Square Tests**

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.606 <sup>a</sup>	1	.436		
Continuity Correction <sup>b</sup>	.280	1	.597		
Likelihood Ratio	.599	1	.439		
Fisher's Exact Test				.463	.296
Linear-by-Linear Association	.600	1	.439		
N of Valid Cases	102				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.44.

b. Computed only for a 2x2 table

Pearson Chi-Square value shown in table 4.11 is 0.6, which is more than 0.05. Therefore, the null hypothesis is accepted and the alternative hypothesis is rejected. There is no association between respondents who think plastic is harmful and their willingness to use recyclable shopping bag.

Table 4.12

Shows respondent' sense of belonging.

**Sense of belonging to CBSWMS**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid yes	96	94.1	94.1	94.1
no	6	5.9	5.9	100.0
Total	102	100.0	100.0	

According to table 4.3, 94.1% of people felt they belong to the waste management system while only 5.9 % of people said they do not feel they belong to the waste management system.

Table 4.13.

Aspects of the waste management that needs improvement.

**Aspects of CBSWMS that needs improvement**

	Frequency	Percent	Valid Percent	Cumulative Percent
No need for improvement	18	17.6	17.6	17.6
waste collection service	36	35.3	35.3	52.9
composting	3	2.9	2.9	55.9
Valid selling of compost	6	5.9	5.9	61.8
selling mechanism of used iron & aluminium	2	2.0	2.0	63.7
open burning	14	13.7	13.7	77.5
community awareness sessions	23	22.5	22.5	100.0
Total	102	100.0	100.0	

Table 4.13 shows aspects of CBSWMS that needs improvement. 35.3% said improvement is needed in waste collection service, 13.7% improvement is needed in the way waste was burned and 22.5% of people said improvement is needed in the way council conducts awareness sessions. 17.6 % of people felt the current waste management system does not need any improvement,

## CHAPTER 5

### DISCUSSION AND CONCLUSION

#### 5.1 Summary of Main Findings from Chapter 4.

Analysis of results showed Ukulhas waste management Centre utilizes 79.2% of organic waste brought to the waste management Centre to make compost. Composting is a popular method used by many waste management Centers to recycle bulk of organic waste generated in residential neighbourhoods. By selling compost Ukulhas waste management Centre earns a monthly income of MVR15000. The consumers were Ukulhas locals who practiced home gardening and nearby resorts. Analysis to find out if there was any difference between spread of dengue and diarrhoea cases after implementation of waste management system showed, there was a drop in number of dengue and diarrhoea cases since 2012.

The inferential statistics showed a Spearman's rank order value of 0.165 indicating there was no association between respondent's satisfaction level and their willingness to pay for waste collection service. Kruskal Wallis test showed there was a significance difference in satisfaction level towards waste management system across different age groups, and Chi-Square test showed there was no association between respondent's attitude towards plastic and their willingness to use recyclable shopping bags.

## 5, 2 Discussion of Findings in relation to theory.

A large proportion of organic waste generated in the islands consists of kitchen waste and leaf litter. Unlike iron or aluminum that can be stored for a longer period of time, organic waste cannot be kept in storage because they get spoiled within one or two days. (Ministry of Tourism, 2015). Ari Atoll Solid waste management project was the first project that introduced the concept of composting in the Maldives. Composting is a low cost method used by many waste management Centers in the world to reduce organic waste generated in the community. One of the prime objectives of this research was to find out how much organic waste generated in Ukulhas was utilized by the waste management Centre for composting. For this study, organic waste brought to the waste management Center was weighed for 7 days. The analysis of the results showed 79.2% of organic waste conveyed to the waste management Centre was utilized to make compost every week, as more than 50% of organic waste brought to the waste management Centre was utilized to make compost, it can be said the system of windrow composting in Ukulhas was very efficient in removing majority of organic waste produced in the island

In Maldives, open burning and dumping of solid waste to coastal areas was a common practice. It was only very recently interest for recycling activities such as composting gained popularity. (Loedeman & Bardon, 2002) explains compost gives better results than chemical fertilizers due to its chemically balanced composition and its ability to retain moisture in the soil. Function of compost in the soil is quite different from the functions of chemical fertilizers or organic fertilizers. (Debertoldi, Vallini, & Pera, 1983) explains when fresh organic fertilizers were added to the soil, it results in change in the soil composition because of production of intermediate metabolites by microflora present in the soil. The main effect of compost is not about balancing the carbon, nitrogen and potassium concentration needed by the plants, but rather bringing a balance to the moisture content of the soil. According to

Loedeman & Bardon, (2002), compost is a suitable product for agricultural activities. When compost is added to the soil, compost stabilizes soil ecosystem by biological oxidative transformation similar to that occurs in the natural ecosystem. But on the other hand, Debertoldi, Vallini, & Pera, (1983) adds, if the organic matter such as cellulose, hemicellulose, and lignin present in the compost were not adequately humified, the incomplete humification of organic matter leads to production of toxic intermediate that may harm the plants. Therefore care must be taken to maintain the quality of the compost produced to ensure consumer satisfaction. (Debertoldi, Vallini, & Pera, 1983).

When looked at demand for compost, analysis of the results showed 49% of locals practiced home gardening and from this population of home gardeners 39% of people buy compost from waste management Centre. On the other hand only 14% of people use imported fertilizers in their home gardens while 48% of people do not use any compost or fertilizer on their plants. From these result it can be seen there are people who do not prefer compost over chemical fertilizers. Consumer preferences for composting can only be maintained if the quality of the compost is ensured, however at present composting for commercial markets is a new concept in the Maldives and since most of these projects are pilot projects, quality assurance of compost is not carried out in the Maldives. Yet, if the quality of compost can be ensured through science and research, waste management Centre will benefit by having the advantage of gaining trust of new clients in the future.

When looked at the motives behind why locals buy compost, the results showed 58% of people bought compost because it gives better yield. 29% of people bought compost because it was safer to health and 8% of people said they buy compost because it was cheaper. Only 5% of people bought compost because it was easily available. Compost has numerous advantages over chemical fertilizers, which might be one of the reasons why locals show interest to buy compost from Ukulhas waste management Centre. (Loedeman & Bardon,

2002) explains compost can improve soil texture and promote healthy growth of plants in dry soil. Compost also gives better harvest because of its ability to increase organic matter in the soil without destabilizing the soil. Secondary sources of information obtained from Ukulhas waste management Centre showed the Waste management Centre earns an income of MVR 15000 every month by selling compost. Market for compost in Ukulhas looks promising.

Ukulhas waste management Centre sells 3000 kg of compost every month to local home gardeners and nearby resorts. Result table 4.2 shows Uklulhas waste management Centre sell 2000kg of compost to resorts and 1000kg to locals. Table 4.2 also showed demand for compost from resorts was twice compared to demand from local people. Resorts market will be a good market to increase profit of the waste management Centre in the future. If the waste management Centre can sell more compost to resorts, they can increase their income considerably. For example if the waste management Centre sell 3000 kg of compost to resorts instead of the current 2000 kg amount, the extra 1000kg will increase the income from MVR 15000 to MVR 20,000 at MVR 5 rate. Even though additional production of compost looks profitable to the waste management Center, supplementary composting is hindered due to limited space in the island. Figure 5.1 shows there was hardly any space left in the island to develop additional infrastructure.



Figure 5.1: Map of Ukulhas. (Source Ukulhas island council.)

According to Figure 5.1, Ukulhas waste management Centre is located at the very end of the island. Due to infrastructure surrounding the waste management Centre, there is hardly any room for future expansion of the waste management Centre. The only possibility of expansion is from the beach side. But recently beach near waste management Center is experiencing severe erosion with the threat of inundation (Sumaish, 2014). Maldives is a country vulnerable to climate induced threats such as sea level rise, therefore expansion of waste management Centre towards the coast will be risky especially if the beach is eroding severely. (Hoad, 2015) explains SIDS like Maldives has been recognized by intergovernmental Panel on Climate Change (IPCC) as one of the most vulnerable countries to experience immediate impacts of extreme events such as extreme rain fall, drought, rising sea level, and increase in water and air temperature. Main climate induced risk for waste management facilities according to (Ministry of Tourism, 2015) appears to be flooding, storms and strong winds. Therefore establishing waste management Centre near the cost will be risky in the Maldives, especially if the island is affected by beach erosion. According to (Barnett & Adger, 2003) islands are vulnerable to coastal erosion because of exploitation of beaches for developmental activities such as infrastructure development. Almost every island in the Maldives is experiencing beach erosion. Land reclamation projects over the last few decades have increased the vulnerability of inhabited islands to erosion. Situation is made worse by poorly designed coastal infrastructure, removal of coastal vegetation and sand mining. (Ministry of Environment 2015).

Land is a scarcity in the Maldives, locating waste management Centre away from coastline will be challenging as the island communities will not like to have waste management Center near their place of residence also known as “not in our backyard” attitude. (Kadfak, 2011) in his study tries to answer the question why people are fine with dumping waste to abandoned land but not fine with keeping waste in their backyard. His explanation was the conception

of “dirt” in people’s mind and how they associate dirt with their daily life and self-identity. According to (Kadfak, 2011) purity and cleanliness are values that are appreciated in the society. Clean houses in a society is perceived as symbol of good health, respectable lifestyle, therefore societies associates cleanliness as part of their self-respect, in this sense, people do not want to keep waste in their homes or near their homes because people associate bad smell and unpleasant site of discarded waste as dirty and unhygienic and not reputable. The waste abandoned in a faraway land does not represent the individual lifestyle or self-respect, but becomes a collective problem, far removed from the personal perception of self- respect that was associated with waste while it was at one’s house. (Kadfak, 2011).

In small island states, where land is limited, “not in my backyard” attitude is a significant problem because in island like Ukulhas where there is hardly any space left for development of infrastructure, development of waste management Centre will be least of the concerns for the people as land is needed for other attractive development projects such as housing projects than solid waste management plans.

(Ministry of Environment, 2015) reports 42% of population and 47% of all housing are located within 100 meters of coastline. Infrastructure developed near the coast is very unsafe as Maldives is a low lying island less than 1 meter above the sea level. Appropriate land use plans that takes into account climate change induced hazards is urgently needed in every island of the Maldives. This urgency is reflected in the National waste management policy issued in 2015 by Ministry of Environment and Energy. According to this policy, planning and developing solid waste management systems is mandatory for island councilors. Islands that face severe erosion like Ukulhas, counsellors can look into soft engineering techniques such as beach nourishment that may prevent beach erosion and at the same time allow expansion of waste management Centre from the coastline. But infrastructure development near the coast is not a safe option as these structures near the coast will be susceptible to

inundation and flooding that might results from sea level rise from climate change. In addition, due to limited budget and lack of human resource in the Maldives, sophisticated coastal protection projects will be very expensive, unless island councils get support from external funding agencies. Therefore even though the market for composting looks promising, compost production in Ukulhas is hindered by land scarcity and beach erosion.

The second research question aims to find out if the spread of Dengue and Diarrhoea cases became less after implementation of waste management Centre in the island. Analysis of the result showed that before implementation of waste management system during 2011, there were 15 cases of dengue and 318 cases of diarrhea, however after implementation of waste management Centre in 2013, there was a decrease in spread of dengue fever from 15 cases to 2 cases. Diarrhea cases dropped from 318 to 274. One possible reason for the decrease in dengue and diarrhea cases might be because of regular awareness sessions conducted by island council on matters related to hygiene and solid waste management to promote a healthy community. As a result of these awareness sessions, the community might be applying more sanitary methods in their daily routine which may leads to decrease in number of Dengue and Diarrhea cases.

Dengue is a mosquito born viral disease. Dengue exists in two clinical forms, dengue fever and dengue hemorrhagic fever. In a study done by (Pai, Yu-Jue, & Hsu, 2006) on *“Impact of a short-term community-based cleanliness campaign on the sources of dengue vectors”*, they found community awareness played a significant role in controlling dengue outbreaks. The result of the study suggests as community becomes more aware about causes and consequences of dengue fever, the community put extra effort to minimize mosquito breeding grounds in their neighborhoods. Even though this study suggest that community awareness can reduced spread of dengue fever, still in the case of Ukulhas, further investigation is

needed with a large set of data to establish a significant relationship between community awareness and spread of dengue cases.

In an alternative study done by (Rego, Moraes, & Dourado, 2005) about “*diarrhea and garbage disposal in Salvador, Brazil*”, the study showed there was a direct association between mismanaged garbage and spread of diarrhea cases in children below 5 years of age. The study inferred, discarded diapers contaminates soil with fecal matter. This contamination provides a pathway for pathogens such as bacteria, viruses, protozoa and helminthes to multiply in the soil and transmit diarrhea via soil. (Rego, Moraes, & Dourado, 2005) also agrees there were other causes of diarrhea such as lack of personal hygiene, proper sewerage condition and unsafe drinking water. These studies suggest there was some association between mismanaged wastes and spread of dengue and diarrhea cases, however in the case of Ukulhas, data shown in table 4.31 is inadequate to establish a causal linkage between waste management Centre and spread of dengue and diarrhea cases to establish a definite relationship.

In a CBSWMS the main actors are clients, operators and regulators. (Dorer & Humboldt-Universität zu Berlin, 2012). In the case of Ukulhas solid waste management system, the client was the community, operator was the island council and regulators were Environmental Protection Agency and Local Government Authority. The clients from their side expects quality waste management services from the operators. On the other hand operators expect clients to pay a fee for the services they provide, charging a fee for the council is possible according to decentralized policy of the Maldives. Decentralization policy was introduced in 2010 along with local election act in the Maldives to delegate power to councils to run their island in a regionalized manner. Under this act, island councils have the power to charge fees for the services they provide. (UNICEF, 2013).

In the context of solid waste management, decentralization have the advantage of giving flexibility to island councils to design and implement waste management systems as they desire. But, decentralization automatically does not lead to the expected positive results. Success of decentralization depends on historical, geographical, socio- cultural and political set up of the location. (Fong & Lo, 2015). It is from this sense, community participation plays an important role in the success of solid waste management system programs.

Community involvement is essential for long term success of developmental projects. (Fong & Lo, 2015) refers to community involvement as sharing issues and knowledge about their daily lives within their communities. Through this knowledge sharing process communities empower each other. Empowerment is defined as the capacity of individuals or groups in determining their own affairs and it is a process where people take control over the factors that influence their lives. (Fong & Lo, 2015). Community empowerment depends on the level of inclusivity or their sense of belonging they have with the waste management system. Inclusivity and sense of belonging are two essential features that contribute to the success of community based solid waste management systems. Community satisfaction and their willingness to contribute to the system are key social factors that contribute to the efficiency of the system. Therefore, in order to measure the effectiveness of Ukulhas CBSWMS from client perspective, community satisfaction level and their willingness to pay for the waste management system were formulated in the form of research questions.

When looked at overall satisfaction level from scores of 1 to 14, most people from the community gave scores that ranged from 7 to 14 with a mean score of 12.3. These results showed majority of the community was satisfied with the services provided by the council. However, there were aspects of waste management system that still need improvement. 35.3% of people said improvement was needed in waste collection services, 13.7% said

improvement was needed in the way waste was burned and 22.5% of people said improvement is needed in the way council conducts awareness sessions.

Decentralization act provides opportunities for councils to work closely with their communities to bring improvements for projects such as CBSWMS that are implemented in the islands. But then again, client's willingness to cooperate with island councils depends on their satisfaction level, their sense of belonging and level of awareness. The results show the community was very much satisfied with the waste management system, but at the same it should be noted that success of CBSWMS very much depend on the relationship the island council has with the community. When communities feel they are important part of the waste management system, they will feel a sense of ownership and belonging towards the system and this creates the opportunity to build trust with the service providers for a long lasting cooperation. Analysis of the results showed 94.1% of people felt they belong to the waste management system while only 5.9 % of people said they do not feel they belong to the waste management system. When such high percentage of people from the community feels that they belong to the waste management system, this is a positive indicator that the CBSWMS is effective in meeting with the expectation of clients' needs.

It was interesting to note that even though majority of the people in the community were satisfied with the waste management system, satisfaction level varied across different age groups. Results of kruskal-Wallis test showed a p value of 0.04, which is less than 0.05, indicating there was a significant difference in the satisfaction level about waste management system across different age groups. Inspection of the mean ranks for the groups suggests that the age group 35 to 44 had the highest rank scores for satisfaction, while the younger group between ages 18 to 24 had the lowest scores. In a study done by (Longe, Longe, & Ukpabor, 2009), they have found that age plays a significant role as older age groups with their maturity level have more understanding and knowledge about environmental health and sanitation

issues than younger people. (Swami, Chamorro-Premuzic, Snelgar, & Furnham, 2011) in their study found that age directly predicts waste management behavior. Older individuals are more likely to report a positive attitude towards waste management systems than younger individuals. In Ukulhas also it was the age group 35 to 44 who showed more satisfaction with the waste management Center compared to younger group 18 to 24.

(Longe, Longe, & Ukpebor, 2009) explains, economic considerations such as household income plays a major role in determining people's perception on waste management. In the case of Ukulhas, analysis of the results showed there was no significant difference in the satisfaction level of the people with the waste management system across different income groups. Since waste generation is related to economic prosperity and level of income, this results suggest further investigation is needed to see as to why there was no association between household income level and community satisfaction level.

CBSWMS are usually low cost systems, but even these systems needs a source of income to cover the expenses such as repair and maintenance of the waste collection vehicles salary of employees who work in the waste management Centre, their accommodation and medical insurance, water and electricity bills, repair and maintenance of machinery such as glass chipper used in the waste management center. To cover these costs, a sources of income is necessary for the waste management Centre. One of the main source of income comes from the fee collected from household registered in the island council for waste collection service. The council collects MVR 100 from each household. The council also made it mandatory for each household to segregate waste into four categories, (leaf litter, kitchen waste, glass and metals) if they want the service from the council.

Waste Segregation at household level is very important in small island communities when there is no space in the waste management center to keep waste for segregation by employees. In addition, due to few numbers of employees present in the waste management Centre, it will be difficult for employees to spend much time in waste segregation in the Centre. (Longe, Longe, & Ukpebor, 2009) explains community willingness to pay for the waste management system will determine the reliability and success of the waste management system in the long run. If more people were willing to contribute to the waste management system, then the waste management system will have a positive impact, while if the community is not willing to pay a fee for waste management system, then hostility may build between the community and the service providers, which eventually may lead to a halt of the system. Such negative impact will threaten the sustainability of the system in the long run. Analysis of the results showed, in Ukulhas 97% of people agreed a fee must be taken for waste collection services. Only 3% of people disagreed it was important to take a fee for waste collection services. Most of the people in the community were willing to pay MVR 100 to 200, with majority preferring to pay a value of MVR 150. Hence people's perception on fees for waste collection service is a significant factor for the success of the waste management system. Since majority of the people in Ukulhas agrees that a fee should be taken for waste collection services, this is a positive sign that indicates the community is willing to participate for the sustenance of the waste management system.

Analysis to see if there was any association between respondent's satisfaction level and their willingness to pay a fee for waste collection service showed a very weak

correlation between respondent's satisfaction level and their willingness to pay more for waste collection service. Some studies have shown that the willingness to pay for solid waste management services is associated with income, education, quantity of waste generated, household size, and age. (Seth, Cobbina, Asare, & Duwiejuah, 2014). Even if, income, education, quantity of waste generated, household size, and age show an association with willingness to pay, in the case of this research these factors were overlooked, therefore a further study is needed to find out if there was any association between willingness to pay with income, education, quantity of waste generated, household size, and age in Ukulhas community.

One of the primary objective of this research was to find out if there was any change in behavior of the community members in utilizing plastic bags within the island. Consumption patterns of the community was identified in the DPSIR framework as one of the drivers of pollution. Plastic pollution is one of the foremost problem in the Maldives due to their easy availability. Almost all the shops in the Maldives use plastic bags, when goods are purchased, the goods are given to the customer in plastic bags. Recently many shops have shifted to use environmentally friendly plastic bag, yet the danger of plastic bag is not always about their age of biodegradation. Most of the harm to marine organisms is caused by ingestion of floating plastic wastes. Marine organisms mistake floating plastic as for food.

Analysis of the of the research question to identify community attitude towards plastic and their willingness to use recyclable shopping bags showed respondents who believe that plastic is harmful to the environment was across in all educational qualifications, however, even with this awareness 50 % of people were willing to use

recyclable shopping bag while 31% respondents were not willing to use recyclable shopping bag. On the other hand, from the 21% of people who thought plastic is not harmful to the environment, 11% of people were willing to use recyclable shopping bag, while 10% people were not willing to use recyclable bags. The Chi-Square test done to find out if there was any association between people who think plastic was harmful and their willingness to use recyclable shopping bag, the result showed there was no association between respondents who think plastic is harmful and their willingness to use recyclable shopping bag.

According to Chen & Chai (2010) a person's attitude towards the environment and their behaviour might have no relationship with their attitude as behaviour depends more on the person's self-identity towards a particular situation in a particular setting. Chen & Chai (2010) explains a person's attitude towards the environment is rooted in the person's mind and the degree to which the individual associate him or herself to the natural environment. Product purchasing decisions are often based on the consumer's attitude towards the environment. However, a favourable attitude towards environment does not necessary lead to similar behaviour. Consumers who are aware of and interested in environmental issues will only modify their behaviour to become more environmentally friendly only if their primary need for performance, quality, convenience and affordability were met. Individuals have multiple identities. The effect of environmental identities on behaviour depends on competing from other identities that the individual holds. A particular set of behaviour is not chosen on the basis of discrete, personal decisions but depends on the actor's participation in the broader social structure and on their social networks. Another way of expressing this

idea is through the concept of life style. (Chen & Chai, 2010). The argument from (Chen & Chai, 2010) suggests knowledge on environment issues does not necessarily leads to environmentally friendly behaviour. Change in behaviour is more linked to the identity the person has with the environment. If the person identifies he/she is part of the environment and is responsible for the health of the environment, environmental friendly behaviour can be seen, but this is only reinforced if the society the person lives in also identify the same values, meaning social influence is more powerful in triggering environmental friendly behaviour than individual attitudes.

5.3 Findings with reference to the DPSIR framework.

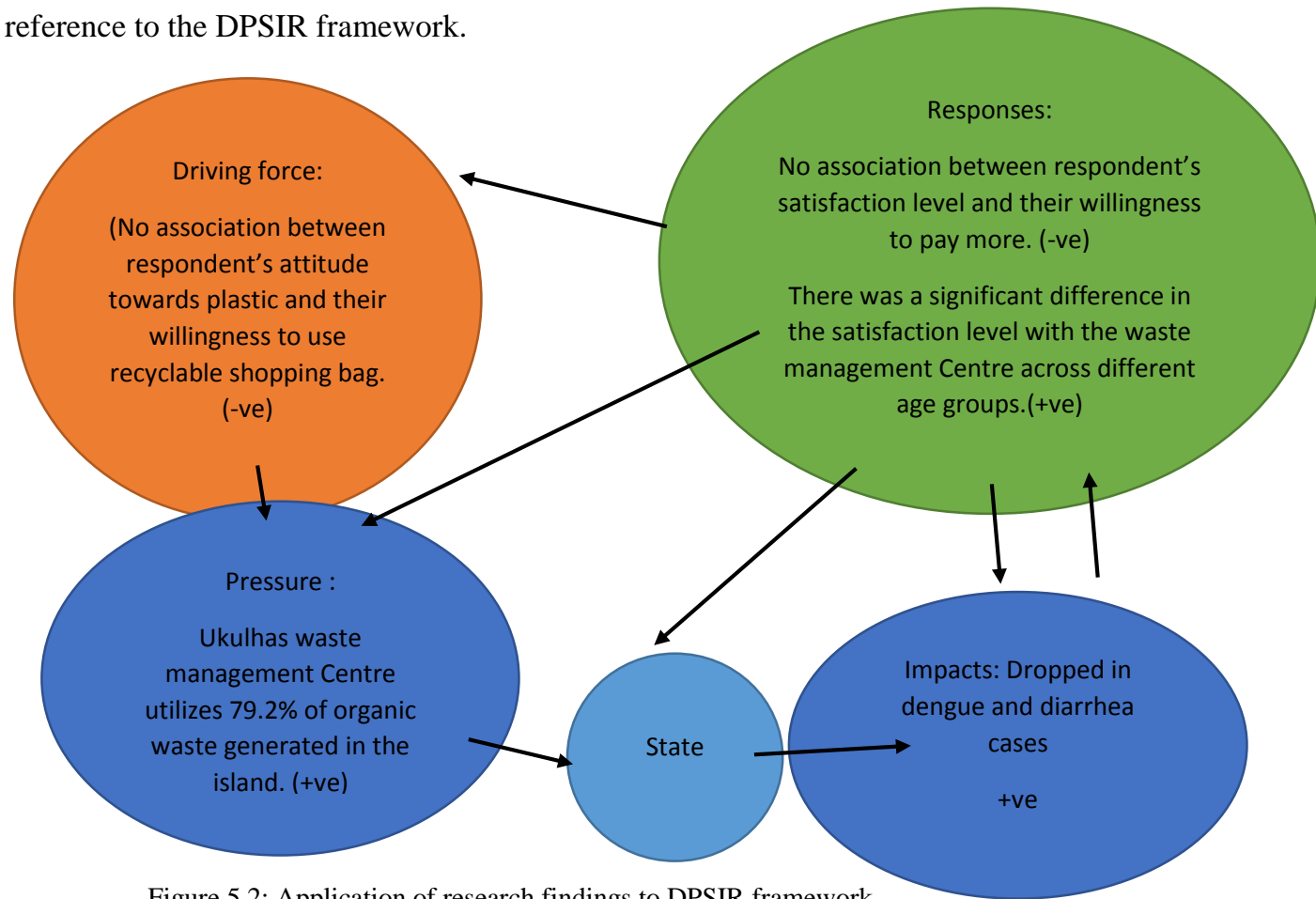
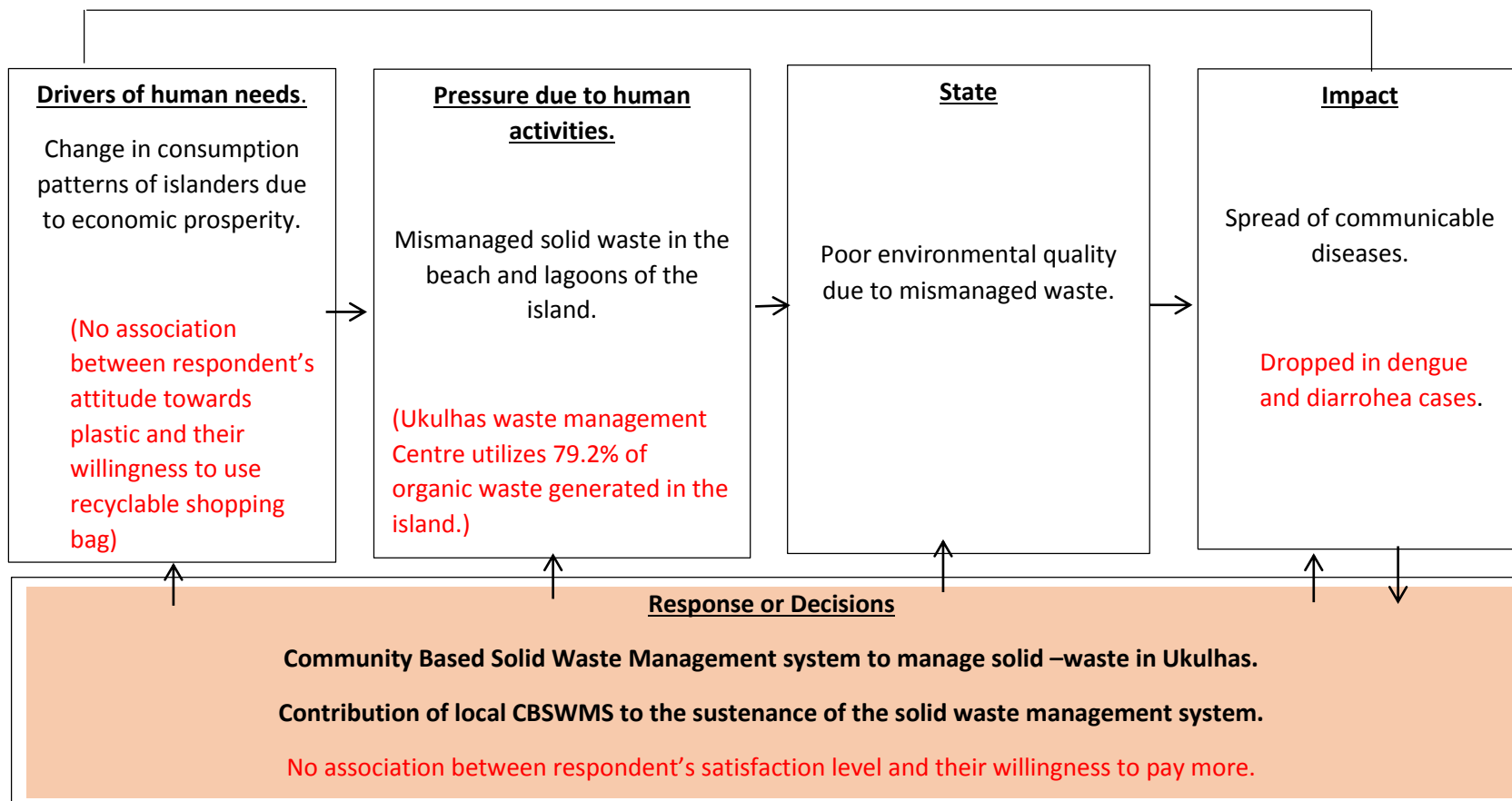


Figure 5.2: Application of research findings to DPSIR framework.

## Conceptual Framework



*Figure 5.3 shows the conceptual framework of the application of DPSIR framework for Ukulus waste management facility with Research findings.*

Figure 5.2 shows the application of the research findings to the DPSIR framework. Figure 5.3 shows how the research findings relate to the proposed conceptual framework. DPSIR framework is a framework that tries to explain the interactions between society and the environment. (Khajuria & Ravindranath, 2012). According to the framework, driving forces refer to the social, economic and technological factors that shape human behaviours which exert pressures on the environment. In the case of Ukulhas, one of the driving forces that contributes to the pollution of the island was, change of the consumption patterns of the community due to changes in lifestyle. One of the biggest problem that arose with lifestyle changes was plastic pollution. Plastic bottles, plastic bags were the biggest contributor of marine and coastal pollution in Ukulhas, therefore one of the objective of the research was to find out if there was any change in behaviour of the people in using plastic bags due to the awareness sessions conducted by the council since 2012 onwards. According to figure 5.3, there was no association between respondent's attitude towards plastic and their willingness to use recyclable bags. This means even if people think plastic is harmful or not harmful to the environment, their willingness to use plastic bag is independent of their knowledge. The Chi-Square test done to find out if there was any association between people who think plastic is harmful and their willingness to use recyclable shopping bag, showed there was no association between respondents who think plastic is harmful and their willingness to use recyclable shopping bag. Since many people are still willing to use plastic bags instead of recyclable plastic bags, a -ve sign is given to the driving force shown in figure 5.2. This is because, even though people adopt environmentally friendly behaviour such as putting plastic bags into a dustbin, there was no reduction in the rate of plastic bag

utilization. Therefore the island still generate the same number of plastic bags as before, consequently there is still pressure for pollution as the waste management Centre has to deal with huge quantities of plastic bags that are discarded by the consumers. The collection service provided by the waste management Centre reduces coastal and marine pollution from plastic bags, but when the bags have to be burned in the waste management Centre, the open burning of the plastic bags results in air pollution. Therefore it can be said that, as long as people are not willing to change their consumption pattern of plastic bags, there was no positive change in the driving force of plastic pollution in Ukulhas with the establishment of waste management Centre.

Ajzen's theory of planned behaviour (TPB) is a widely used model in social psychology to predict individual behaviour based on attitudes, subjective norms, perceived behavioural controls such as intention. (Damron-Martinez, Presley, & Zhang, 2013). According to Ajzen, a person will only perform a specific behaviour if that person has an intention to perform that behaviour. Therefore in the TPB model, intention comes before behaviour. Ajzen further explains that behaviour intention is determined by three factors known as attitude towards the behaviour, subjective norm, and perceived behavioural control. In conclusion Ajzen explains if there was a positive attitude, a greater perceived behaviour control such as the expectation that a person can control and outcome, in collaboration with a favourable social influence, the intention to perform the desired behaviour will be much higher outcome of the desired behaviour. (Pickett et al., 2012).

Based on Ajzen's theory of planned behavior it can be said that in the case of Uaklhas, just merely establishing the waste management Centre and conducting awareness sessions among the communities is not enough to change the communities current lifestyle and consumption behavior of plastic. Further research is needed to identify factors that influence attitudes, subjective norms, perceived behavioral controls such as intention of the people so that much focused workshops, activities and awareness sessions can be designed by island council to reduce major drivers of pollution in the island.

The second element from DPSIR framework under investigation was pressure on the island due to human activities such as pollution. Prior to establishment of the waste management Centre, organic waste generated in the island was discarded on the beach or the lagoons of the island. Coastal pollution degrades the coastal habitats and also threatened the health of the coral reef ecosystems surrounding the island. However, with the establishment of the waste management Centre, 79.2% of organic waste generated in the island is recycled into compost. Since more than 50% of organic waste generated in the island can be recycled by the waste management Centre, a +ve indicated in figure 5.2, showing that a Uaklhas waste management Centre has a positive effect in reducing organic waste generated in the island.

The third element under investigation was the impact on the health and the wellbeing of the community. The impact under investigation was spread of dengue and diarrhea in the island. The result showed that there was a drop in the dengue and diarrhea cases since 2012 onwards. Since this is a positive change, a +v sign is indicated in figure 5.2 for this element.

From the element “response” two community interactions were measured. They were community satisfaction level with the waste management Centre and their willingness to pay more, and community satisfaction level across varying age groups. These interactions were measured to find out how they influence the functioning of waste management Centre. The results showed there was no association between respondent’s satisfaction level and their willingness to pay for waste collection service however, the results also showed there was a significance difference in satisfaction level towards waste management system across different age groups, the age group 35 to 44 had the highest rank scores for satisfaction, while the younger group between ages 18 to 24 had the lowest scores. This is a noteworthy because this findings indicate that the island council has to consult with youth between the ages of 18 to 24 to see what aspects that they feel not satisfied with the waste management system. Often the view and experience given by youth will be far different from the view of older generations. So overall, it can be said that even though majority of the older people in the community was satisfied with the waste management Centre, still work needs to be done to enhance the satisfaction level of the younger generation as well. The second thing that was learnt from the result was that even though majority of the people were satisfied with the waste management Centre, they were not willing to pay more than MVR of 150 for the service. Since a profit is needed by the waste management Centre for the sustainability of the system, an increase in fee if needed should be kept in the range between MVR 100 to MVR 150.

Overall it can be said that CBSWMS is very effective in reducing pressures such as pollution in the island. From social dimension, since majority of the people in the community were satisfied with the waste management system, their

cooperation is positive which means they were willing to cooperate with the island council for the sustenance of the waste management system. From the economic dimension, since the waste management system earns an income from selling compost, the profit they earn by selling compost combined with the fee the island council charge from households for waste collection service, covers the economic expenses of running the system. In addition, composting activities carried out by the waste management system has opened employment opportunities for the communities making it an effective system economically as well. But still improvement is needed in the economic sector as the market of composting can be expanded by increasing demand from resorts.

## 5.6 Recommendations.

1. Composting is an organic process based on the microbial activity, therefore elements such as moisture, oxygen and suitable temperature is needed to be regulated consistently to ensure the quality of the compost. Ukulhas, waste management Centre lack sophisticated equipment to monitor most necessary requirement needed by the microbes in the soil for composting such as oxygen availability, nitrogen to carbon ratio, moisture content, optimum pH etc. Nevertheless, it is essential that the waste management Center buy a simple thermometer to check the temperature of the composting mixture. Optimum composting is carried out within 45degree to 50 degree Celsius temperature range. Temperature above 50 degree Celsius actually slows down the microbial activity and in cases where the temperature becomes very high such as 95 degree Celsius, the high temperature may kill most of the microbes present in the composting mixture leading to sterility of the composting mixture. In the absence of microbes the organic matter will not decompose into compost. Therefore to ensure optimum temperature needed to compost organic matter, it is very important that the staff employed in the waste management Centre regularly measures the temperature of the windrow composting using a thermometer so that if the temperature becomes too high, they can lower the temperature of the windrow pile by turning the windrow pile from time to time. (Tiquia, Richard, & Honeyman, 2000) explains regular turning of windrow pile is the primary method of temperature control in windrow composting. In addition regular turning of the compost ensures good aeration of the pile which in turn will increase rate of composting by microbes present in the windrow pile.

2. Since there is potential for expansion of compost market among the resorts, it will be good to have more resorts as potential buyers of compost, having multiple buyers will ensure the market of the compost is sustainable in the future.
3. The most effective way to manage waste is by minimizing waste generation rate. This can be done by systematically conducting awareness sessions within the community to promote environmentally friendly behavior such as green consumer behavior. By targeting workshops to themes such as green consumer behavior, it will be easier for the council to focus their attention to the most challenging aspect of waste management hierarchy such as behavior modification of the community to minimize waste generation rate in the island.
4. Since satisfaction level with the waste management system was low among youth age group between 18 to 24 years of age, the council can conduct consultation workshops with youths belonging to this age group to find their expectation, perception and attitudes with the waste management Centre in depth. Sharing of information through consultation where both parties contributes to dialogue have the potential to generate very constructive feedback that is vital for the improvement of the waste management system in the future.
5. Results from table 4.3 shows improvement is needed in the waste collection services provided by the council, as the community is not happy that waste is not collected on a daily basis from some households, it is very important to collect waste from every household registered for the waste collection service on a daily basis to ensure community satisfaction with the waste management system.

## 5.7 Limitations of the research.

One of the biggest limitation of the research, the research does not represent all the elements of the DPSIR framework. DPSIR framework consists of Driver, Pressure, State, Impact and Response. However for this research drivers, pressure, impact and response was only measured using limited indicators. The state of Ukulhas environment was ignored, therefore effectiveness of the Community Based solid waste management system was captured very narrowly in this research. A detailed in-depth study is needed for each element to measure effectiveness more accurately.

Analysis of the organic waste utilization rate by Ukulhas waste management Centre was measured using data collected only for one week period. Rate of organic waste generation by the island may vary from month to month. For example during the fasting month of Ramadhan and during school holidays, rate of organic waste generation may be higher than other months, therefore data collected within a seven day period cannot capture the accuracy of organic waste generation rate and organic waste utilization rate in Ukulhas. To get more accurate picture, data on organic waste generation should be collected for at least six month period.

The social survey done with the community captured community satisfaction level, their willingness to pay for the waste management system and their sense of belonging, but the survey lack variables to measure the level of inclusivity of the community. Therefore the social survey does not capture how much the community was part of the waste management system from a participatory

perspective. More refined questionnaire is needed to capture the socio-economic impact of the waste management system on the community.

The secondary data obtained to find how much Ukulhas council receive by selling compost does not reflect the profit made by the waste management Centre. It only indicates how much the waste management Centre was able to earn in one month by selling compost to consumers.

## 5.8 Conclusion.

Waste management in preindustrial times was simple because most of the waste comprised of organic materials which decompose naturally. However with the introduction of non- biodegradable synthetic materials such as plastic, waste treatment and waste disposal have become a pressing concern in the Maldives due to limited financial and human resources available in the country. Ari Atoll Solid waste management project was the first project that introduced the concept of composting in the Maldives. Community involvement is essential for long term success of developmental projects. Inclusivity and sense of belonging are two essential features that contribute to the success of community based solid waste management systems.

DPSIR framework is a framework that tries to explain the interactions between society and the environment. According to the framework, driving forces refer to the social, economic and technological factors that shape human behaviors which exert pressures on the environment. In the case of Ukulhas, one of the driving forces that contributes to the pollution of the island, was change in the consumption patterns of the community due to lifestyle modifications. Therefore

one of the objective of the research was to find out if there was any change in behavior of the people in using plastic bags due to the awareness sessions conducted by the council since 2012 onwards. Since there was no change in the consumption patterns of plastic bags utilized by the community, the island still generate the same number of plastic bags as before, consequently there is still pressure for pollution as the waste management Centre has to deal with huge quantities of plastic bags that are discarded by the consumers. The second element from DPSIR framework under investigation was pressure on the island due to human activities such as pollution. Prior to establishment of the waste management Centre, organic waste generated in the island was discarded on the beach or the lagoons of the island. Coastal pollution degrades the coastal habitats and also threatened the health of the coral reef ecosystems surrounding the island. However, with the establishment of the waste management Centre, 79.2% of organic waste generated in the island is recycled into compost. Since more than 50% of organic waste generated in the island can be recycled by the waste management Centre, Ukulhas solid waste management Centre is very efficient in reducing organic waste generated in the island. The third element under investigation was the impact on the health and the wellbeing of the community. The impact under investigation was spread of dengue and diarrhea in the island. The result showed that there was a drop in the dengue and diarrhea cases since 2012 onwards. The fourth element under investigation was the element “response”. Community satisfaction level and their willingness to pay were measured as community response under this element. The results showed there was no association between respondent’s satisfaction level and their willingness to pay for waste collection service however, the results also showed there was a

significance difference in satisfaction level towards waste management system across different age groups, the age group 35 to 44 had the highest rank scores for satisfaction, while the younger group between ages 18 to 24 had the lowest scores.

Overall it can be said that CBSWMS is very effective in reducing pressures such as pollution in the island. From social dimension, since majority of the people in the community were satisfied with the waste management system, their cooperation is positive which means they were willing to cooperate with the island council for the sustenance of the waste management system. From the economic dimension, the income the island council earn by selling compost combined with the fee the council charge from households for waste collection service, covers the economic expenses of running the system. Even though work is still needed in the improvement of the system, it can be concluded that Ukulhas Community Based Solid Waste Management System is a very efficient system in reducing organic waste generated in the island. In addition the system looks promising for sustainability as the system has the capability to earn income by selling compost. The results of the research findings suggests that given the geographic isolation of Maldivian islands and limited financial capability to run a successful centralized waste management system, the solid waste management system adopted by Ukulhas has the potential to relieve the issues of solid waste management at island level.

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# APPENDIX ONE

## Letter of Consent

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### *PART A*

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The purpose of this survey is to measure community satisfaction and their willingness towards the sustenance of the Community Based Solid Waste Management System implemented in Ukulus. If you agree to participate in this research please fill part B of this form. Information provided by you for this research is confidential and would not be shared with anyone.

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### *PART B*

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Please Initial Box

1. I confirm that I have read and understand the research question research objective for the above study and have had the opportunity to ask questions.
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason.
3. I agree to take part in the above study.

I, \_\_\_\_\_, agree to the conditions stated in this letter of consent and certify that I have received a copy of the consent form.

_____	_____	_____
Name of Participant	Date	Signature

_____	_____	_____
Name of Researcher	Date	Signature

## **Survey Questionnaire**

**Please tick in the appropriate box provided in questions where boxes are provided.**

**1) Your Gender**

Male  Female

**2) Age**

18-24  25-34  35-44  45-5

**3) Please tick your Educational Qualification?**

Basic literacy level.  Higher secondary  Degree   
Primary school  higher secondary  Masters   
Secondary  Diploma  Phd

**4) What is the household average income per month?**

1000-3000  3000-6000  6000-9000  more than   
10,000

**5) Who is in charge of handling waste in the household?**

Mother  father  grandmother  grandfather   
siblings

**6) In your household is waste separated before disposal?**

Yes  No

**7) How often is waste cleared (collected and disposed) by your household by the council?**

Once a week  Twice a week  Everyday

**8) How much do you pay for the service?**

100  150  200  250

**9) Do you think a fee should be taken from each household for waste collection?**

Strongly disagree  Dis-agree  Agree  Strongly agree

**10) How much are you willing to pay if the council increases the current fee?**

100  150  200  250  300  350

**11) On a scale of 1 to 5, 5 being the strongest, rate your satisfaction level with the waste management system in the island from the scale given below.**

1 2 3 4 5

**12) On a scale of 1 to 5, 5 being the strongest, rate your satisfaction level with service you receive with the fee you are contributing to CBSWMS.**

1 2 3 4 5

13) Do you buy PET water bottles?

Yes

No

14) With the implementation of CBSWMS do you try to minimize consumption of PET water bottles?

Yes

No

15) Do you carry our own reusable drinking water bottle?

Yes

No

16) Do you carry your own shopping bag?

Yes

No

17) Will you prefer to use your own shopping bag over the plastic bags given by shops?

I strongly do not prefer

I do not prefer

I prefer

I strongly do prefer

18) With the implementation of CBSWMS do you try to minimize consumption of plastic bags?

Yes

No

19) Do you think plastic is harmful to the environment?

Yes

No

20) Do you consume less plastic because of CBSWMS in the island?

Yes

No

21) Do you agree that improper waste management will cause serious effect to the human health?

Strongly disagree  Disagree  Agree  Strongly agree

22) Do you agree there is a relationship between mismanaged waste and spread of dengue fever?

Strongly disagree  Disagree  Agree  Strongly agree

23) Which aspect of the CSWMS should be improved in your opinion?

Collecting service provided by council

Composting

- Selling of compost
- Selling mechanism of reusable iron and aluminum
- Open burning of excess waste
- Transport mechanism of excess waste to Thilafushi
- Community awareness session conducted by council

**24) Do you feel you are part of the CBSWMS in the island?**

Yes  No

**25) Do you feel responsible for the maintenance of CBSWMS?**

Yes  No

**26) Do you practice home gardening or farming?**

Home gardening  farming  neither

**27) Do you buy compost from CBSWMC or do you buy imported fertilizers?**

I buy compost  I buy imported fertilizers

**28) Rank the reasons why you buy compost from CBSWMC.**

It is cheaper

It gives better yield

Organic compost is safer to health and environment

It is easily available when compared to imported fertilizers.

**29) Do you benefit from the awareness sessions on good waste management practices by the Island council?**

Strongly disagree  Dis-agree  Agree  Strongly agree