ASSESSING THE EFFECTIVENESS OF CROWDSOURCED GEOGRAPHIC INFORMATION FOR SOLID WASTE MANAGEMENT IN TIMOR-LESTE

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ABSTRACT

Dili, the capital city of Timor-Leste has been faced with serious solid waste problems in recent years. Responding to this issue, the government has adopted various policies including setting up solid waste collection sites in community areas and outsourcing collection to the private sector to collect waste directly from homes in several areas. Despite, these efforts, waste is still found scattered on the roads and disposed of in rivers and open lands. A proper solid waste management strategy is necessary to transform the city into a clean city.

In order to develop an effective solid waste management strategy, reliable data and public participation are required. This study, therefore, investigated whether crowdsourcing, in particular, Volunteered Geographic Information (VGI) can effectively be used to collect data about solid waste disposal and collection practices in Dili and raise awareness of the impact of waste disposal practices among the public.

The study result demonstrated that crowdsourcing is a viable method for collecting solid waste data. Challenges such as collecting accurate location-specific data still remain, hence, the crowdsourced dataset may not entirely substitute for the usual traditional dataset. At this stage, however, the collected data can still be utilized as a supplementary data source. In the future, by improving data collection methodologies, such as using smaller rewards or providing necessary facilities, a crowdsourcing-based data collection method could be utilized as an adequate substitute for traditional data source because of its ability to collect data in real- time with lower operational costs. This approach is feasible for a developing country such as Timor-Leste where critical area such as waste management has less priority for funding.

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LIST OF ABBREVIATIONS

ESRI : Environmental Sciences Research Institute

CCGI : Citizen Contributed Geographic Information

CGI : Contributed Geographic Information

CGD : Crowdsourced Geospatial Data

DDA : Dili District Administration

GDP : Gross Domestic Product

GIS : Geographic Information System

OSM : OpenStreetMap

PGIS : Participatory Geographic Information Systems

PPGIS : Public Participation Geographic Information Systems

VGI : Volunteered Geographic Information

QGIS : Quantum GIS

3R : Reduce, Reuse, Recycle

4R : Refuse, Reduce, Reuse, Recycle

CHAPTER 1 - OVERVIEW

1.1 Research background

With the fast increase in urban migration and population, enormous quantities of solid waste are generated. Research shows that cities around the world generate at least 1.3 billion tonnes of waste annually (Hoornweg & Bhada-Tata, 2012). These authors also report that global waste generation is expected to rise to approximately 2.2 billion tonne by 2025 with the current urbanization and population growth rate. Solid waste makes up a large proportion of the total, comprising unwanted products derived from the activities of human and animal discarded by society (Hazra & Goel, 2009). Solid waste not managed properly can result in serious health, safety, and environmental consequences (Abul, 2010). Due to the increasing need and complexity of managing solid waste, particularly the developing countries, the term Integrated Solid Waste Management (ISWM) was developed to support emerging nations to address common waste management issues (Marshall & Farahbakhsh, 2013).

The focus of the ISWM is to integrate approaches to optimize solid waste management and achieve the objectives of the 3R principles. The 3R approach in waste management stands for reduce, reuse, and recycle (Memon, 2010). An integrated solid waste management system encompasses management from waste generation to final disposal with the focus of achieving socioeconomic and environmental benefits, and acceptance by society (Marshall & Farahbakhsh, 2013). Therefore, the participation of all the stakeholders such as the government, donors, and citizens is an essential element of an integrated system to best serve waste management needs.

Timor-Leste is a sovereign island nation located in Southeast Asia. It has a population of 1.22 million. The country's GDP per capita was estimated at 1.7 billion in 2017 (World Bank, 2018). The sectors driving economic growth are the petroleum industry, agriculture and tourism. According to the 2015 population and housing census, approximately 23.8% (about 277,279) of the total population currently reside in Dili, the capital city of Timor-Leste, and the population in the area is increasing at an annual rate of 1.55 %, with an average household size of 6.4 (Statistics Timor-Leste, 2015). People migrate to the capital city in search of jobs, to get access to higher education, and for business opportunities to improve their economic situation. Figure 1-1, shows the location map of Dili.

FIGURE 1-1: LOCATION MAP OF STUDY AREA, DILI

Fischer, J. (2017), *Locator map of municipalities of Timor-Leste.* Retrieved from https://commons.wikimedia.org/

As the population increases, the production rate of waste also increases. The Asian Development Bank (ADB) reported that Dili generates at least at least 120 tons of solid waste per day (Zhongming, Linong, Xiaona, Wangqiang, & Wei, 2017). In addition, poor environmental conditions at Tibar landfill (the main dumping area), inefficient and inadequate collection and illegal dumping have been reported as major challenges that

Dili faces (JICA, 2016). Therefore, a proper solid waste management plan is necessary in order to transform the city into a clean city.

1.2 Research problem

Over the last decade, Dili has struggled with the challenge of managing solid waste. Presently, there is no Integrated Solid Waste Management in place. The only waste management solution being practiced is the collection from sites allocated in the villages to the dumping area (Carvalho, 2013). A village is made up of a number of hamlets (often refers to as '*Aldeias*').

The Municipality of Dili is divided into three administrative levels, from highest to lowest: administrative posts (or *Sub-district*), villages (*Sucos*) and hamlets (*Aldeias*). Unsegregated solid waste from households is disposed of in various types of containers located on the roadside as the collection points. Anecdotal evidence suggests that the distance between allocated collections sites is approximately 1km (A. Piedade, personal communication, April 30, 2018). These collection containers include large containers (4 tonne loads capacity) and smaller containers (1.2 tonne capacity) that are installed across the city. In the villages, brick-and-mortar containers are built for the community to dump waste. Figure 1-2 show the types of containers. Each village has at least 3 to 7 brick-and-mortar containers depending on the land size of the village (Woodruff, 2014). These containers are not fully enclosed therefore garbage are often found overflowing on the street. In areas where there are no collection containers, empty lands near the residential areas are used as collection points. These types of illegal dumping sites are referred to as '*wild sites*' throughout this document. Figure 1-3 shows examples of wild collection sites.

 4 tonne bin	 1.2 tonne bin
 brick-and-mortar container	 Garbage bin

FIGURE 1-2: MUNICIPAL WASTE COLLECTION SITES

[Author's own images]

 Wild site	 Wild site

FIGURE 1-3: WILD DUMP SITES

[Author's own images]

1.2.1 Current collection system

Currently, waste stored in all the collection sites are manually emptied by municipality employed waste collectors, often with unprotected hands, which then are transported to the final dumping site in Tibar. The Dili Weekly reported that in 2017 the government contracted 40 privately owned trucks to collect waste (Quintão, 2018). The trucks do three collection runs each day from Monday to Saturday. Rubbish is not collected on Sundays and during public holidays. The trucks sign a timesheet each morning at the municipal office before starting the collection. A supervisor is placed at the landfill to verify if the trucks make three collection runs. There is no form of control to ensure if they have collected waste properly.

All the collection sites are located in public spaces and main roads. Waste in the unenclosed bins attracts flies and rodents to scatter. This, therefore, creates not only an aesthetic problem but also creating a significant risk to human health and the environment. A study by da Costa and de Jesus (2018) found that at least 58% of the population suffer from respiratory disease, 23% from malaria and 22% from dengue due to the waste problem. The study was conducted in four administrative posts namely Vera Cruz, Dom Aleixo, Nain Feto and Cristo Rei in Dili.

The public waste collection is administered by the Dili District Administration (DDA) under the Ministry of State Administration. Waste collection services are currently provided by the government and privately contracted companies. However, the collection practice is not effective due to limited collection capacity (JICA, 2016) and the lack of a proper monitoring system, leaving waste pickers to focus mainly on the sites located near the main roads (JICA, 2016; Woodruff, 2014). Hence, a proper waste management strategy is required to tackle these issues.

Responding to this issue, the government has been promoting several initiatives to ensure that solid waste is properly managed. These initiatives include a 4 hour clean-up day on Friday mornings by government officials as established by Government Resolution number 7, 2009 (Timor-Leste, 2009) and through collaborative works with non-government organizations, the government occasionally runs a healthy village competition as part of the campaigning activity to raise people's awareness about waste management. However, despite these efforts, waste is still not being disposed of properly. Solid waste is discarded on the streets, rivers, open spaces and drains, which causes blockages and results in overflowing and flooding during rainy seasons. Uncollected waste also ends up in the ocean causing harm to marine life. Lastly, illegal disposal and burning of waste are still commonly practiced.

Apart from the campaigning initiatives, there are also recycling programs established by the government and private sectors. Recycling handled by the private sector is still limited to recovering metals, plastic and aluminium, which is then sold to companies abroad given that there is currently no recycling industry in Timor-Leste. These wastes are recovered manually by waste pickers from households, waste collection points, and the main dumping site. In 2015, the government launched a project to build a plasma furnace system at Tibar landfill that would liquefy solid waste from recyclable materials to produce energy in the form of gas (Government of Timor-Leste, 2015). However, due to some unknown issues, the project has yet to be implemented.

1.2.2 Solid waste management issues in Timor-Leste

Like any other new developing country, Timor-Leste faces various technical, financial, institutional, economic and social challenges. A significant institutional challenge that the country experiences is the lack of coordination among the institutions responsible for solid waste management. Since various organizations are involved in managing solid waste but there are no distinct definitions of rules or mandate, efforts are often duplicated (Ministry of Commerce, 2016). Moreover, solid waste management is not considered high-priority due to other prominent priorities such as infrastructure development, education and health; therefore, limited funds are allocated for this sector. In addition, the waste collection services in Timor-Leste are currently free and there is no tax or fee structure to sustain a solid waste management program. Without a solid revenue base, it is relatively difficult to run an effective waste collection program.

Timor-Leste also faces technical constraints relating to solid waste management. These technical challenges range from limited human resources and technical expertise to plan and manage solid waste to lack of appropriate technology for managing the collection, transportation, and waste treatment. Without adequately trained personnel and proper technical infrastructure, a solid waste management program would be difficult to implement efficiently and sustainably.

As well as the institutional, financial and technical challenges, Timor-Leste experiences social problems such as a low level of awareness of the impact of solid waste to health and the environment, improper waste handling and disposal, and lack of community involvement (Ministry of Commerce, 2016). As a result waste collection sites are not effectively utilized while the number of illegal dumping sites is increasing significantly. Due to this social issue, many citizens, particularly the low-income population, are forced to live in unhealthy and unhygienic conditions.

A way forward to improve solid waste management is to optimize public participation and increase public awareness of the impact of solid waste on their health and the environment. Furthermore, promoting the sorting of waste at the source is likely to decrease the total amount of waste through recycling. Proper waste segregation requires establishment of appropriate collection points. However, currently, there is no data on the location of waste collection points including formal and illegal dumping sites. Furthermore, as yet no studies have been conducted to assess the effectiveness of the current solid waste collection practices in Dili.

1.3 Research response

To gather sufficient information to assess the key issues outlined above, this research study proposes to use crowdsourcing; in particular Volunteered Geographic Information (VGI). It is envisaged that the data obtained from this study will be useful for relevant authorities to design an integrated solid waste management strategy in the municipality of Dili, Timor-Leste.

Volunteered Geographic Information is a method that allows the wider public to create and produce digital spatial data and maps, whether individually or collectively using web mapping tools (Elwood, 2008). Tools that adopt the approach are now available on the Internet, smartphones and other handheld devices, allowing people to collect geographical data and a broad range of other information (Sui, 2008). Some early notable examples of VGI projects involving a wider public are the OpenStreetMap[1] and Wikimapia[2]. VGI has also been used to collect data for various scientific studies in domains including computer science, social and natural science, environmental sciences, and astronomy and space sciences (Bordogna, Carrara, Criscuolo, Pepe, & Rampini, 2016). VGI is being used because of its ability to leverage a large number of dedicated volunteers to capture geographically accurate data.

In the last few years, Timor-Leste has experienced growing technology usage and internet user numbers. According to the Internet World Statistics, in 2017, there are about 410,000 internet users (or 31% penetration rate) and the same number of users also subscribed to the social media platform, Facebook (Internet World Stats, 2017). The country also experiences growth in mobile broadband penetration rates, reaching a 33% in January 2016 (GSMA Intelligence, 2016). In September 2017, one of the internet service providers (Telkomcel) launched 4G services, allowing its subscribers to have faster network speed, capacity and overall network performance. The estimation data of Timor-Leste's literacy rate according to the 2015 Population and Housing

[1] https://www.openstreetmap.org/
[2] http://wikimapia.org/

Census shows that 67.7% of the population above 10 years old are literate (General Directorate of Statistics, 2017). The literacy rate for men is 70.6%, while the literacy rate for women is 63.9%. Youth literacy between 15 to 25 years old is 84.4% out of which 94.3% are living in urban areas, while 78.5% are residing in rural areas.

With the availability of these technologies, crowdsourced data collection becomes an interesting area to explore for solid waste data collection, specifically for a developing country like Timor-Leste where financial and human resources are limited. The VGI method does not require face-to-face data collection, therefore, citizens have the convenience of responding to a questionnaire or other data collection format anytime, anywhere. The VGI approach has potential to empower citizens to report problems and challenges that exist in each collection site they observe using their smartphones and other personal devices. Meantime, the authorities responsible for solid waste management can make more well-informed decisions to prioritize improvements to solid waste collection points.

1.4 Research objectives and research questions

The purpose of this study is to investigate whether crowdsourcing can be an effective method for collecting data about solid waste disposal and collection practices in Timor-Leste. Moreover, the study seeks to identify the opportunities and barriers to crowdsourcing in developing countries like Timor-Leste compared with developed countries and how this affects the design of crowdsourcing projects. Using Dili, the capital city of Timor-Leste as a case study area, this research aims to achieve the following objectives:

- To obtain data about solid waste disposal and collection practices in Dili, Timor-Leste
- To investigate whether crowdsourcing is an effective method for raising awareness of the impact of waste disposal practices among the public

- To assess whether crowdsourced data can be used for optimising the location of solid waste collection sites
- To assess whether crowdsourced data of sufficient quality and quantity to enable government to evaluate the effectiveness of the current waste collection system
- to identify the opportunities and barriers to crowdsourcing and to explore how they affect the design of crowdsourcing projects.

These research objectives are translated into the following research questions:

1. Is crowdsourcing an effective method for collecting data about solid waste disposal and collection practices in a developing country?
2. Is crowdsourcing an effective method for raising awareness of the impact of waste disposal practices among the public?
3. Can crowdsourced data be used for optimising the location of solid waste collection sites?
4. Is crowdsourced data of sufficient quality and quantity to enable the government to evaluate the effectiveness of the current waste collection system?
5. What are the opportunities and barriers to crowdsourcing in developing countries compared with developed countries and how does this affect the design of crowdsourcing projects?

1.5 The study area

The area selected for this research study is Dili, the capital city of Timor-Leste. Dili has an estimated land area of about 48.27 square kilometres. The city of Dili comprises 6 administrative posts, 31 villages, and 241 hamlets. The six administrative posts are Atauro, Cristo-Rei, Dom Aleixo, Nain Feto, Metinaro and Vera Cruz. The villages are within the administrative posts. Each village has a number of small areas or hamlets as often refers to as *'Aldeias'*.

Dili experiences two local climates (rainy and dry seasons) and the average temperature is 27.5 ^{0}C. The population of Dili, according to the 2015 census was 277,279. This number is expected to increase by at least 30% by 2020. According to the Asian Development Bank report, Dili produces approximately 120 tons of solid waste per day (Zhongming et al., 2017). Table 1-1 provides a breakdown of the size of the population in Dili by administrative post, gender, and household size. Figure 1- 4 show the number of population by gender and age group.

Administrative post	Population			Average household Size
	Total	Male	Female	
	277,279	143,677	133,602	6.49
Atauro	9,274	4,669	4,605	5.31
Cristo Rei	62,848	32,509	30,339	7.01
Dom Aleixo	130,095	67,646	62,449	6.30
Metinaro	5,654	2,908	2,746	6.68
Nain Feto	32,834	17,067	15,767	6.67
Vera Cruz	36,574	18,878	17,696	6.54

TABLE 1-1: SIZE OF POPULATION

Adapted from "Dili em números," by Statistics Timor-Leste (2016)

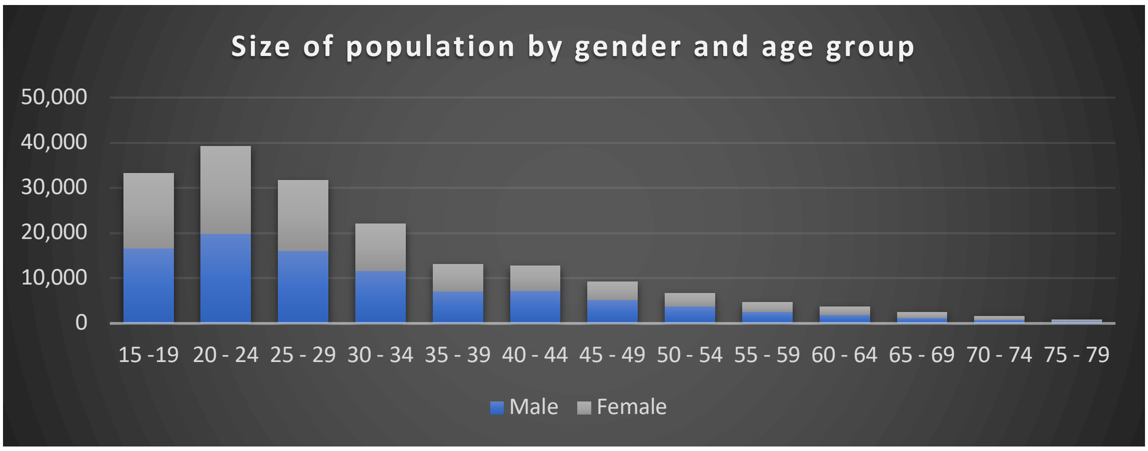

FIGURE 1-4: SIZE OF POPULATION BY GENDER AND AGE

Adapted from "Dili em números," by Statistics Timor-Leste (2016)

1.6 Scope of the study

Dili comprises 6 administrative posts, 31 villages and 241 hamlets. Two of the administrative posts, Atauro and Metinaro, are located outside the urban area, therefore have been excluded from this study.

1.7 Thesis outline

By using crowdsourced-based data collection method, this study obtained data about solid waste disposal and collection practices in the Municipality of Dili, Timor-Leste. Chapter 2 provides a summary of the data collection process and the result of the study. This chapter also reviews previous studies that have been conducted using a crowdsourcing method. Gaps were identified in the existing studies and were filled by this thesis.

As this study involves collecting location-specific data, an appropriate background map for the survey application was required. Thus, an additional study was conducted to select the best background map. Chapter 3 describes the process involved in this study as well as reviews the literature on people's map reading skills and how well they can identify objects using maps and images with different resolutions.

By utilizing the data collected through this research, this study designed a proposal for optimised bin site location. Chapter 4 details the process involved in designing the optimised location. Several possible schemes were presented together with their associated costs. Furthermore, this chapter reviews previous models related to the optimisation of solid waste collection and identifies a gap that is addressed by this study.

Chapter 5 provides a summary of the research described in this thesis and its main findings, as well as evaluating the research method. The chapter also identifies the limitations of the study and points out areas that may be addressed in the future to improve data collection using a crowdsourcing method.

CHAPTER 2 - DATA COLLECTION USING CROWDSOURCING

2.1 Introduction

This chapter provides an overview of a crowdsourced data model for the collection of data for solid waste disposal and collection practices in the Municipality of Dili. The chapter begins by reviewing the literature around the use of VGI to collect data about solid waste management in developing countries. Furthermore, it discusses the overall design of the research study including how data were collected and analysed. Lastly, the results of the study will be presented.

2.2 Literature review

There are a number of previous studies that have explored the use of VGI as a spatially intelligent public participatory tool in solid waste management in developing countries. This section provides an overview of these studies, and provides details of the relevant concepts in VGI applications in general and issues associated with their implementation.

2.2.1 Crowdsourcing

Crowdsourcing was first established by Howe (2006) as an act that involves outsourcing tasks or other functions to various participants to acquire a cumulative result as opposed to the traditional data collection method where a task is designated to a specific agent.

Crowdsourcing is then phrased as a collective wisdom of crowds in which knowledge is acquired from a large number of people rather than a few experts (Surowiecki, 2007; Verplanke, McCall, Uberhuaga, Rambaldi, & Haklay, 2016). A crowdsourcing project has three essential elements (Estellés-Arolas & González-Ladrón-De-Guevara, 2012). These elements are:

- A crowdsourcer (refers to individuals, groups or organizations that initiate a crowdsourcing project)
- A crowd (a group of participants that are willing to perform tasks allocated by the crowdsourcer)
- A process (tasks and activities involved in the project)

As crowdsourcing has gained prominence in scientific projects, the term '*citizen science'* has emerged. Citizen science describes the public's contribution to scientific research projects that are purposed to address a real-world problem (Goodchild, 2007; Haklay, 2013). Citizen science projects involving geographical locations are identified as Volunteered Geographic Information (VGI) projects.

2.2.2 Volunteered Geographic Information (VGI) data collection

Citizens' participation is essential for waste management planning. Involving citizens in the decision making process will help to gain community awareness, input, and acceptance. This section presents an overview of VGI and discusses the opportunities and challenges of using VGI in solid waste management with particular focus on the context of developing countries.

2.2.2.1 Overview of VGI

The term VGI refers to the creation of geographic information through engaging a large number of people from a range of expert and non-expert sources (Goodchild, 2007). The term was coined by Mike Goodchild in a seminal paper published in 2007. As technology has advanced, particularly with the birth of the internet, data collection has been made easier and faster by volunteers on a large scale (Gouveia, Fonseca, Câmara, & Ferreira, 2004). The uniqueness of the VGI approach is that some participants may have little to no training or knowledge of spatial technology. However, their voluntary participation can make a substantial impact in the reduction of overheads (Goodchild, 2007).

Since VGI involves voluntary participation of the content producers, it is often defined as user-generated content (Coleman, Georgiadou, & Labonte, 2009; Sieber, 2006) or citizen as sensor (Goodchild, 2007). Several other terms generally used to describe VGI related activities include Citizen Contributed Geographic Information – CCGI (Spyratos, Lutz, & Pantisano, 2014), Contributed Geographic Information - CGI (Harvey, 2013), Crowdsourced Geospatial Data- CGD (Rice, Paez, Mulhollen, Shore, & Caldwell, 2012), and spatial crowdsourcing (Crampton, 2009).

Other terms that correlate with VGI are the PPGIS (Public Participation Geographic Information Systems) and PGIS (Participatory Geographic Information Systems). The term PPGIS emerged in the US and popularly used in developed countries as an effective means to encourage public participation and community consultation. On the other hand, PGIS emerged as an avenue to promote social advocacy and policy change to eliminate social, economic and environmental injustice (Brown, Kelly, & Whitall, 2014). PPGIS and VGI are similar in a way that both are focusing on investigating and obtaining the spatial location of a subject of interest. The difference between them lies in the purpose of the project and the motivation to participate (Tulloch, 2008). PPGIS explicitly seek a policy or social change by engaging the public in decision making. Therefore, in data analysis, public datasets may be used. On the other hand, VGI collects datasets through a casual and entertaining approach from a wider public (Sui et al., 2013). Thus, the coverage of VGI is more extensive compared with PPGIS.

There are three common advantages of VGI identified in the literature. These are cost-saving, access to vast amounts of data, and knowledge acquisition. Data collection is often costly and requires a large amount of logistical resources, but having a crowd to fulfil tasks can significantly reduce research and development costs (Howe, 2006). Another advantage of VGI is its ability to produce vast amounts of data in a relatively short period of time (Fekete et al., 2015). Furthermore, contribution from a vast number of users will result in accumulation of large amounts of useful geographic information that can be applied in various areas (de Oliveira, de Souza Baptista, Campelo, Acioli Filho, & Falcão, 2015). For example the base mapping coverage projects such as OpenStreetMap and Ushahidi platforms used for aiding humanitarian efforts, emergency reporting, and crisis mapping (Fast & Rinner, 2014; Kent & Vujakovic, 2017).

VGI also provides the opportunity to obtain local knowledge that in some instances cannot be captured through traditional mapping methods (Bishr & Mantelas, 2008; See et al., 2013). For example, characteristics of a given street would be best described by the people living nearby (Gould, 2007). In addition, the VGI approach gives opportunities for a citizen to participate in various processes in a meaningful way, as well as improving citizens spatial mapping skills as they interact directly using the mapping tools (Tulloch, 2007).

2.2.2.2 Components of VGI

Generally, a project is implemented through various interrelated components. According to Fast and Rinner (2014) there are three main components or building blocks of a VGI system. These components, as shown in Figure 2-1 are the project, which can be triggered by a problem or a purpose, participants (volunteers) and the technical infrastructure (collection of hardware, software and the geoweb).

VGI Components

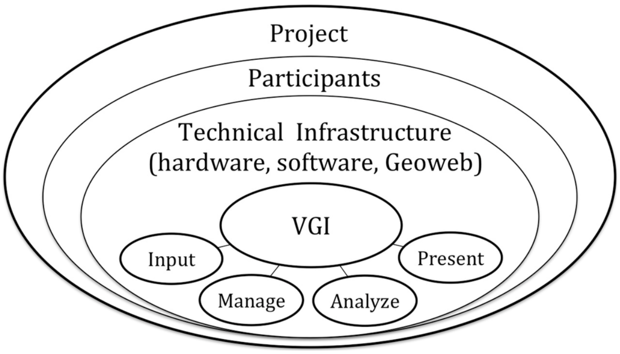

FIGURE 2-1: THE COMPONENTS OF VOLUNTEERED GEOGRAPHIC INFORMATION (VGI) SYSTEMS

Adapted from "A systems perspective on volunteered geographic information," by Fast & Rinner (2014, p.1283)

Each of these components has activities that need to be thoroughly planned and executed for a VGI project to be completed successfully.

Project

The result of a VGI project is highly dependent on how it is designed (Fast & Rinner, 2014). Therefore, it is of utmost importance that the goal and strategy of the VGI project are clearly defined prior to the commencement of the project. Various components that need to be considered during the project development stage include the selection of the study area, the project timeframe, and peoples' participation strategy. The project timeframe involves identifying whether it is an ongoing project, a project to address an immediate emergency situation or a funded project with a specific timeframe.

Participants

A key element of crowdsourcing is the voluntary participation of the crowd. Therefore, it is essential to identify the participants during the project preparation stage. The participation strategies, however, may vary between projects and solely depend on the type of project and the tasks participants are required to perform. Particularly in citizen science projects, participants can play either an active or passive role (Haklay, 2013). In active VGI, citizens are actively engaged to collect information for a particular purpose, for example bird sighting, street mapping, landfill siting, etc. In contrast, in passive mode, information is generated without user intervention. Passive mode VGI are often conducted by commercial companies for marketing or behaviour analysis (Huang, 2017). For example, information is generated from geotagged tweets of Twitter, geotagged photographs from Flickr and Instagram posts (Fast & Rinner, 2014). This shows that VGI projects are collaborative but do not necessarily mean participative.

Technical infrastructure

To support the implementation of a VGI project requires a technical infrastructure. Deployment of technical infrastructure for a VGI project depends largely on the goals and the objectives of the project and the type of information the project aims to collect. Common VGI system infrastructures proposed by Fast & Rinner (2014) are:

- Hardware (e.g. client-server computers, smartphone and other handheld devices with GPS capabilities, PCs, sensors)
- Software (e.g. Geoweb, which is a set of location-enabled services and infrastructure that provide users with a mapping interface allowing them to identify a geographic area. Examples of platforms that contains Geoweb tools are ArcGIS online, Ushahidi, OpenStreetMap, GeoCommons, etc).

The technical infrastructure supports the management of VGI project to deliver technical functionalities including obtaining data (input), managing data, analysing and presenting outputs.

2.2.2.3 Types of VGI projects

There are three major categories of VGI projects according to Shirk and Bonney (2015). The first category are projects that involve volunteers collecting a large amount of data to be used in scientific studies. Bonney et al. (2009) categorized these types of projects as '*contributory projects*, in which citizens collect and contribute data for projects designed by a scientists. This type of projects has been in existence since 1990, in studies relating to the environment and natural resources. For example, the EBird[3] project, iNaturalist[4] and Project Noah[5] that allow citizens to record observations of a wide range of organisms. The data obtained from this type of project are used for scientific research such as conservation efforts and sustainable use.

The second category of VGI project is where citizens are actively involved in managing, transcribing, or interpreting large quantities of data. Bonney et al. (2009) classified this type of project as "*co-created projects*", in which volunteers are also involved in project's development. The type of projects in this category often concentrate on local or regional environmental policy issues, for example, the West Oakland Environmental Indicators Project[6], where citizens collect information on air quality and health data to identify pollution effect.

The third category is *collaborative project* (Bonney et al., 2009), which are designed by scientists but citizens are allowed to provide input and feedback necessary to adjust project designs, for example the OpenStreetMap project.

Bonney et al. (2009) categorize the three different typologies according to the level of collaboration between citizen and scientist whereas Haklay (2013) groups them

[3] https://ebird.org/home
[4] https://www.inaturalist.org/
[5] http://www.projectnoah.org/
[6] https://www.woeip.org/

according to the level of engagement. Haklay also classified the VGI project into four levels:

- Level 1 - citizen as sensor (crowdsourcing),
- Level 2 – citizen as basic interpreter (distributed intelligence)
- Level 3 – citizens participate in defining the problem and collecting data (participatory science)
- Level 4 – Citizen participate in defining the problem, collecting and analyzing data (extreme citizen science).

2.2.3 Adoption of VGI in developing countries

There are various factors that encourage the use of VGI in developing countries. Some of these include lack of institutional data, limited resources, cost-effectiveness, and social accountability and governance.

The most common driver of VGI is the scarcity of geographical data in crucial situations (Haklay, Antoniou, Basiouka, Soden, & Mooney, 2014), for example in the case of natural disasters and emergencies, VGI allows the collection of large datasets quickly, specifically in places where responsible mapping agencies do not exist or data are scarce (Genovese & Roche, 2010). A notable example of this situation is the VGI that provided mapping to facilitate the humanitarian and first aid effort to Haiti after the earthquake in 2010 (Soden & Palen, 2014). A similar initiative is a VGI project on mapping schools and health facilities in areas of high magnitude-earthquakes in Kathmandu Valley, Nepal. The geographic dataset was intended to facilitate the delivery of humanitarian aid when required (Soden, Budhathoki, & Palen, 2014). This suggests that VGI is crucial for disaster response in areas where data is scarce.

Lack of resources to support infrastructure development is another driver for VGI project (Haklay et al., 2014). Example of this kind of driver includes the need for data on basic topographic features to establish a new state, as in the case of South Sudan

(Brown & Heaton, 2011). Similar example include the mapping and updating existing maps in developing countries that are yet to be mapped (Genovese & Roche, 2010). A further example is to satisfy the need of data for initiatives such as smart cities projects, for instance the Ulaanbaatar, Mongolia project in which local stakeholders and volunteers worked collaboratively to create and update a topographic map (Menard & Deffner, 2013). These examples show that spatial data is important to the development of a country.

Another common driver of crowdsourcing initiatives is the cost saving for data collection (Johnson & Sieber, 2013). Involving a crowd to collect data with what they already own such as smartphones and internet access can significantly lower the operational costs (Bott, Gigler, & Young, 2014; Howe, 2006). Particularly now that developing countries are experiencing exponential growth of the internet and mobile networks allowing access to smartphones and fast internet access (Genovese & Roche, 2010).

The role of citizen participation as a fundamental component of democracy is another driver for VGI projects (Bott et al., 2014; Genovese & Roche, 2010). Having citizens participate in the decision making process fulfils democratic aims of ensuring government transparency and citizen empowerment (Bott et al., 2014). Citizens' direct involvement in the formulation of policies can thus allow changes to take effect efficaciously.

Several examples of the strong impact of crowd participatory efforts in developing countries include the tracking, reporting and coordinating of humanitarian efforts in the aftermath of earthquakes in Haiti and Chile, floods in Pakistan, human rights abuses and violence in Kenya, and civil war in Libya (Gigler & Bailur, 2014). These projects demonstrate that crowdsourcing is an effective tool not only for monitoring and evaluation but can be a valuable tool for addressing other dynamic governance challenges such as conflict, climate change, crime, poverty, as well as environmental issues.

2.2.4 VGI for solid waste management in developing countries

VGI has proven to be an efficient data collection tool for solid waste management purposes, yet has not been investigated widely.

The most recent project is the mapping of landfills in Kinshasa City[7], the capital city of the Democratic Republic of the Congo (Mavakala et al., 2017). This project focuses on identifying, locating and characterizing solid waste landfills. The Ushahidi online platform was used to collect data. The platform allows reporting using mobile phones or the internet through SMS, Email, Twitter and custom surveys. By using a crowdsourcing approach the researchers managed to obtain 187 observations of solid waste disposal including 61 public transit centers, and 151 wild dumps across Kinshasa within two years. The project sought experts' opinions for questionnaire development and data validation. This study, however, had targeted a specific audience, which was the students from environmental science faculties of two universities in Congo. The authors noted three main challenges that the project faced. These challenges include ensuring the collected data is of good quality to be accepted and used by the government and ensuring project sustainability.

Brus, Vrkoč, and Kubásek (2016) implemented a web-based data collection tool using the ArcGIS platform that allows citizens to report illegal waste dumping and other waste related issues using smartphones with GPS capabilities in Prague city, Czech Republic[8]. This data collection system is an improved version of the system established by (Kubásek & Hrebícek, 2013; Kubásek & Hřebíček, 2014). The newest version has features that allow contributors to report other related waste issues as opposed to the first version that was mainly focused on siting illegal dumping sites. Although the authors conducted the project in cooperation with organizations responsible for illegal dumping sites in the Prague city, unlike Mavakala et al. (2017)'s project, the contributors for data collection for this project are citizens from over 40 municipalities and towns. The researchers employed a manual check of reports submitted against the

[7] http://kinmap.grid.unep.ch/ushahidi/main?l=en_US

[8] http://www.zmapujto.cz/

formal guidelines (focusing on size of dump and waste quantity shown on pictures submitted by the contributors) to ensure data obtained are valid. After selecting 52 illegal dumps randomly and checking against the formal standards of a legal dump site, the study found that 48 are real and four have been misplaced. This shows 92% data collection accuracy through this approach. Despite showing great data accuracy, the researchers found that it was difficult to estimate the quantity of waste and encountered problems with inaccurate identification of a dumping site because the report is subjective, for example, people may report overfilled dustbins as illegal dump site.

A similar project for reporting waste issues was implemented in China[9]. The project was called DangerMaps and listed at least 6,000 pollution sites (Capineri et al., 2016; To & Lai, 2015). However, it is available only in Chinese, and despite being cited in two academic journals, the study is not found in any scientific database.

Another example of a VGI project in waste management was conducted by Lee, Kung, and Ratti (2015) in Mombasa, Kenya. This project concentrated on mapping the location and routes taken by informal waste collectors (or waste scavengers) to collect waste using a GPS tracking application and Parse application platforms for phone-to-server communication. Prior to undertaking this study, a map of formal (regularly collected) and informal (unmanaged dumping sites) locations were first mapped. A similar project on mapping informal waste management using GPS application was conducted in São Paulo, Brazil, by Offenhuber and Lee (2012). The project is known as the Forage Tracking project[10]. Both the Mombasa project and the Forage Tracking project targeted specific groups of informal waste pickers as data contributors.

It is unclear whether an extrinsic incentive was used, but the authors of all the projects mentioned above reported that participants participated voluntarily. Despite the

[9] http://www.epmap.org/ngo

[10] http://senseable.mit.edu/foragetracking/#toolsList

successes, these previous studies have mainly concentrated on landfill siting, reporting waste issues and mapping informal waste pickers' collection routes.

The current study differs from these works in that it focuses on mapping actual waste collection sites and wild dumping areas. Furthermore, rather than focusing on a specific group, the study focuses on obtaining data from the general public.

2.2.5 Issues surrounding VGI

There are several aspects that need to be taken into consideration when undertaking a VGI project. These aspects include legal issues, data quality and accuracy, public participation and interoperability (Scassa, 2013).

2.2.5.1 Legal issues

The potential legal issues that may arise in a VGI project ranges from intellectual property, privacy and liability (Scassa, 2013). It is a common practice for a VGI project administrator to utilize third-party platforms. These platforms often have intellectual property restrictions for example, restrictions on the use of data, restrictions to system design and layout, trademarks and rights in software. Therefore, it is essential to be aware of any terms or conditions regarding the use of these materials.

Another legal issue to be considered is the copyright of data. It is unusual for volunteers to claim copyright to data contributed through a VGI project, however, it is essential to ensure that volunteers understood that they cannot retain the ownership of the materials they have contributed (Scassa, 2013). This is to avoid possible claims of entitlement to data contributed post collection. Another material that can potentially be subject to intellectual property claims is georeferenced photographs. It is important to ensure that volunteers have necessary rights to the photographs that they contribute.

Privacy issues in relation to personal information are also of relevance to VGI projects (Harvey, 2013). This consists of any personal information connected to the contributor or other parties. For example, georeferenced pictures featuring a person or a property that belongs to an individual and metadata showing the precise location of where the picture was taken (Scassa, 2010). The project design, therefore, needs to establish privacy policies and obtain consent in relation to the collection, usage and disclosure of personally identified information.

Another legal issue to be aware of when designing a VGI project is that of liability. In VGI projects, potential liability of data quality is connected with the reliability and accuracy of collected data (Sui, 2008). Similarly, Harvey (2013) stressed that liability concerns are linked to data quality and safety of contributors by the disclosure of VGI data. For instance, in VGI projects where participants' comments and feedback are required, defamation can arise. It could be in the form of comments on a specific geographical feature with comments that might damage a reputation of an individual. Hence, Scassa (2013) suggested that disclaimers or notices regarding data quality and reliability need to be published in order to mitigate any potential liability. Another way to mitigate the issue is through establishing a screening procedure that validates text-based inputs to ensure that the information is correct prior to the publication.

2.2.5.2 Quality and accuracy issues

Two main measures of data quality are validity and reliability. Data is of good quality when it meets the requirements of its intended use (Jensen, 2016). There are three main components of data quality; accuracy, validity and reliability. Accuracy refers to the closeness of the value measured to the accepted value; validity refers to the appropriateness of the measurement use and reliability refers to the consistency of the measurement (Wiggins, Newman, Stevenson, & Crowston, 2011).

Due to the voluntary nature of VGI projects, the quality of data collected can be low given that the information is provided by participants with a diverse level of knowledge and skills (Iren & Bilgen, 2014; Mummidi & Krumm, 2008). Another substantial issue related to information quality and accuracy is information bias. According to Bégin, Devillers, and Roche (2013), information provided by contributors may contain biases given participants responses often are influenced by their interest. Other factors influencing biases including the volunteers access to and knowledge of technological tools used in the VGI projects, language used in the VGI application, cultural differences and length of time volunteers need to participate (Zook & Graham, 2007).

Errors in data and spatial analysis also affect data quality. Errors encompass imprecisions and inaccuracies of a data value (Haining & Haining, 2003). The sources of inaccuracies and imprecisions are inherited from various sources. Thapa and Bossler (1992) divided spatial data errors into three types:

1. Gross errors and blunders
2. Systematic errors
3. Random errors

Gross errors are caused by human negligence or equipment failure that leads to the wrong target or outliers being recorded. These often occur during the measurement process and data handling processes (Haining & Haining, 2003). Gross errors can be mitigated through repetitive observations (Thapa & Bossler, 1992). However, they may not be removed systematically. Systematic errors are either personal, instrumental or methodological mistakes that causes data to deviate in one direction from the true value. An instrumental error occurs when a measurement value drifts away from the standard or the true value. A methodological error transpires when wrong indicators are used for certain measurements, and personal error occurs when an observer constantly recording wrong values or misapplies a classification (Burrough, McDonnell, McDonnell, & Lloyd, 2015). Random errors are unpredictable errors caused by variations in the measurements used. Random errors are always present in any measurement and often associated with precision (Heuvelink, 1998).

2.2.5.3 Motivation and incentives

As VGI relies on inputs from participation, it is important that participants' motivation is considered during project development. User motivation refers to their willingness to contribute to VGI projects and greater collective knowledge (Budhathoki & Haythornthwaite, 2013). Several motivating drivers according to Coleman et al. (2009) include interest of helping others (altruism), personal or professional interest to engage in activities that stimulate greater intellectual effort, or a personal interest in gaining social reward or reputation. There can also negative motivation which can include to harm others, to pursue a political and social economic agenda, and to pursue a criminal intent. Sharing the same view are Ingensand et al. (2015), however, the authors classified user motivation according to two sources: intrinsic and extrinsic motivations.

The intrinsic drivers range from personal satisfaction, recreation, and or freedom of speech. Examples of projects driven by intrinsic drivers are eBird[11] and Artportalen[12]. Other projects known to be driven by intrinsic motivations are the Scipionus project in which people collaborated to map a flood zone caused by hurricane Katrina in 2005 in New Orleans, and the WikiProject relating to the Haiti earthquake[13] (Tulloch, 2007). In fact, Nov, Arazy, and Anderson (2011) note that intrinsic motivations are pivotal factors that encourages participation in crowdsourcing projects, and drives participants to engage longer.

Extrinsic motivations according to Ingensand et al. (2015) are motivations that are triggered by external forces mainly to earn a reward or grades. On the other hand, Parker (2014) suggests that users' motivations are prompted by various multidimensional aspects including emotional connection to the project, overall benefit of the project, knowledge acquisition, as well as legal, moral and social values. Parker (2014) further noted that participation is key to successful implementation of a VGI

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[11] https://ebird.org
[12] https://www.artportalen.se/).
[13] http://wiki.open- streetmap.org/wiki/WikiProject_Haiti

project, therefore, it is important to keep volunteers motivated and stimulated to contribute.

There are various ways to recruit participants and keep them engaged in a VGI project Tweddle, Robinson, Pocock, and Roy (2012) discuss strategies for disseminating VGI project information and ways to recruit participants. Commonly VGI projects are promoted through email, social media, and press. However, Composto et al. (2016) found little success in using these platforms. The authors suggest that participant's interest is stimulated through the development of project goals, the direct benefits that the project provides or use a gamification technique. These suggestions also noted by Haklay et al. (2014) and See et al. (2016). In contrast, Budhathoki and Haythornthwaite (2013) recommend the use of a combined method of media campaigning and side events such as conferences and workshops, to describe the aims of the projects as well as for gaining volunteer interest.

Meanwhile, Aristeidou, Scanlon, and Sharples (2017) argue that factors that engage volunteers in citizen science projects are volunteers' attitudes towards the project, as well as satisfaction and the sense of belonging. Hence, the authors propose that project designers should consider developing a software platform that recognizes active participants through the provision of feedback and support, and allowing participants to be mentors for newcomers. This, in turn, would create a sense of belonging and encourage participants to remain involved in the project.

2.2.5.4 Digital divide

Other participation issues that need to be considered are the selection and application of VGI tools. VGI's reliance on technologies such as web services and mobile phones may create a digital divide and hinder participation by specific groups such as people with disabilities, the elderly, or those lacking financial capacity to pay for connection costs (Giff & Coleman, 2002; Newman et al., 2010). Haworth, Bruce & Middleton (2015) noted that VGI projects often participated by tech-savvy, male, and young educated individuals. Hence, project design must ensure that these issues are considered prior to project implementation.

2.2.5.5 Interoperability

Due to the diversity of the contributors and their level of knowledge and abilities, VGI collected data could potentially have higher levels of semantic heterogeneity (Sui, Goodchild, & Elwood, 2013). This is mainly because how each participant views a feature is different in terms of size and quantity. It would be challenging to integrate VGI data with other sources. This project, therefore, needs to develop a clear structure of how data is to be recorded, in order to address this issue.

2.2.5.6 Quality assurance and data validation

There are various methods that can be used to validate data and ensure quality. For geographic data quality, the standards ISO 19113:2002 and ISO 19114:2003 are often used to define data quality related to the positional accuracy, consistency, completeness, and lineage (Bordogna, Carrara, Criscuolo, Pepe, & Rampini, 2014). Alongside this, given VGI involves using the web and relies on volunteers' contributions, it is imperative to ensure that the collected data is of good quality.

There are various approaches to ensuring quality information is obtained through VGI projects. Some of the approaches involve identifying factors that contribute to poor data quality, and the implementation of policies to mitigate errors and biases (Bordogna et al., 2014; Fonte, Bastin, See, Foody, & Lupia, 2015; Wiggins et al., 2011). Factors contributing to poor data quality include the differences in level of knowledge and expertise, participants commitment and willingness to take part in the project, the technology and the data collection methodology adopted (Bordogna et al., 2014).

To ensure quality control, various work presented frameworks with distinct features and techniques that can help project designers to validate inputs. Wiggins et al. (2011) suggest identifying errors at the source (participants) by establishing data quality assessment protocols using three intervention points: *before, during and after participation*. A similar concept is proposed by Fonte et al. (2015), however, this framework does not only focus on data, but also concentrates on assessing participants' credibility at every stage of VGI creation, including the *conception phase; the acquisition phase; and the post-acquisition phase.*

Bordogna et al. (2014) recommend a framework that concentrates on evaluating data quality based on three qualities: *extrinsic, intrinsic and pragmatic*. In contrast, Goodchild & Li (2012) present three approaches for VGI quality assurance: *crowdsourcing* (assessment by group), *social approach* (assessment by hierarchical structure), and *geographical approach* (assessment by geographical knowledge). The *crowdsourcing approach*, focuses on using groups to validate data and correct errors. The *social approach*, which emphasizes the need to set a hierarchical management structure for experienced participants to validate observations of others, and the *geographical approach* that focuses on comparing participants' contributed data to the existing geographical data.

The crowdsourcing approach is also suggested by Daniel, Kucherbaev, Cappiello, Benatallah, and Allahbakhsh (2018), however, the authors propose a rating technique using individuals or groups to select best outputs. Additionally, the authors recommend using computation-based techniques, where a machine is used to compare sets of outputs with pre-defined answers.

Involving groups or experts in verifying inputs (peer verification) can potentially increase the reliability and trustworthiness of the data obtained. However, Leibovici et al. (2017) argue that this method can be inefficient when there are large amounts of data involved. Therefore, they propose designing quality assurance based on project objectives. Their measure involves setting protocols to identify sources of variability and quality through various requirements implemented at different data collection stages: at data capture level, a *priory* quality assessment, a *posteriori* quality assessment and a *hic and nunc* (interactive quality assessment). Detailed information including techniques involved in these frameworks are presented in the Table 2-1.

Quality Control Frameworks

Quality control approach	Techniques involves	Literature
Assessing data quality by setting protocols to assess data at the source using three intervention points: *before, during and after participation*	Before: • Quality assurance project plan • Participant training • Participant testing During: • Repeated samples/tasks • Participant training • Participant testing • Rating participant performance • Cleaning unusual data (filtering) • Request submission of paper sheets • Digital proof (e.g photos, audios) After: • Performance rating • Cleaning unusual data (filtering) • Follow up on errors • Apply automatic recognition techniques • Perform expert review • Verifying data using other sources • Normalizing, mining and documenting quality assurance process	(Wiggins et al., 2011)
Assessing data quality based on three qualities: *extrinsic, intrinsic and pragmatic.*	Extrinsic quality (contributor's credibility): • The organization the volunteer belongs to • The organization's role in the project • The volunteer's role and expertise Intrinsic quality (validity)	(Bordogna et al., 2014)

	• Validity of measurements • Validity of a spatial component • Validity of categorical information • Temporal validity • Textual validity Pragmatic quality • User needs and intended purposes	
Assessing data quality by performing quality control at every stages of VGI creation, which include the *conception phase; the acquisition phase; and the post-acquisition phase*.	Conception phase • Determine volunteers based on their profiles • Training and instruction materials for volunteers • Establish protocols for data redundancy • Establish the point of reference or the 'gold standard' data • Establish procedures for making contributed data available to crowd • Recording metadata (e.g. locational accuracy from the device used, information about volunteers such as age, position, education level, skills and expertise in the subject area) • Restrictions on contributions Acquisition phase: • Collecting metadata (checking contribution using majority rules, corrective feedback) • Collecting the information on volunteers degree of confidence in the data they provide • Establishing real- time quality control procedures by applying a form of corrective feedback • Deploy an easy to use VGI portal or website	(Fonte, Bastin, Foody, et al., 2015)

	Post-acquisition phase: • Assess respondents' credibility • Assess the reliability of the VGI tool • Establish quality control (either by the crowd or selected volunteers) • Establish quality control or validation by experts	
Quality assurance using crowd-sourcing, social, and geographic approaches	Crowdsourcing approach – using a group of people to validate data submitted by respondents Social approach – using experienced participants (according to a hierarchal structure) to validate submissions Geographical approach - using broader geographic knowledge (authoritative data) to verify whether the information provided is in accordance with the normal practice in the real world	(Goodchild & Li, 2012)
Assessing quality through the use of three actors: individual, group, and computation-based	Individual Participants involved rate the output (data obtained) Group Multiple participants peer review several examples of input, rate and select the best Computation-based: Using a machine to compare set of outputs with a pre-defined correct answer	(Daniel et al., 2018)
Setting protocols to identify sources of variability and quality through various requirements implemented at different	Data capture level - Setting validation rules within the data collection app (e.g. extracting data according to specific established criteria)	(Leibovici, Rosser, et al., 2017)

stages: at data capture level, a *priory* quality assessment, a *posteriori* quality assessment and a *hic and nunc*	- Use of simple user interface design - Pilot study *Priory* quality assessment - Setting preventive mechanism prior to data collection *Posteriori* quality assessment - Correcting and comparing data after data collection *Hic and nunc* (interactive quality assessment) - A process that occurs between priori and posterior (e.g. asking volunteers to perform another task to validate previously entered inputs)	

TABLE 2-1: DIFFERENT FRAMEWORKS FOR QUALITY CONTROL

Leibovici et al. (2017) also set out a quality assurance framework based on the Citizen Observatory WEB (COBWEB) FP7 project[14] with seven (7) pillars formulated to assist citizen science project designers to establish quality assurance (refer to Table 2-2). This 7 pillars framework is an extension of quality assurance set out in the study of Goodchild and Li (2012).

The Seven Pillars of Quality Assurance in Citizen Science Project

Pillar Name	Pillar Description
1. Location-based-services (LBS)-Positioning	Location, position, and accuracy: *Location-Based-Services focusing on the position of the volunteer and of the targeted feature (if any), local conditions, or constraints, e.g., authoritative polygon, navigation, routing, etc.*
2. Cleaning	Erroneous entries, mistakes, malicious entries: *Erroneous, true mistakes, intentional mistakes, removals, and corrections are checked for the position and for the attributes. Feedback*

[14] https://cobwebproject.eu/

Pillar Name	Pillar Description
	mechanism can be an important part of this pillar if the mistakes can be corrected.
3. Automatic Validation	Simple checks, topology relations, and attribute ranges: *Carries further the cleaning aspects by validating potential good contributions. Its aim is towards positive rewarding with more inclusive rules than with Pillar 2, focusing more on excluding rules.*
4. Authoritative Data Comparison	Comparison of submitted observations with authoritative data: *Either on attributes or position performs a statistical test, a (fuzzy) logic rule based test, qualifying the data captured, or reversely qualifies the authoritative data. Knowledge of the metadata of the authoritative data is paramount.*
5. Model-Based Validation	Utilising statistical and behavioural models: *Extends Pillar 4 testing to modelled data, e.g., physical model, behavioural models, and other volunteer contributed data within the same context. This may use intensively fuzzy logics and interactions with the volunteer within a feedback mechanism of interactive surveying. (If some tests are similar to Pillar 4, the outcome in quality elements can be different)*
6. Linked Data Analysis	Data mining techniques and utilising social media outputs: *Extends Pillar 5 testing to using various social media data or related data sources within a linked data framework. Tests are driven by a more correlative paradigm than in previous pillars.*
7. Semantic Harmonisation	Conformance enrichment and harmonisation in relation to existing ontologies: *Level of discrepancy of the data captured to existing ontology or crowd agreement is transformed into data quality information. In the meantime, data transformation to meet harmonisation can take place*.

TABLE 2-2: THE 7 PILLARS OF QUALITY ASSURANCE IN CITIZEN SCIENCE PROJECT

Adapted from "On data quality assurance and conflation entanglement in crowdsourcing for environmental studies," by Leibovici et. al (2017, p.7)

To compensate for any weaknesses found in any quality assurance framework, participants trustworthiness can be used to validate citizen science data (Leibovici, Williams, et al., 2017). The stakeholder quality model proposed by Meek, Jackson, & Leibovici (2014) in Table 2-3 summarizes various dimensions related to participants trustworthiness and elements that qualify their contributions.

Quality Elements of Active Volunteers

Quality element	Definition
Vagueness	Inability to make a clear-cut choice (i.e., lack of classifying capability)
Ambiguity	Incompatibility of the choices or descriptions made (i.e., lack of understanding, of clarity)
Judgement	Accuracy of choice or decision in a relation to something known to be true (i.e., perception capability and interpretation)
Reliability	Consistency in choices / decisions (i.e., testing against itself)
Validity	Coherence with other people's choices (i.e., against other knowledge)
Trust	Confidence accumulated over other criterion concerning data captured previously (linked to reliability, validity and reputability)

TABLE 2-3: QUALITY ELEMENTS OF ACTIVE VOLUNTEERS FOR THE STAKEHOLDER QUALITY MODEL

Adapted from "A flexible framework for assessing the quality of crowdsourced data," by Meek et.al (2014, p.2)

2.2.6 Conclusion

VGI systems have already proved useful for applications where participatory data and knowledge are required in the decision-making process including in emergency situations. Furthermore, as VGI projects not only reduce cost but provide data during time-sensitive situations, enabling democratic inclusion, interaction, and participation, they have increasingly been used as an alternative data collection tool in both developed and developing countries. Although VGI is evidenced to have many advantages, there are still various significant issues that need to be considered before embarking on a VGI project. These include data quality and accuracy, barriers to participation (digital divide) and data interoperability issues. While VGI has successfully been applied as an alternative data source in various sectors, its application in solid waste management is yet to be explored comprehensively. In addition, its application in developing countries is yet to be investigated widely. These limitations form the basis of this research study.

2.3 Methodology

This section describes the methodology used in this research. It covers steps involved in the data collection throughout to the analysis.

2.3.1 VGI data collection method

This research study utilizes the VGI data collection method, where citizens (volunteers) act as sensors and actively collect and record data (Coleman et al., 2009). This approach was deemed appropriate for the intended purpose of this study given one of the objectives of this study is to obtain geographical locations of waste collection sites. Furthermore, the VGI data collection method has been widely used in crowdsourcing projects that require participants to identify and observe a feature, and submit the observation report through a web interface. Data collection is conducted by the use of a web-based survey questionnaire.

2.3.2 Questionnaire construction

A questionnaire refers to a written list of questions, to which respondents are expected to record their answers (Kumar, 2014). The questionnaire comprises a mix of closed-ended and open-ended questions. The closed-ended questions provide the options for participants to select from rating scales or a choice of yes or no. Open-ended questions allow participants to provide additional comments and feedback. In order to obtain wider participation, the survey was developed in two languages: English and Tetun (one of Timor-Leste's official languages). Tetun is the *'lingua franca'* of Timor-Leste which is widely spoken. English is spoken by approximately 15% population (General Directorate of Statistics, 2017). Information and instructions for completing the questionnaire were in English and Tetun. Both versions were tested prior to the actual campaign. Two videos were also made, in Tetun, explaining how to answer each survey question. The videos can be found on Youtube at https://youtu.be/Guoxrr9cdck and https://youtu.be/vqd0NDv0NKI.

This study has two sets of questionnaire. The first questionnaire are developed from the categories of information below:

- Demographic information: general information about the participant
- Recycling knowledge, attitudes and practices: participants' knowledge of recycling and their willingness to pay if the collection services were taxed
- Awareness of solid waste and its impact: participants' awareness of the impact of unmanaged waste to their health and the environment
- Waste collection site: questions related to where and how participants dispose of their rubbish, the types of waste they found in the collection sites, the quantity, and how effective is the current collection service

The second questionnaire asked participants to identify other collection sites in Dili. This section focuses specifically on the collection of the geographical location of the sites, the types of waste found and the quantity of waste. Figure 2-2 shows the flowchart of the survey process.

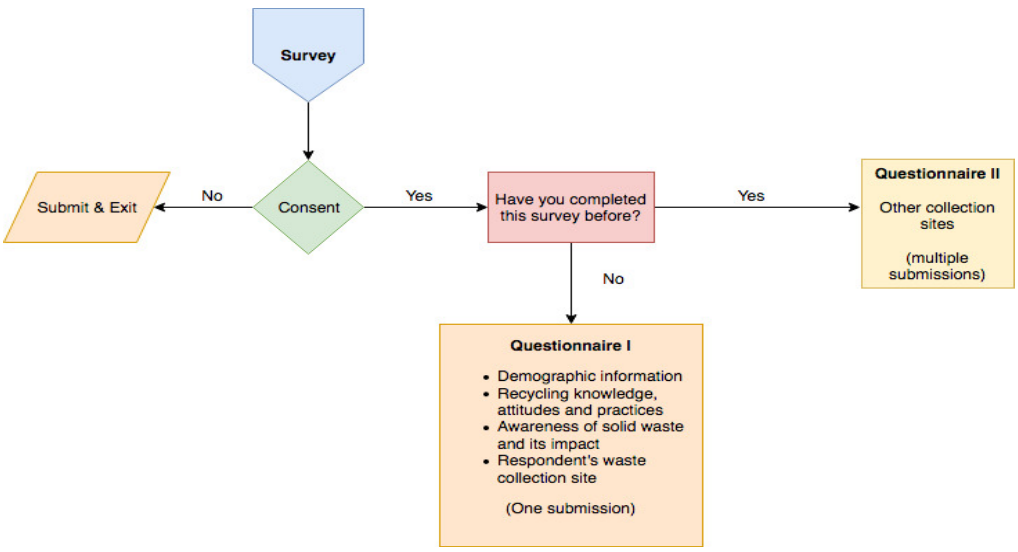


FIGURE 2-2: SURVEY COMPLETION FLOWCHARTS

2.3.2.1 Demographic information

Demographic data provides information on the group of people using three different types of waste collection sites (municipality's allocated bin/waste, wild site, and home collection service) in Dili. In this study, three particular datasets of demographic information were collected: age, gender, and employment status. This demographic information is essential in determining the overall composition of people who have access to the government operated waste collection sites and those who have not. This information also provides context to decision making by local authorities.

In particular, a question on the employment status was asked as an indicator to determine participants' capacity to pay for waste collection services if it was taxed based on their employment background.

2.3.2.2 Recycling Knowledge, attitudes and practices

Participants were asked about their knowledge of recycling and whether they think it is important to have recycled materials separated from other waste. In this section, participants were also asked if they would be willing to pay for the collection services if it is taxed, as well as the amount they would be willing to pay. These questions were asked to investigate participants' perceptions regarding a taxable waste collection service.

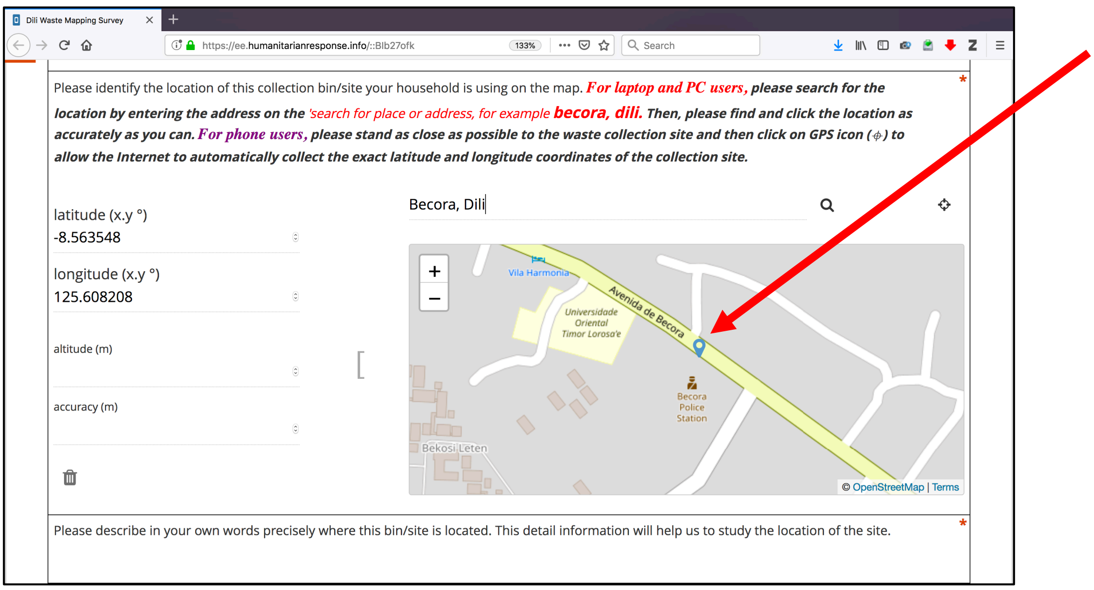
2.3.2.3 Awareness of solid waste and its impact

Two questions were asked relating to participants awareness of solid waste and its impact to their health and the environment. The questions were asked in order to understand whether people are aware of the risks associated with improper waste management.

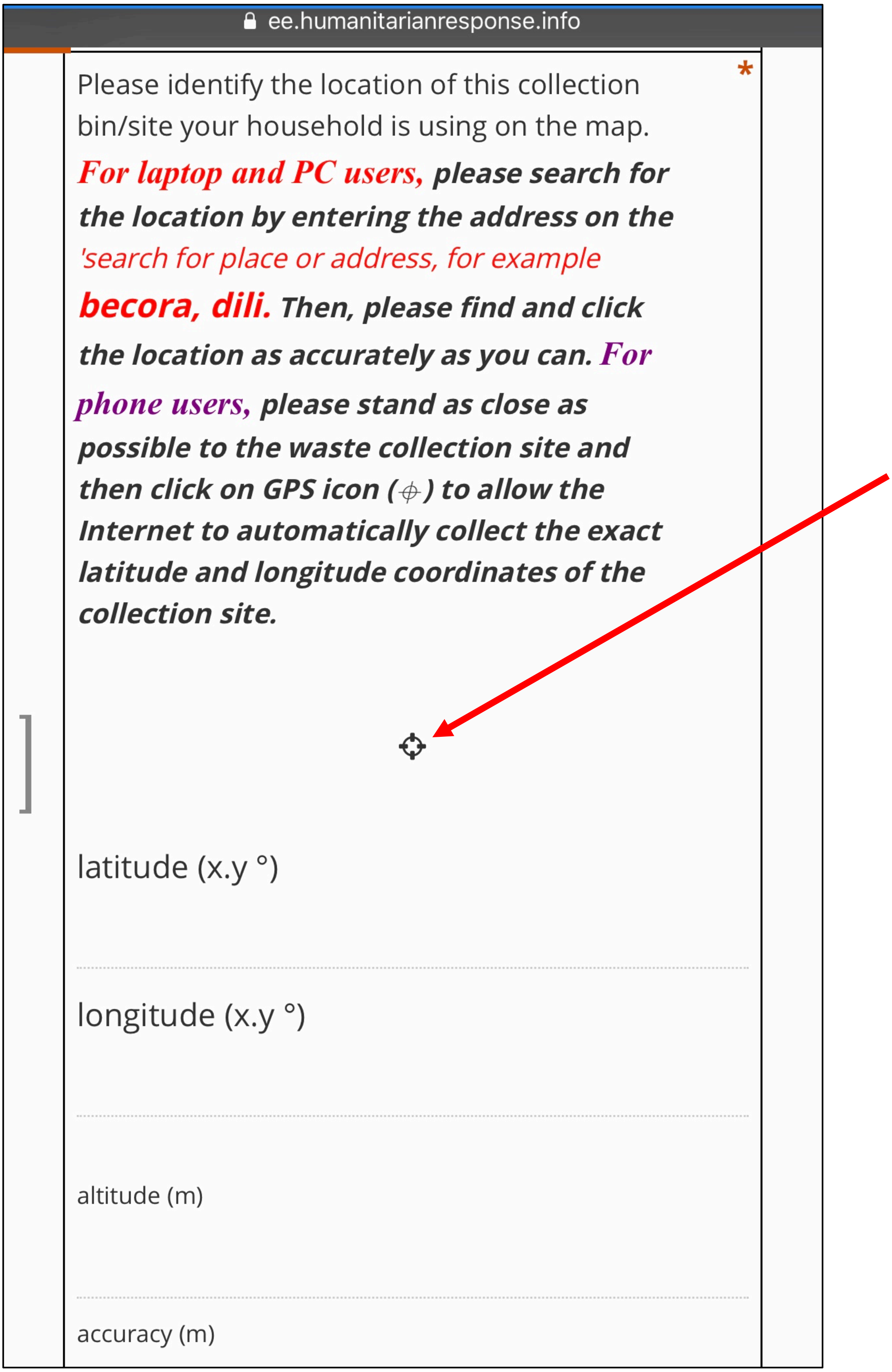
2.3.2.4 Waste collection site

The questions in this section were developed to gather information on whether crowdsourcing data collection method can effectively be used to obtain data on solid waste disposal and collection practices in Dili. First, participants were asked about how their household disposes of rubbish, which site they use, and whether they are satisfied with the overall condition of the site. Participants were then asked to mark the location of the collection site on a map if they use a computer or collect the location using the GPS in their mobile phones (example as indicated by the red arrows, as shown in Figure 2 -3).

Additionally, respondents were asked to describe the precise location of the site in their own words and describe the types of waste and the volume of waste it contains when they last saw it.



Computer view



Mobile phone view

FIGURE 2-3: INSTRUCTIONS ON HOW TO COMPLETE THE QUESTIONNAIRES

To ensure that good quality responses are obtained in a timely manner, the questionnaire has been kept simple, clear and as short as possible. The full survey questions used by this study can be found in Appendix 1 and 2 or can be accessed at https://ee.humanitarianresponse.info/single/::BIb27ofk

An example of the questions is shown in Figure 2-4.

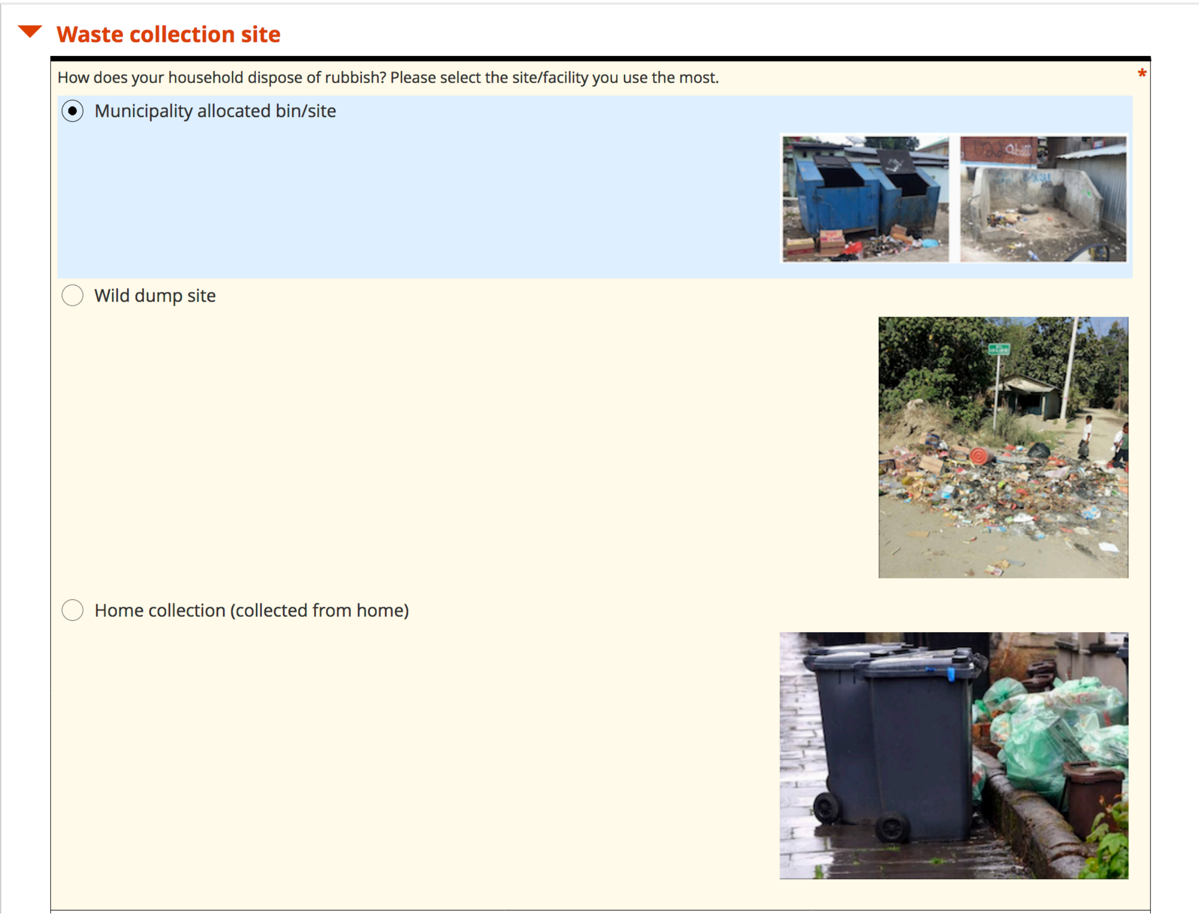


FIGURE 2-4: SAMPLE QUESTION

Sample of the question that asked participant to mark the location of solid waste collection site is displayed in Figure 2-5.

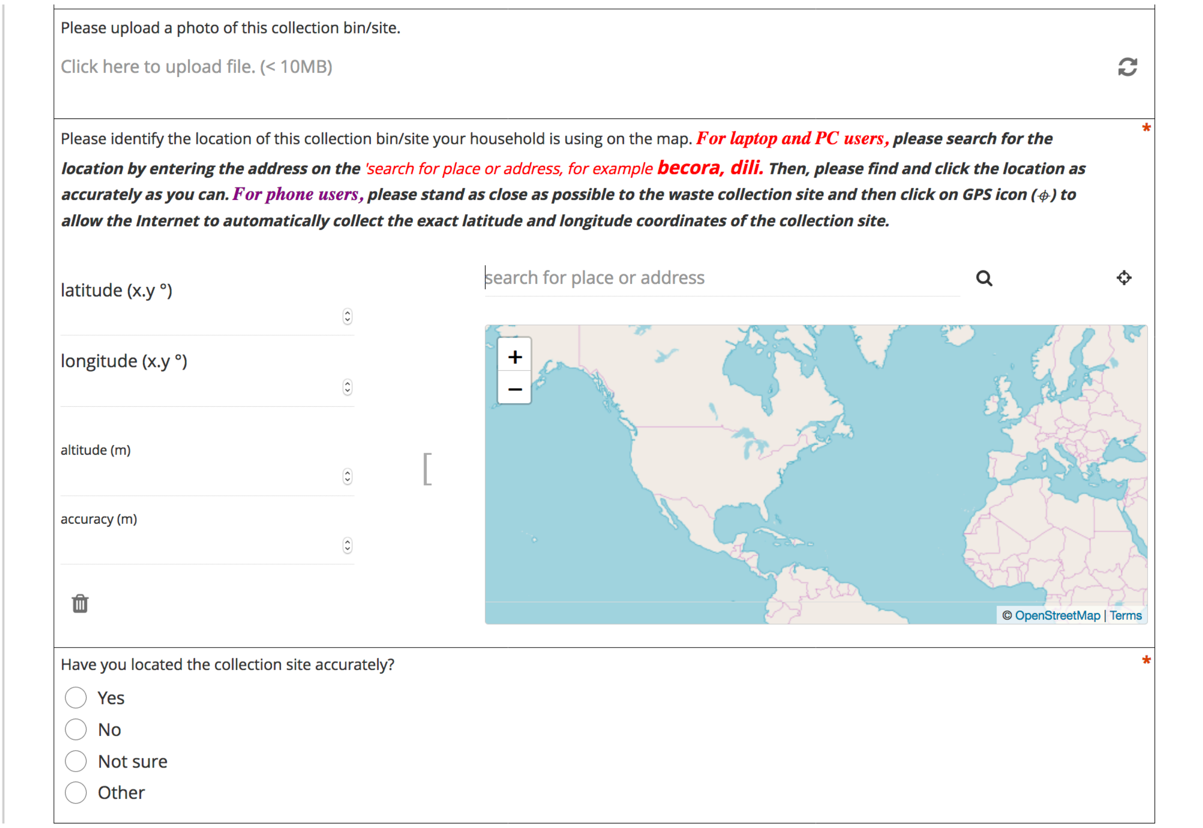


FIGURE 2-5: LOCATION SPECIFIC QUESTION

2.3.3 Participants

The participants for this study were residents of Dili, including permanent and temporary residents. An incentive (a $100 cash prize draw) was offered to those who participated. Participants consent was also sought prior to responding to survey questionnaire. The consent included the element such as a statement about their voluntary participation, information about the purpose of the research, its duration, and procedures involved, expected benefits, legal issues regarding intellectual property, anticipated risks, as well as the researcher's contact information.

Participation in the research was anonymous, however, the contributors were given the option to either allow or disallow the researcher to conduct a follow-up after a response had been submitted by providing an email address. Although participation is anonymous, the study involved people, therefore, ethics approval was sought. The project was evaluated by peer review and judged to be low risk therefore only low risk approval was obtained and it was not submitted to the University's Human Ethics Committee.

2.3.4 Data collection process

This project employs a project-oriented model for data collection, meaning the activities involved in this stage encompass three consecutive steps: testing (pilot), project advertising including the approach to respondents, and the actual data collection.

Pilot

Two pilot tests were conducted to ensure the usability of the application and the clarity of the questionnaire. The usability testing involved checking users' ability to install the survey application (KoboCollect) in their android phones, and to access the survey questionnaire via a web browser. The survey questionnaire was also tested to find out whether the questions are clear and easy to follow.

Participants in the pilot testing were four NZAID scholars currently studying at Massey University, as well as four friends currently living in Dili.

Eight people in total participated the pilot. Several minor changes were proposed, which were mainly related to the Tetun translation.

Advertisement

Campaign materials together with a guideline (Appendix 2) about how to respond to the questionnaire were disseminated through Facebook and printed fliers. A Facebook page entitled 'Dili waste mapping' was created to advertise the survey. Printed fliers were disseminated at three universities namely the National University of Timor-Leste (UNTL), Dili Institute of Technology (DIT) and Universidade da Paz (UNPAZ).

The Ministry of State Administration and several local organizations was contacted for support to advertise the survey. However, only three local organizations responded namely Hopeseller, Permatil and Oasis. These organizations disseminated the survey to their networks via emails and Facebook. Two of Dili's local television networks and a local radio station were contacted, however, only the radio station, Radio Voz, responded.

Approach to engage participants

Although the survey conducted for this study is on a one-off basis, participants were expected to mark the locations of many more collection sites they found in Dili by completing the second questionnaire. Previous works documented that one of the challenges in crowdsourcing is keeping participants interested (Budhathoki & Haythornthwaite, 2013; Coleman et al., 2009; Zeng, Tang, & Wang, 2017). Therefore, in order to attract volunteers and keep them engaged throughout the data collection process, a varied approach was utilized. The engagement strategy includes:

1. Clearly defining the goal and objectives of the project in the survey particularly in the information section
2. Provision of incentive in the form of random drawing of monetary gift

3. Advocating the project as a medium for participants to share their knowledge about current solid waste management practices
4. Advocating the project as a channel for participants to voice their recommendations that could possibly trigger improvements
5. Promoting the project as a medium, for participants to learn new knowledge that may help to advance their career
6. Engaging participants in the project by continually updating them on project progress, particularly about the number of submissions received and the number of collection sites identified.

Strategy numbers 3 to 6 were carried out via the '**Dili Waste Mapping'** Facebook page (https://www.facebook.com/Dili-Waste-Mapping-2272842716323760/?modal=admin_todo_tour)

Data collection

Data collection occurred over two months, starting from November 8 to January 12. During this time, the researcher remained available via email and social media (Facebook and WhatsApp) so that participants could make contact if required for any information or clarifications. At least ten participants asked questions but mostly from Facebook. The most queried information was related to how to access the survey using smartphones. Several Samsung users reported they were not able to access the survey. This problem was solved by updating the web browser. Other question asked was whether the survey can be completed while they were abroad.

2.3.5 Technical design

In order to fulfil the objectives of the data collection, the following technical infrastructures were required:

- Data collection application: a form-centric data collection application that could capture geographical locations as well as recording images, furthermore, allowing data collection using mobile devices such as mobile phones and tables, and computers.
- High-resolution maps: a data collection tool allowing users to navigate high-resolution maps of the study area to help them locate solid waste collection sites accurately.
- Location search: allowing users to navigate the map and identify locations, it was important that the tool allowed users to search location by addresses or other referential features.
- Geo point location: a tool having the functionality to record geo point location by the latitude and longitude of waste collection sites.
- Online and offline data collection: since internet connectivity can be a challenge in some areas of Dili, such functionalities were desirable.

2.3.5.1 Survey platform

We assessed four commonly used platforms for VGI projects as potential tools for this project. These platforms were Kobotoolbox, ArcGIS online platform from ESRI, QMAP from QGIS and Ushahidi. Previous VGI projects related to solid waste management have mainly used Kobotoolbox, ArcGIS platform and Ushahidi. The similarities and differences between these three platforms are summarized in the Table 2-4 below.

VGI Data Collection Platforms

	Kobotoolbox[15]	123Survey Arc GIS[16]	QMAP QGIS[17]	Ushahidi[18]
Data collection style	Form centric	Form centric	Form centric	Form, SMS, email, and Twitter
Supports capturing new data	Yes	Yes	Yes	Yes
Supports editing existing data	Yes	Yes	Yes	Yes
Smart forms	Yes	Yes	Yes	Yes
Works offline	Yes	Yes	Yes, but a syncing option is required	Yes
Platforms	iOS, Android, Windows (7,8,10), Mac, Linux, Web	iOS, Android, Windows (7,8,10), Mac, Linux, Web	Windows-based	iOS and Android
Technical support	Kobotoolbox community	Esri and community	QMAP community	Ushahidi community
Cost	Open source	Proprietary	Open source	Open source but requires payment for customized features

TABLE 2-4: DIFFERENT TYPES OF DATA COLLECTION PLATFORMS

Kobotoolbox was chosen for this research because of its ability to store and visualize spatial information. The platform also has the ability to collect and display crowdsourced information in real-time, making it useful for this study since a core

[15] https://www.kobotoolbox.org/
[16] https://survey123.arcgis.com/
[17] http://nathanw2.github.io/qmap/
[18] https://www.ushahidi.com/

component of this study is to continually update contributors on spatial data collection progress. Kobotoolbox also allows data to be collected through web browsers and mobile phones (Android and Iphones). Moreover, Kobotoolbox provides functionalities to create forms in multiple languages, to collect spatial data (points, polylines, and polygons) to record coordinates using GPS. Lastly, Kobotoolbox was chosen among others because it is an open source platform that is free, easy to set up and deploy.

Kobotoolbox, however, is not equipped with a high-resolution image. Given the cost constraints for available aerial photography, an additional study was conducted to investigate whether people can identify locations accurately using OpenStreetMap or a lower resolution image. The study result shows that people can still identify locations accurately if they are familiar with the area. Thus, the study proceeded to use an OpenStreetMap. Details about the study to select the background map is presented in Chapter 3.

2.3.5.2 Kobotoolbox survey form

Once the survey platform was selected and the questionnaire was developed, the survey form was created using Kobo's form builder. Kobotoolbox allows forms to be created using either form builder or by importing from an external file in the XLSForm format. The survey form can be accessed through either web browser or by using the KoboCollect application on Android devices. Data collected were immediately available while being submitted by the respondents and can be downloaded in xml. csv, spss, zip (for photos, audio and video files), and kml (for GPS point files) for analysis and reporting. Figure 2-6 shows an overview of the Kobotoolbox data collection systems.

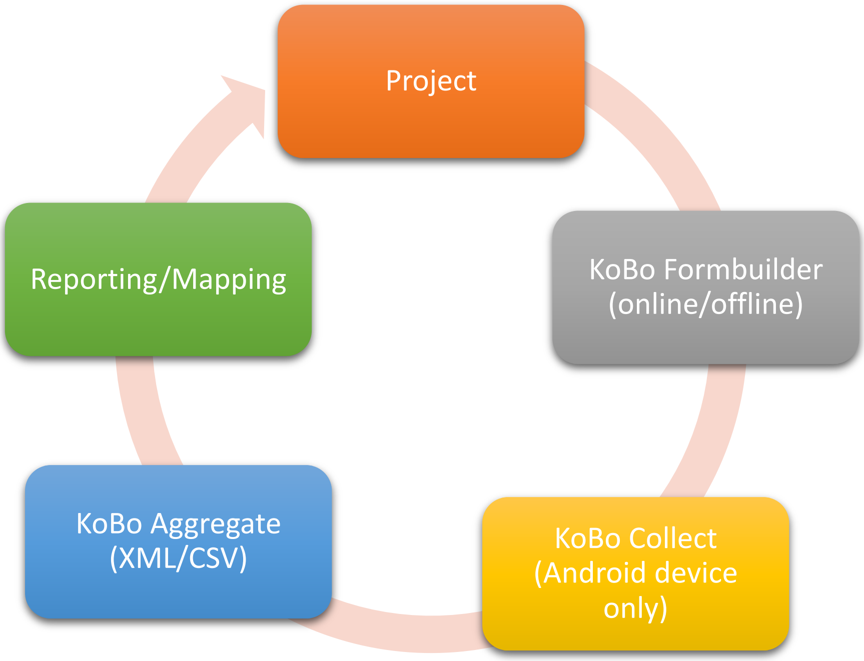


FIGURE 2-6: KOBOTOOLBOX DATA COLLECTION SYSTEM

Diagram drawn by researcher based on the information collected from https://www.kobotoolbox.org/

2.3.6 Data analysis

Data attributes assessed in this study include completeness, validity, accuracy, and consistency. Completeness focuses on ensuring whether all data items are recorded.

Validity determines whether data is valid and conforms to the syntax (e.g. format, type, range). Accuracy refers to whether the data values stored for an object are the correct values. Consistency defines whether the input to a particular question is similar to the input from other respondents.

This study adopted data quality assessment criteria from Goodchild & Li (2012) to measure geographic information data quality. These essential elements are positional accuracy, attribute accuracy, logical consistency, completeness and lineage. *Positional or spatial accuracy* refers to the accurate allocation of coordinates obtained from participants compared to the real world. *Attribute accuracy* pertains the additional information that describes the object observed. *Logical consistency* refers to the relationship between the values of related attributes. *Completeness* is referenced to the data obtained or found in the data set that must meet the criteria set in the database. *Lineage* refers to the metadata of a dataset that contains information such as the currency, accuracy, data content, and attributes, etc. The attributes such as the logical consistency, attribute accuracy, completeness, and lineage are established through the validation techniques in the data collection tool.

With regard to positional accuracy, for the participants who chose to use their mobile phones, it was expected that the phones will determine the approximate location of the solid waste collection site observed. However, in instances where the location was not captured automatically, self-assessment was made based on the following criteria:

1. The solid waste collection sites identified need to be located on the side of the road or streets. An exception applied to waste collected from home
2. Locations identified with great distance from the road or streets were considered invalid

1 Location marked that did not match textual descriptions were discarded
2 Locations identified out from area of interest (AOI) were discarded
3 Locations identified in close proximity to each other that were suspected to be referring to the same collection site were filtered by using the images submitted by participants

2.3.6.1 Data Quality Assessment Measures

In order to measure the effectiveness of crowdsourcing data collection methodologies, certain benchmarks need to be developed. This project employs the *contributory project* model, where the project is designed by the researcher while volunteers' participation is limited to providing data. Therefore, effectiveness is measured by output (data) quality and quantity. The output quality is dependent upon various aspects including, the peoples' (volunteers) abilities and credibility, the description of the tasks, the incentives provided and protocols established to detect errors (Daniel et al., 2018). For quality assurance, this study adopted various techniques derived from Bordogna et al. (2014), Fonte et al. (2015) Goodchild & Li (2012) and Wiggins et al (2011). Table 2-5 presents a summary of the quality attributes and the assessment criteria, as well as the mechanism used to ensure that the study obtains good quality data.

Quality Assessment Criteria

Quality attribute	Assessment	Quality Assurance
People	Profile, skills, abilities	Characteristics of volunteers (age, gender, location, and professional associations) Provision of instruction materials for volunteers on how to complete survey questionnaire
Data	completeness, validity, accuracy, and consistency	Use of data cleaning method to assess data based positional accuracy
Task	▪ Description (clarity, complexity)	Questionnaire easy to follow with clear and direct instructions/questions
	▪ User interface (usability, learnability, robustness)	A user-friendly survey platform that even non-technical savvy users can use with minimal training
	▪ Incentives (intrinsic, extrinsic)	Intrinsic and extrinsic motivation
	▪ Terms and conditions (privacy, Intellectual Property protection,	Non-disclosure agreement for any personal information was incorporated in the participants consent form

	information security, compliance	

TABLE 2-5: ASSESSMENT CRITERIA FRAMEWORK

Derived from (Bordogna et al., 2014; Daniel et al., 2018; Fonte et al., 2015; Goodchild & Li, 2012; Wiggins et al., 2011)

People

People in this context refers to volunteers involved in this study. The profile characterizes an individual's identity (age, gender, location) and their credibility (reputation and professional affiliations). It is assumed that volunteers participating in this study have skills and abilities to execute tasks, therefore a self-assessment strategy will be applied, allowing people to assess the quality of their own work by rating their responses. The output refers to the data that are obtained from participants through the completion of the survey questionnaire. However, participation in this survey requires basic technical skills such as the ability to browse the Internet, download the survey application to mobile phones (if volunteers wish to use their mobile phones), locating solid waste collection sites on the map and taking and uploading pictures in the survey platform.

To enhance participants' skills and abilities to participate, training materials that include guidelines about how to complete the survey were provided.

Task

Task refers to the work proposed for a crowd to undertake and other attributes such as task descriptions, user interface, incentives, and terms and conditions.

Description of tasks

The task description includes instructions on how to perform the task (or how to complete the questionnaire). In this study, participants were required to complete a survey questionnaire which include mapping the geographical location of waste collection points and uploading a picture of the site observed. Clarity and complexity of the description of the tasks, therefore, were important to determine the quality of the responses. To ensure accurate and complete responses, the survey questionnaire was designed using simple instructions that are easy to understand.

User Interface

The user interface is the application survey participants used to enter their responses. The design of the user interface determined whether the application is easy to learn and use, and whether the system is able to cope with errors during execution. Stone, Jarrett, Woodroffe, and Minocha (2005) note that a good user interface should allow users to provide information that is complete and accurate (effective), should allow a user to engage with the system with minimum effort (efficient), and should be enjoyable to use (satisfaction).

To evaluate the usability of the user interface utilized for this study, three evaluation techniques from Stone et al. (2005) were adapted. These three techniques are:

1. Observing how participants work
   The observation took place only during the testing period. Two tests were conducted to allow the researcher to make changes. Several changes proposed regarding the Tetun translations. The initial questions had included several words in Portuguese. The pilot participants suggested to change the Portuguese words in Tetun, to words that people are more familiar with. For example the question that ask about participants' employment status *'Are you currently in employment?"*. The initial translation was – *"Ita bo'ot atualmente iha*

emprego?" This was changed to "*Atualmente Ita boot serbisu ka lae*?" (Are you currently working?).

2. Examining users performance through asking questions
   During the testing process, participants were also asked about their ability and satisfaction in using the survey platform. All participants were satisfied with the survey platform and indicated that they had accurately marked the location.

Incentives

As crowdsourcing is voluntary in nature, often incentives are paid to attract and stimulate volunteers' participation. There are various incentives targeting the extrinsic (reward-driven) and intrinsic (interest-driven) motivation of volunteers. However, according to Hossfeld, Keimel, & Timmerer (2014) extrinsic motivation leads to faster task completion, while intrinsic motivation leads to higher output quality. This study applied both intrinsic and extrinsic methods. The intrinsic motivation was the encouragement that this study will inform the decision makers to improve the current solid waste management in Dili, while an incentive was offered as the extrinsic reward.

Terms and Conditions

There are also terms and conditions that govern the relationship between the crowdsourcing project initiator and the crowd. These general rules include privacy of participants, the protection of intellectual property (IP), compliance with laws, and ethical standards. To ensure participants' contributions were protected, the researcher informed participants about the strict protection of any personal information provided throughout the study. Furthermore, participants were informed about how the data obtained would be used.

2.3.6.2 Data Analysis Tools

The survey questionnaire focused on obtaining data on three important elements: solid waste disposal and collection practices, the effectiveness of the current waste collection system and citizens' awareness of the impact of waste disposal practices. Therefore, the spatial analysis of responses were carried out using Quantum Geographic Information System (QGIS)[19]. Meanwhile, descriptive statistics such as demographic variables and data related to awareness and the impact of waste disposal practices were analysed using statistical analysis tools (SPSS). For the text-based responses in which participants were asked to input their opinions, comments, and feedbacks, keyword analysis were applied. Thematic groupings were assigned to the types of responses based on their frequency.

2.3.7 Method limitation

Given the nature of VGI, participation is voluntary. Therefore, some participants may have contributed more than the others. As noted by Foody et al. (2015), the inequality of participation and bias in user generated content is expected. The data obtained may also be spatially biased due to the social divide, in which higher contributions often made by tech-savvy, male, educated individuals (Haklay, 2013; Haworth, Bruce, & Middleton, 2015). Biases in user-generated content have been assessed as significant issues by other studies including highly successful projects such as Wikipedia and OSM (Foody et al., 2017; Haklay 2013). For example, Wikipedia's active users are reported to only generated around 3.5% of its content (He, 2015), and only 10% of registered OSM users contributed content actively (Neis & Zielstra, 2014). This study did not collect data concerning participants details, educational level, and technical skills. Therefore, it was difficult to assess the representability of participants in detail. Due to these limitations, the finding of this study can be treated as explorative research only. Further research needs to be taken to make definitive findings.

[19] https://www.qgis.org/

2.4 Results

This section presents the results of the survey. The results are divided into four main parts: demographic, information about solid waste disposal and collection practices, citizens' awareness of the impact of waste disposal practices, and spatial location of solid waste collection sites.

2.4.1 Demographic

Demographic information is collected to understand whether there was any bias in the group of survey respondents relative to the general population of Dili. The survey was initially scheduled to take place between 8 November and 31 December 2018. However, due to the low responses during the Christmas holidays, the survey was extended to January 12th, 2019. 99 people completed the whole part of the survey. 37 of those participants completed the second part of the survey which focuses on marking the location of additional collection sites in Dili. Each person made on average 2.27 submissions. A total of 186 submissions were received including 3 respondents that later opted not to participate. Details are shown in the Table 2-6 below.

Description	Number of participants	Number of submissions
Survey + respondents' collection site	99	99
Location of additional collection sites	37	84
Declined to participate	3	3
Total		186

TABLE 2-6: NUMBER OF RESPONDENTS

The participants who completed the survey were aged between 16 and 64. The highest number of respondents were between the age range of 25 and 34 followed by those between the age of 35 and 44. This is probably due to high number of smartphone and technology use by this age group. The least proportion of respondents are between the age of 45 and 64. No response had been received from participants between 65 and 74, and 75 and above. Results are based on 99 responses.

To ensure that the sample was representative of the population, the respondents were compared with the population based on age groups. The analysis revealed that the respondents represent almost all the age groups the study is targeting. The highest proportion of the population of Dili, between the age of 15 and 64 years old, are those aged between 15 and 24 (40.97%) followed by the population aged between 25 and 34. This study targeted participants from 16 to 75 and above, hence, a lower proportion is observed in the 15-24 age group (11%). The largest percentage of participants were from the 25-34 and 35-44 age groups. The population data were taken from *Dili em Números* or Dili in numbers (Neis & Zielstra, 2014; Statistics Timor-Leste, 2016). These results are presented in Figure 2-7.

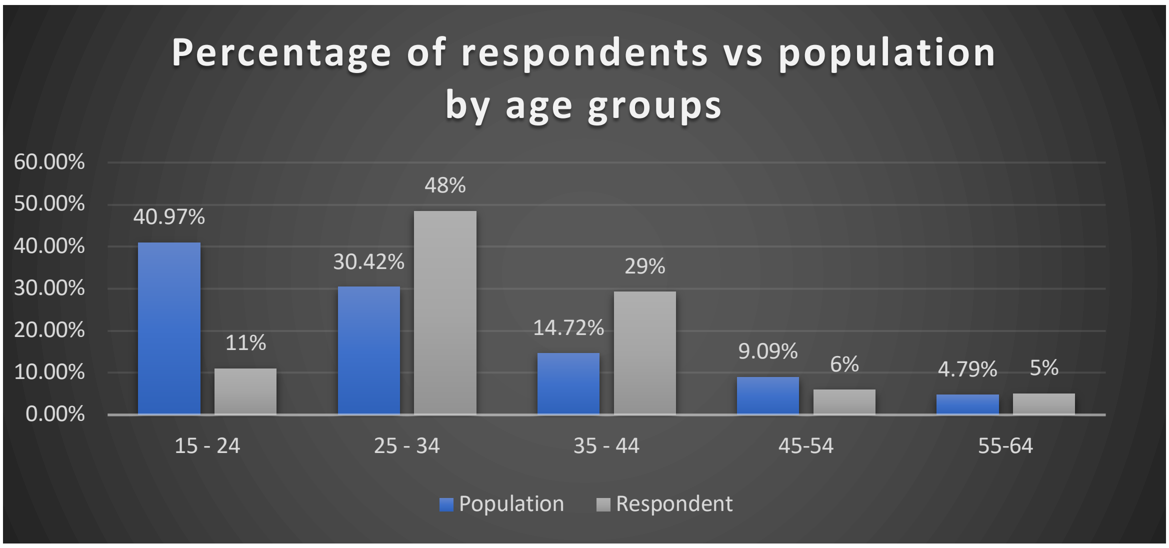


FIGURE 2-7: NUMBER OF RESPONDENTS VS SIZE OF POPULATION

Among the participants, the highest number of respondents were male. Male participants made up 70.70%, while female respondents only account for 28.3% of the proportion. The low proportion of female respondents could attribute to limited access to smartphones and the internet or limited access to social media (Facebook and twitter) that were used as platforms to promote this survey. Another possible reason could be a lack of interest to participate in online surveys, particularly in relation to mapping. Stephens (2013) noted that female participation rates in geographic related projects tend to be lower than men. Details on the number of respondents by gender are illustrated in Figure 2-8.

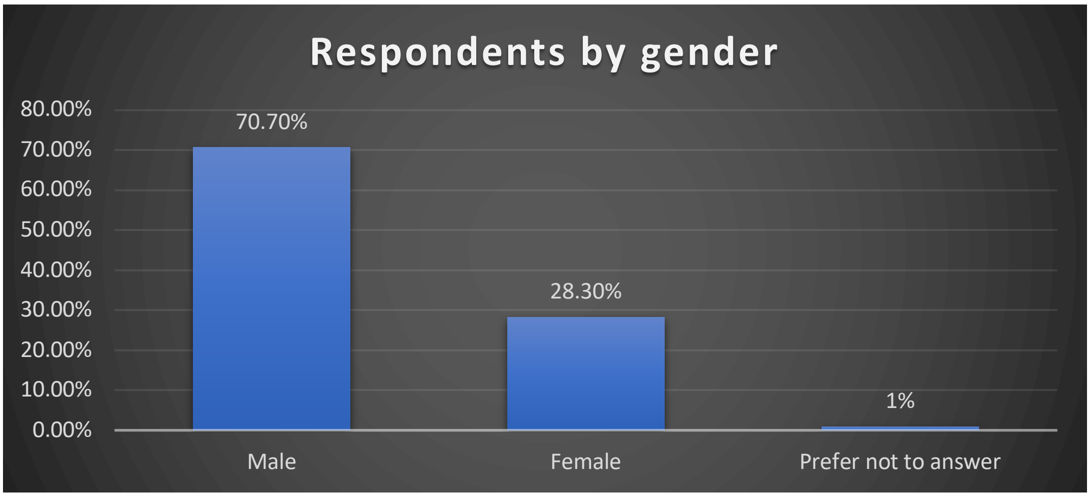


FIGURE 2-8: NUMBER OF RESPONDENTS BY GENDER

Survey participants were from various sectors including the public, private and voluntary sectors. The highest proportion of respondents (32.79%) work in the public sector, 31.15% in charity organizations, and 26.23% work in the private sector. The other 9.84% were made up of students in full-time education, and those out of work and actively looking for jobs. There was a low response from students despite the survey being advertised at three universities in Dili. The low proportion could result from limited access to computers and the Internet at these universities as the session times for accessing computers are limited to a maximum of two hours only daily. Another possible reason for low responses from students is the high cost of the Internet that many cannot afford. The highest rate of participation was from those who were in employment, which may be attributable to access to smartphones and the Internet. The proportion of respondents by employment sector is shown on Figure 2-9.

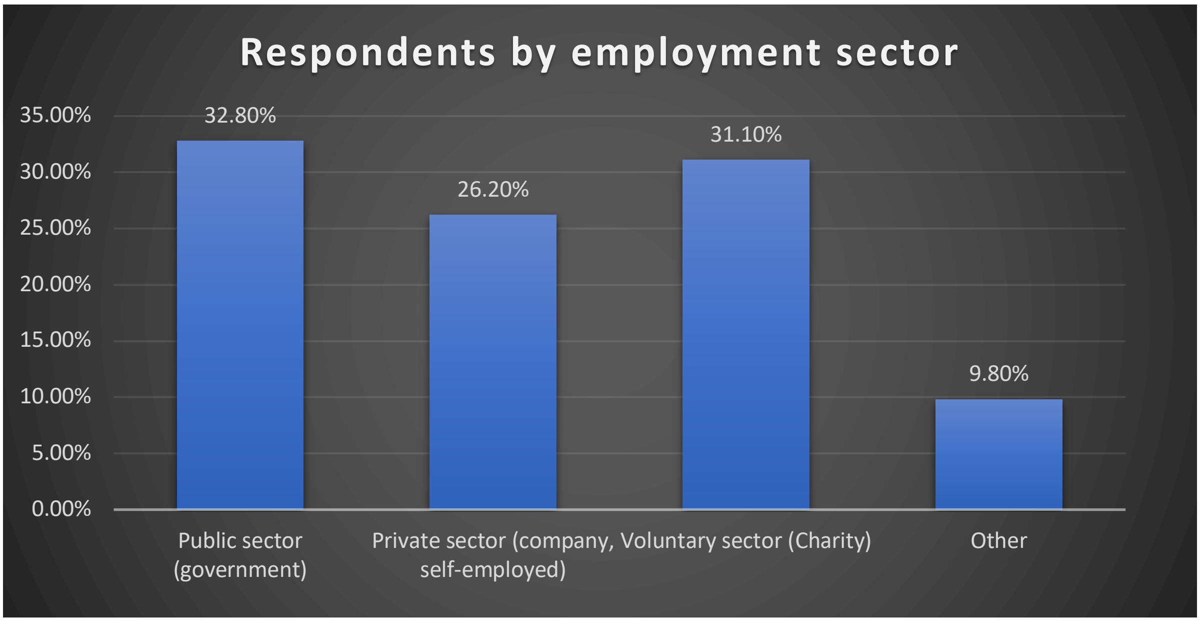


FIGURE 2-9: NUMBER OF RESPONDENTS BY EMPLOYMENT SECTOR

2.4.2 Information on recycling knowledge, attitude and practices

Participants were asked about their recycling knowledge, attitudes and practices. Among all participants, almost 93% stated that they have heard about recycling and most of them were of the opinion that recycling is important and were willing to segregate waste for collection practices if a recycling program was set up. However, only 78.6% were willing to pay if the collection service were taxed. Respondents who were not willing to pay were mainly those in full-time education and the unemployed. The proportion of responses are shown on Figure 2-10.

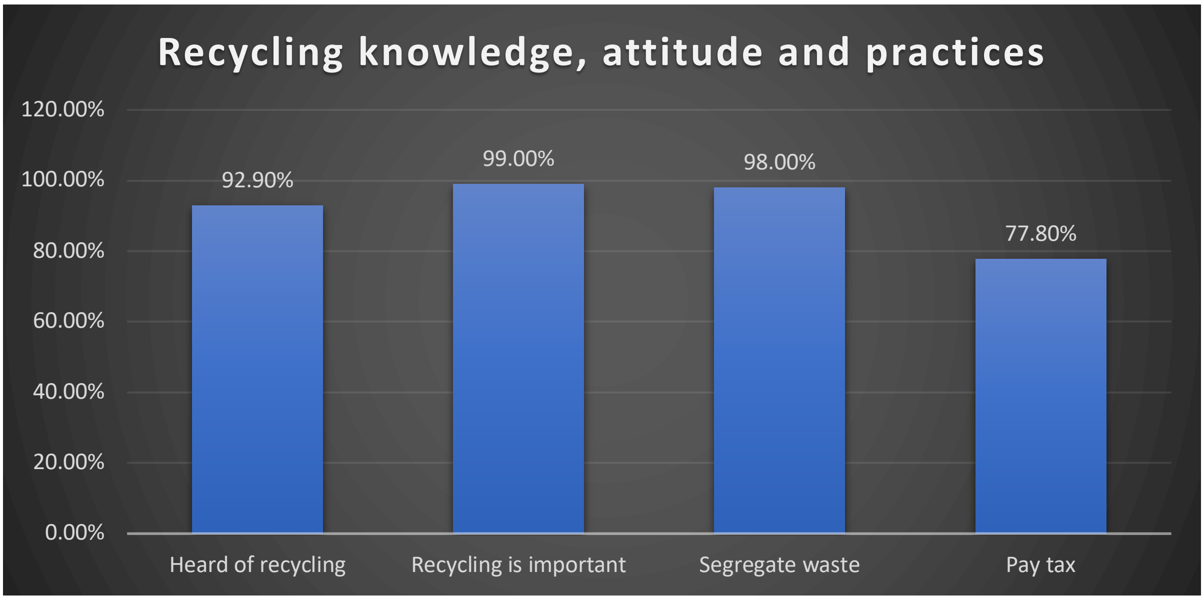


FIGURE 2-10: RECYCLING AWARENESS, ATTITUDE AND PRACTICES

With regards to participants' willingness to pay for collection service if it was taxed, it was hypothesized that that people with higher income would be willing to pay more. To assess this hypothesis, a Pearson correlation analysis was carried out to test if there is a linear relationship between the two variables. The level of significance (p-value) was set at 0.05. The result showed a positive Pearson Correlation (.276) and a significant p-value of .017. These values indicate that there is a small positive correlation, however, there is no evidence to suggest that the correlation exists in the population given the significant value is greater than the p-value. Figure 2-11 shows the amount respondents were willing to pay. Over half of the respondents are willing to pay between $1 and $5 USD while one-fourth of respondents only to pay less than $1 per month. Less than one-fifth of participants are willing to between $5 and $10.

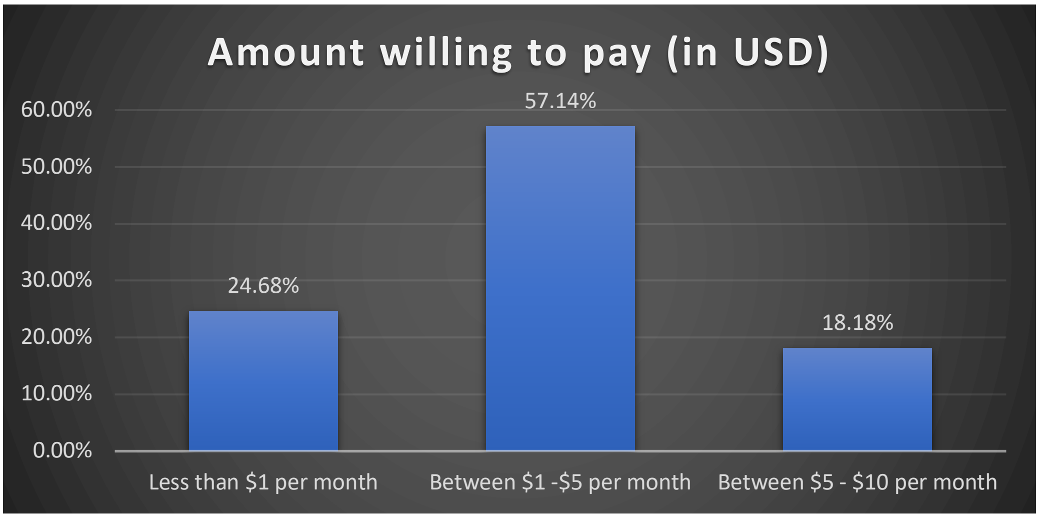


FIGURE 2-11: AMOUNT WILLING TO PAY

2.4.3 Information on citizens' awareness of the impact of solid waste

This section presents respondent opinions about the importance of having a proper solid waste management system and their views on the impact of improper solid waste management. The result of the survey indicates that majority of respondents (98%) thought that it was important to have a proper solid waste management system. Only 2% were of a different view. Figure 2-12 illustrates the result.

FIGURE 2-12: RESPONDENTS VIEW OF SOLID WASTE MANAGEMENT SYSTEM

When asked for their opinion on what would happen if solid waste was improperly managed, nearly all respondents indicated human hazards and water contamination. The proportion of responses are illustrated in Figure 2.13 below.

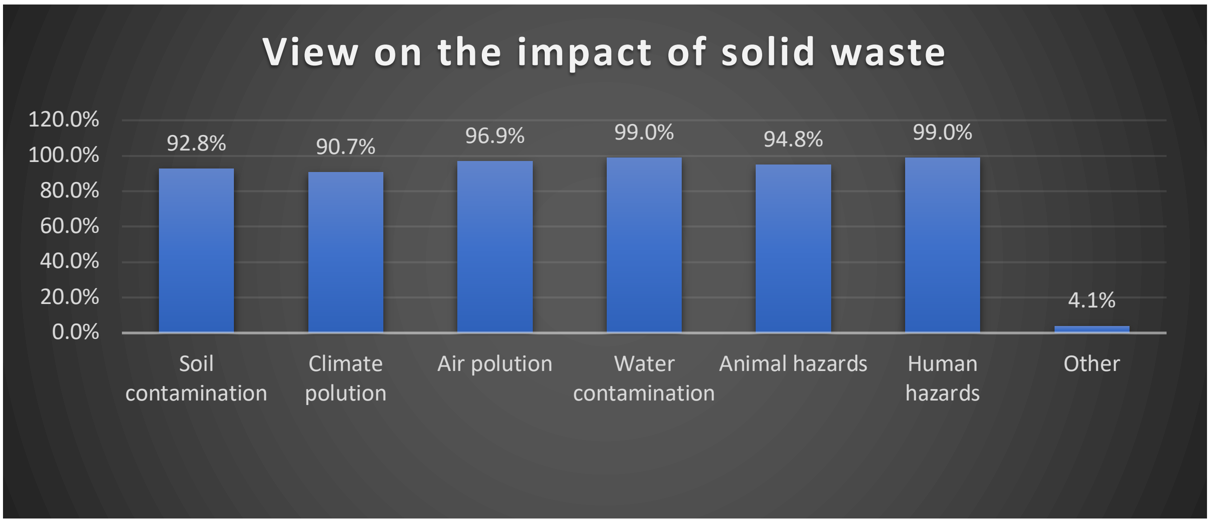


FIGURE 2-13: RESPONDENTS VIEW OF THE IMPACT OF IMPROPER SOLID WASTE MANAGEMENT

2.4.4 Information on solid waste disposal and collection practices

The following section outlines solid waste disposal and practices in Dili. This section presents the participants' responses on how their household dispose of rubbish, the site and their satisfaction with the facilities. Results of participants' observation of other waste collection sites in Dili are also summarized.

2.4.4.1 Collection sites

Figure 2-14 provides the percentage of respondents using each type of collection sites. Of the total respondents, 56% were using municipality allocated bins. 33% had access to home collections service while 14% were using illegal dumping sites (wild sites).

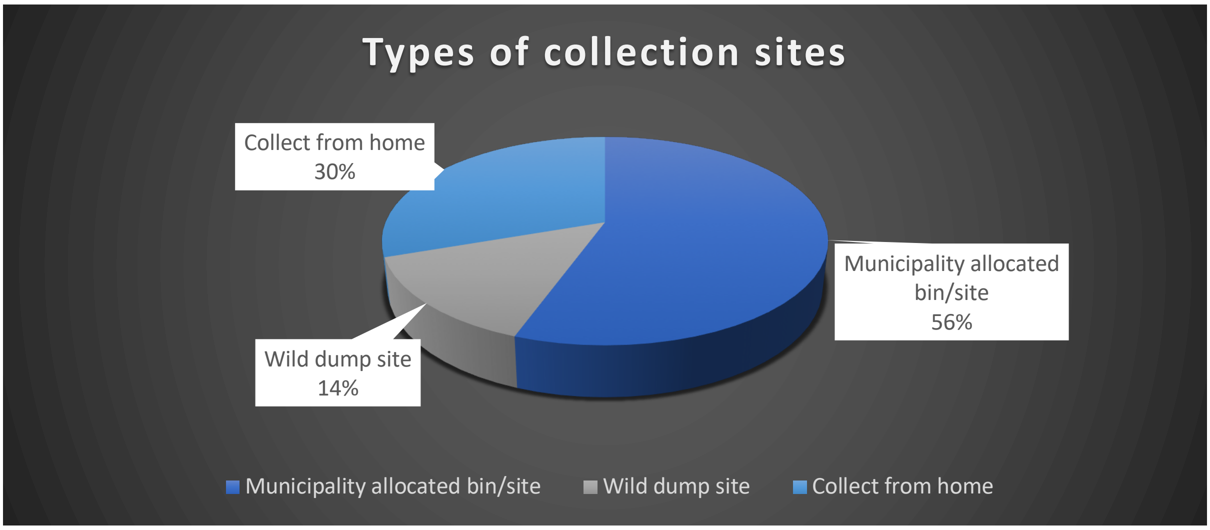


FIGURE 2-14: TYPES OF COLLECTION SITES USE BY RESPONDENTS

Participants were also asked if they are satisfied with the collection sites they are using. Satisfactions were measured on a simple yes and no question. 89.1% of participants who use municipality allocated bin/site expressed dissatisfaction over the facility (Figure 2-15). The dissatisfaction reasons were attributed to bins being too small (not enough space) and not enclosed causing spillage, bin located far from home, and unreliable collection service.

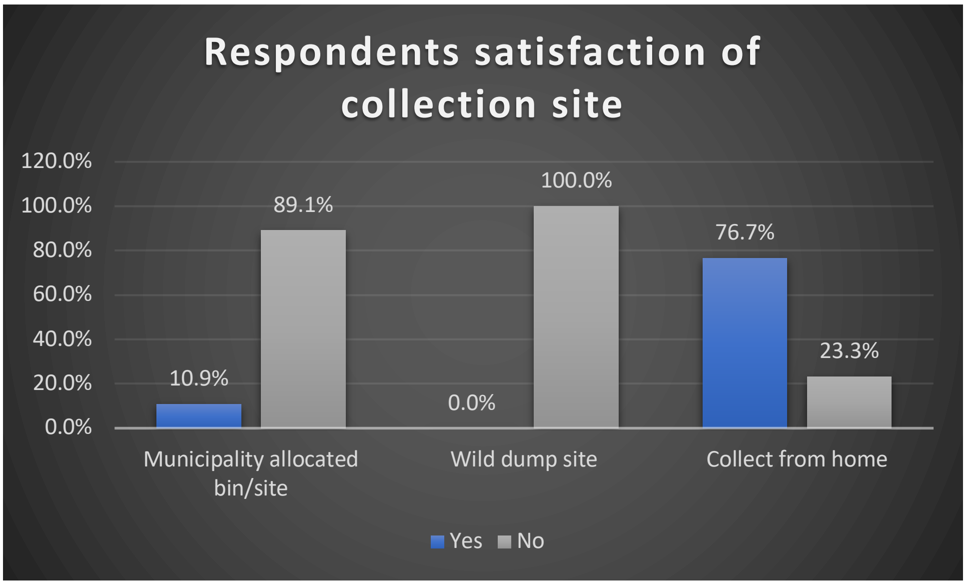


FIGURE 2-15: RESPONDENTS SATISFACTION OF COLLECTION FACILITIES

Those who have access to home collection service are mostly satisfied with the service, only 10% stated otherwise. Meanwhile, all respondents who use wild sites to dispose of waste indicated that they are not satisfied with the sites. The dissatisfaction reasons are attributed to the absence of properly enclosed bin and unreliable collection service. The other reason of dissatisfaction mentioned was the absence of nearby collection points. The highest rate of dissatisfaction among the participants indicate that improvement is needed.

2.4.4.2 Collection frequency

In order to determine whether the current collection practices are efficient and effective, participants were asked how often waste were collected from the bin/site they are using. The responses varied considerably. Waste in the municipality allocated bins always gets collected although the frequency varied from every day to three times a week. Similarly, the frequency of waste collection from home varies from every day to three times a week. Only 3.3% respondents using home collection service reported that their waste is never collected. Likewise, 21.4% of waste in wild dumps are never collected. Waste in these sites may have not been collected because they are located a significant distance from the main road. The wild sites in particular may have been overlooked for the fact that they are illegal dumping sites and the collection trucks were only focusing on collecting waste from the municipality allocated bins in that area. Figure 2-16 shows the result of responses.

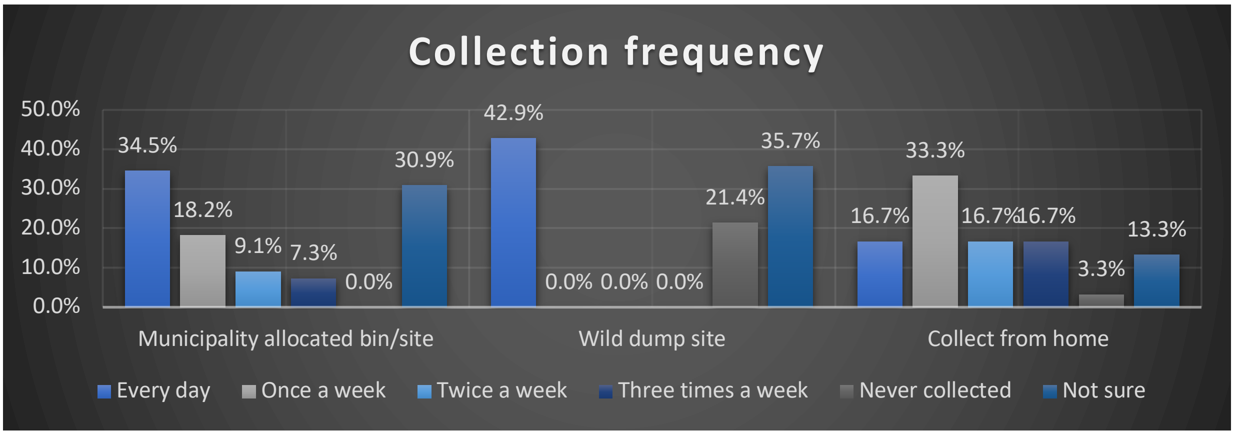


FIGURE 2-16: FREQUENCY OF WASTE COLLECTION

The survey result also reveals that almost a third of participant are unsure when the wastes are collected from their collection sites.

2.4.4.3 Waste volume (quantity) of waste

In order to find out how much waste each site/bin contain on average, participants were asked to indicate how much waste they had last seen in the collection site they were using. The majority of the collection sites had more than two cart loads (approximately 300kg). One cart load has a carrying capacity of approximately 150kg. Many bins had also been found to contain about a truck load of waste (approximately 3 tonnes). These bins were mostly the municipality allocated bins (45.5%). Meanwhile the wild sites and home bins containing this volume of waste were respectively 7.1% and 26.7%. These sites were mostly located in commercial areas. Figure 2-17 shows the details.

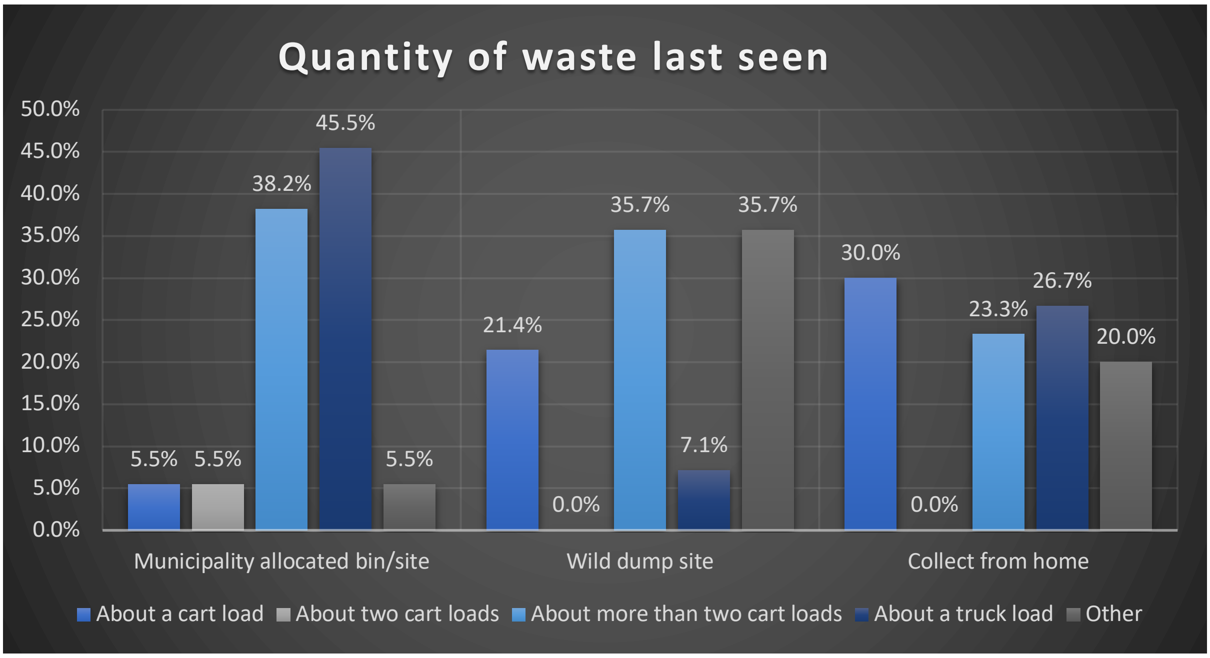


FIGURE 2-17: QUANTITY OF WASTE LAST SEEN

2.4.4.4 Types of waste seen

Organic and recyclable waste have been seen more and mostly in wild dump sites and home bins. Meanwhile toxic waste was spotted more in municipality allocated bins and home bins. The wild sites, however, were reported to have more soil waste compared to the other sites. Other waste listed are dead animals. These results are presented in Figure 2-18.

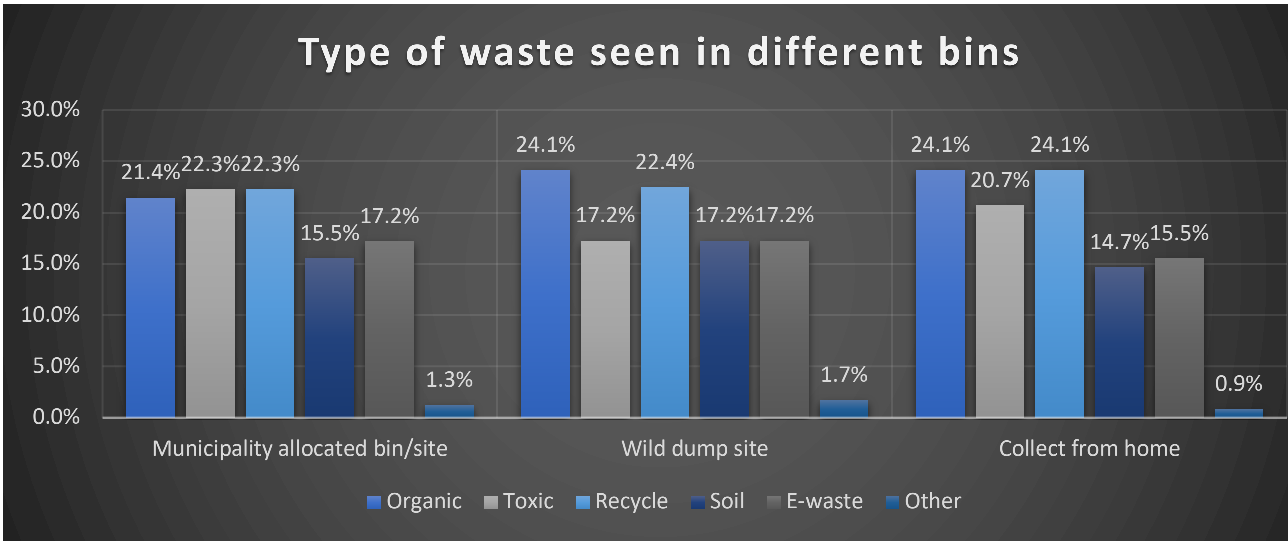


FIGURE 2-18: TYPES OF WASTE SEEN IN DIFFERENT COLLECTION SITES

2.4.4.5 Other waste disposal practices

Figure 2-19 shows the breakdown of other waste disposal methods that respondents were practicing. Out of the total participants, 56.70% burn waste and 41.20% compost waste. Meanwhile, 36.10% bury waste and 7.20% keep garbage at home.

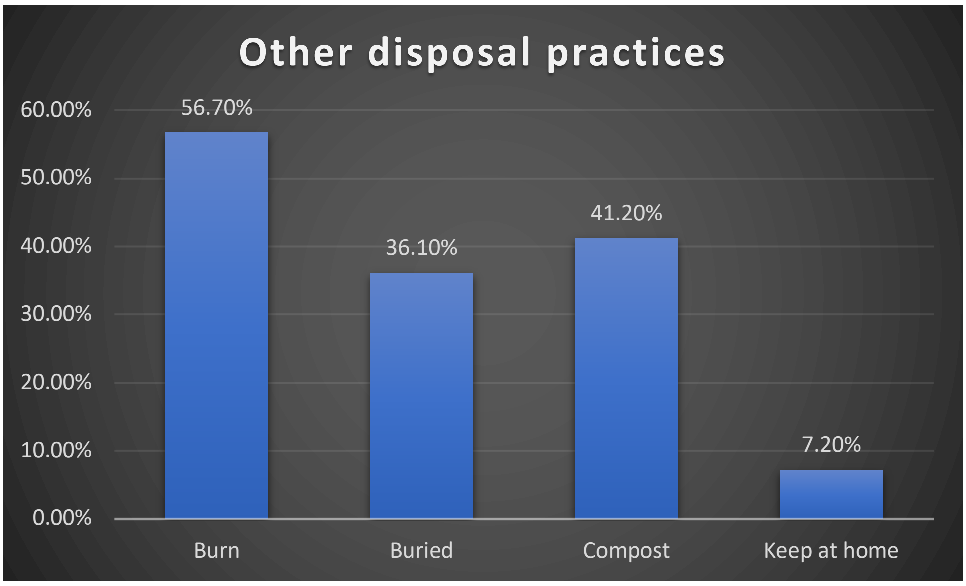


FIGURE 2-19: OTHER CURRENT DISPOSAL PRACTICES

The result shows that a large number of respondents still practice waste burning. This could indicate that there is a lack of awareness of the significant health impact from this disposal method.

2.4.5 Additional collection sites

Figure 2-20 shows the type of other collection sites in Dili. Of the 84 waste collection sites that respondents identified in Dili, 66.7% are municipality's allocated bins and 22.6% are wild sites. The other remaining 11.7% are bins of waste collected directly from home.

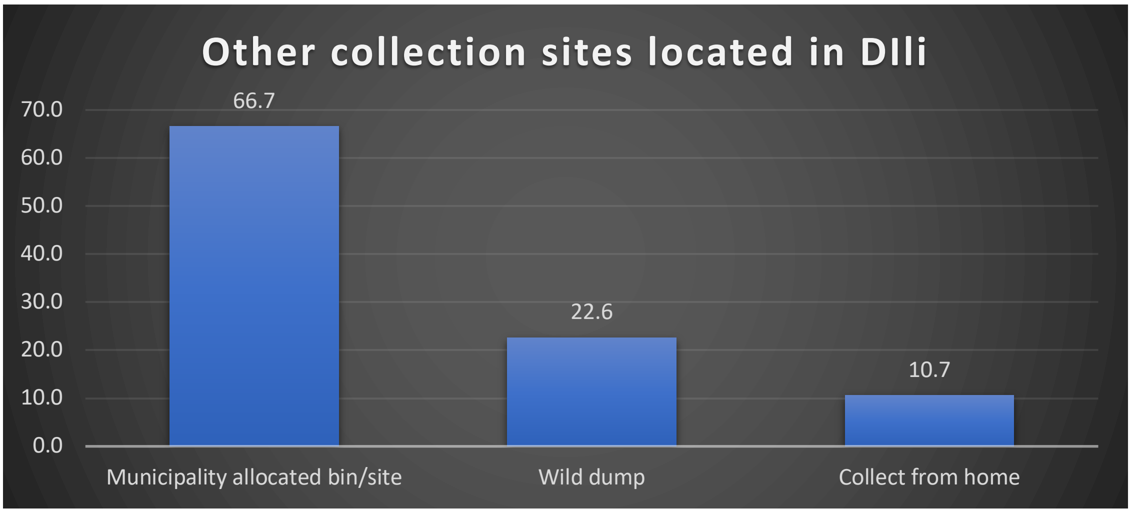


FIGURE 2-20: ADDITIONAL COLLECTION SITES IN DILI

Respondents were also asked about the types of waste they had seen in the sites they had located. Figure 2-21 shows the types of waste respondents had seen in the three different types of collection sites they had identified. The survey results show that each type of waste was found in all three collections bin/sites. The most common type of waste sighted were organic waste and recyclable waste. The organic waste in particular was seen most in wild sites (36%) and municipality allocated bins (27.1%) while recyclable waste was seen most in wild sites (36%) and home bins (27.3%). Soil waste and e-waste are mostly found at home bins than in other sites.

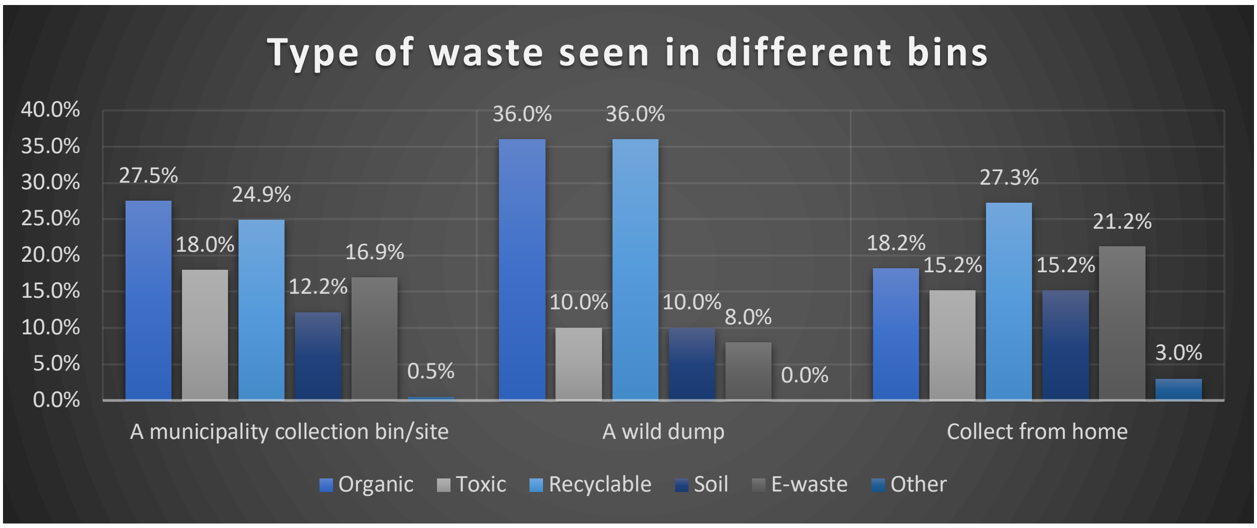


FIGURE 2-21: TYPES OF WASTE FOUND IN COLLECTION SITES

The volume of waste found in all three different types of collection sites were commonly about more than two cart loads. One cart load has a carrying capacity of approximately 150kg. Waste with the amount of about a truck load (around 3 tonnes carrying capacity) has also been found but mostly in municipality allocated bins (19.6%) and wild sites (21.1%). Other waste volume found in the 33% of home bins and 3.6% of municipality allocated bins were more than a truck load. These sites were located in market areas. These results are presented in Figure 2-22.

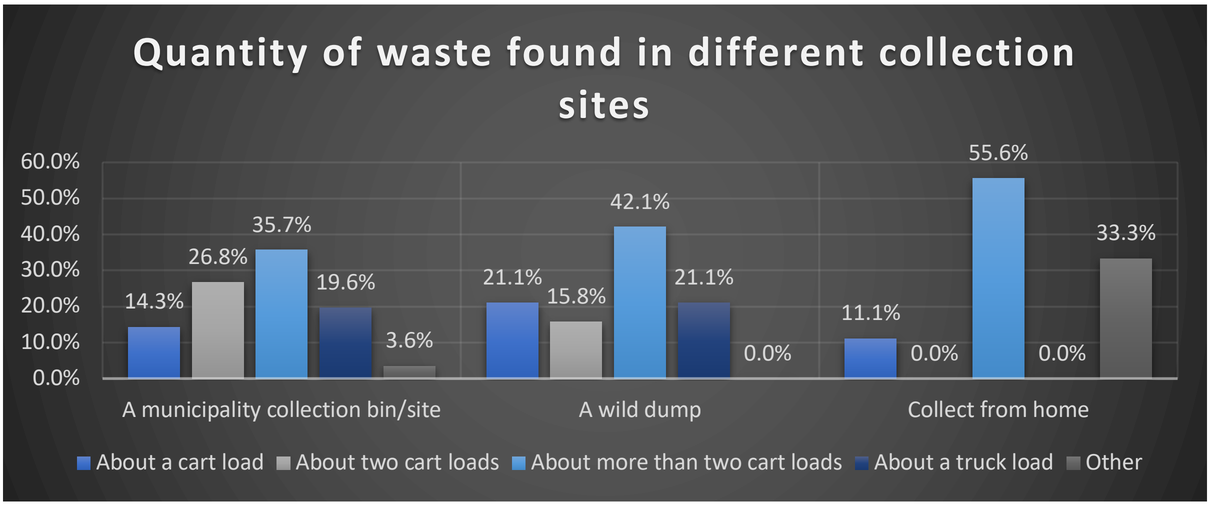


FIGURE 2-22: QUANTITY OF WASTE FOUND IN EACH COLLECTION SITES

2.4.6 Geographical location of solid waste collection sites

This section presents information about the geographical location of solid waste collection sites marked by survey participants. The location includes the collection sites that participants use to dispose of their household waste and the additional sites they found around the municipality of Dili.

Out of 183 submissions, 26 points recorded were out of the area of interest (AOI), three (3) participants opted not to participate and there was one (1) duplicated answer. The duplicated answer together with the points collected outside the area of interest were discarded from the analysis. To ensure that the coordinates recorded were accurate, during the study, participants were asked to measure their confidence level in pinpointing the location and asked to describe in their own words the exact location of the site. A text analysis was conducted using excel to investigate whether the coordinates recorded matched the textual descriptions. The matching process involved manually checking the coordinates using google satellite imagery to ensure the points were located exactly in the area/street/building indicated by participants.

From 183 submissions, 78% of respondents expressed strong confidence that the locations had been accurately identified, however, only 66 coordinates matched the textual descriptions. Coordinates did not match the textual descriptions on 31 submissions, while 7 respondents provided vague textual descriptions. Unfortunately, 39 respondents provided comments on the general waste management subject instead of describing the location identified and 13 submissions did not have textual descriptions because this question was not set as compulsory on the first few days of the release. Table 2-7 provides a summary of the analysis.

Number of coordinate	**Observation result**	**Description**
66	Match textual description	Coordinates considered to have matched the textual descriptions if the points are located precisely on the area/street/building indicated in the textual description
31	Do not match textual description	Coordinates considered ‘do not match’ if points located are not located precisely on the area/street/building indicated in the textual description
7	Vague textual description	Points located in the few meters from the area/street/building
39	Comments irrelevant to the question	Textual description does not refer to the location

13	No textual responses	No textual responses provided
26	Out of the area of interest (out of Dili)	Out of Dili
1	Duplicate	The same coordinates recorded twice

TABLE 2-7: TEXTUAL ANALYSIS SUMMARY

To evaluate the accuracy and reliability of points identified by respondents, the following parameters were set. These criteria were also established based on the assumptions that collections sites or bins are located alongside a road/street (example in Figure 2-23, image A,). Exceptions applied to public premises such as offices, schools, hospitals, etc. For these responses, the point can be placed in front of a building or a house (example in Figure 2-23, image B). However, the building must still be located near a road or street. The same criteria applies to coordinates collected from those who have access to home collection service.

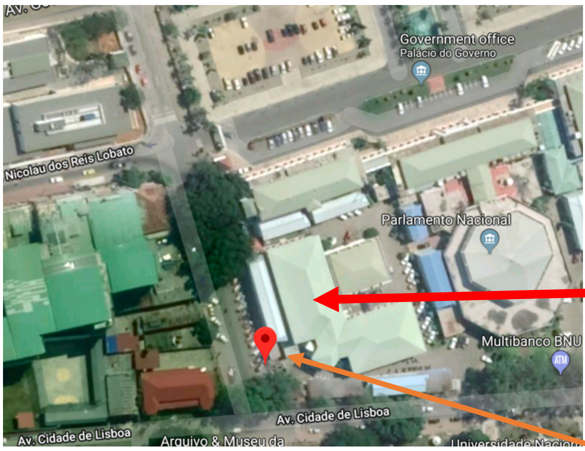
Coordinate location	**Sample textual descriptions:**
 Image A - accurate	*"Alongside the road near the junction behind Palacio Governo (the Government palace)."* Government palace Point selected

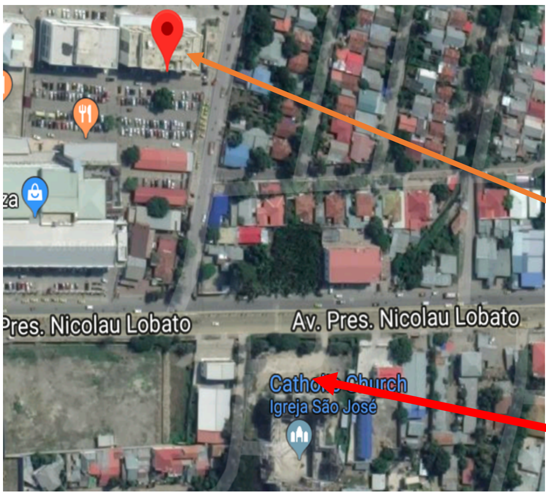
 Image B – moderately accurate	*"In front of kindergarten school, Bebora."* Kindergarten school Point selected
 Image C – vaguely accurate	*"On Rua Tuana Laran (Tuana Laran Street), near Fraleu shop"* Point selected Fraleu Shop
 Image D – inaccurate	*"Near Catholic church, Aimutin "* Point selected Catholic church

FIGURE 2-23: SAMPLE COORDINATE LOCATION

Coordinate located in a location other than the location described are considered inaccurate. For example, point recorded is marked in an area other than the area described or point located behind the building mentioned instead of the front or point marked located at a significant distance from the place/building described. The assessment criteria are grouped into four rating scales based on the responses: accurate, moderately accurate, vaguely accurate and inaccurate. Table 2-8 provides detail of the evaluation criteria.

Rating	**Criteria**
Accurate	- Point matches textual description (area, street, name of place/building described) - Point located alongside the road/street or in front of the building - Image uploaded by participants matches text description (optional) - Example in Image A – Figure 2-23
Moderately accurate	- Point moderately matches textual description - Point located near the road/building described - Image uploaded by participants matches text description (optional) - Example in Image B – Figure 2-23
Vaguely accurate	- Point vaguely matches textual description - Point located few meters from the road/street/building described - Image uploaded somewhat matches text description (optional) - Example in Image C – Figure 2-23
Inaccurate	- Incomplete, little to no text description - Point located far from a road/street - Point located in a location other than the location described - Image provided is not relevant to the point located - Example in Image C – Figure 2-23

TABLE 2-8: POSITIONAL ACCURACY EVALUATION CRITERIA

After responses were filtered using the above mentioned criteria, it was found that 48 coordinates were correctly pinpointed by the respondents while 18 were moderately accurate and 7 were vaguely accurate. A significant number of coordinates (83) were considered inaccurate. This number is accumulated from the 31 coordinates that do not match textual description + 39 coordinates with comments irrelevant to the spatial location + 13 coordinates without any textual descriptions. Table 2-9 provides a summary of the analysis.

Rating	**Number of coordinate**
Accurate	48
Moderately accurate	18
Vaguely accurate	7
Inaccurate	83

TABLE 2-9: ANALYSIS RESULT

2.4.6.1 Coordinate positioning errors

Errors are measured by accuracy and precision of location or point identified. Accuracy as the measurement of the difference between how close a point is to a true point or accepted point. While precision measures how closely two or more points agree with each other (Haining & Haining, 2003).

Most respondents identified the locations of sites in Dili. However, about 26 responses are outside the area of interest (AOI). These errors probably occurred due to several reasons:

- The survey was undertaken in a different location other than Dili while the devices' current location was on, therefore, the device recorded the respondent's current location instead of the intended sites

- The respondents did not understand the instructions correctly, indicating that if they are using a smartphone, they need to be at the site
- Errors produced by the GPS devices due to factors such as the quality of the GPS sensor or the satellite signal strength. Other factors could be the surrounding environment (cloud, building or other structures) that affect the accuracy of locations recorded.

2.4.6.2 Geographic spread of solid waste collection points

This section presents the distribution of geographic locations of the dataset collected during this study. The dataset locates bins in three categories: municipality allocated bins/sites, wild sites and home collection service bins. The study focused on 4 administrative divisions in Dili, with the Area of interest (AOI) as shown in Figure 2-24.

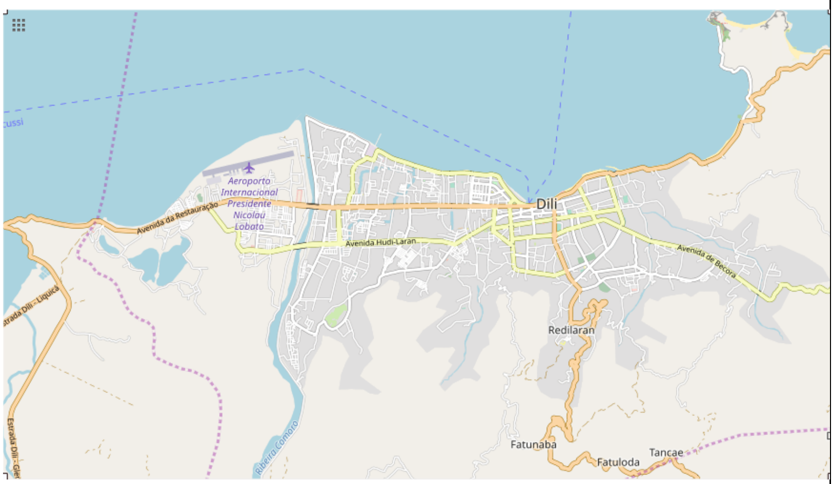
<table>
<tr><td></td><td>-8.5191</td><td></td></tr>
<tr><td>125.4805</td><td>
</td><td>125.6300</td></tr>
<tr><td></td><td>-8.6026</td><td></td></tr>
</table>

FIGURE 2-24: RESEARCH STUDY AREA

a. **Municipality allocated bins/sites**

The majority of the sites recorded by respondents were municipality allocated sites/bins and the points are spread out across Dili. This indicates that almost all areas in Dili have access to municipality allocated bins.

Figure 2-25 shows the distribution of coordinates for municipality allocated bins provided by participants. The west side of Dili saw a lower number of responses despite being the most populated area. About 46% of the total population of Dili reside in this area (Statistics Timor-Leste, 2016). The low number of responses could be that the majority of the population in this area are of low-income families. Thus, have limited access the Internet and smartphones.

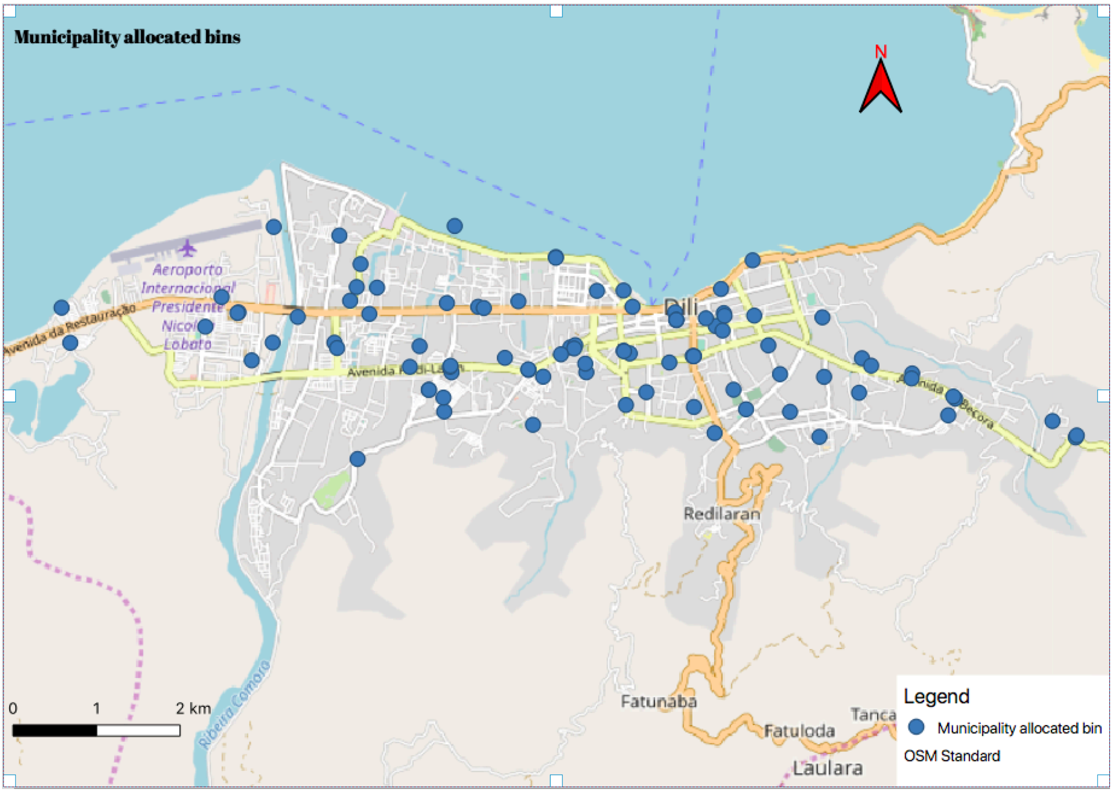


FIGURE 2-25: DISTRIBUTION OF MUNICIPALITIES ALLOCATE BIN/SITE [UNFILTERED POINTS]

*Unfiltered = unclean data, contains inaccurate points

Another reason could be that people in this area lack the skills to use both technologies. Participating in VGI projects requires internet access and familiarity with the devices used ((Brovelli, Minghini, & Zamboni, 2016; Cinnamon & Schuurman, 2013).

b. Wild sites

Figure 2-26 shows the distribution of coordinates for the wild sites. The data shows that most wild sites are located on the outer side of the city and the majority are located around residential areas. Only two points recorded were in the inner side of Dili. One wild site is located alongside the Maloa river, near the Presidential palace (red arrow) and the other located near the embassy area (blue arrow), in Farol, Dili.

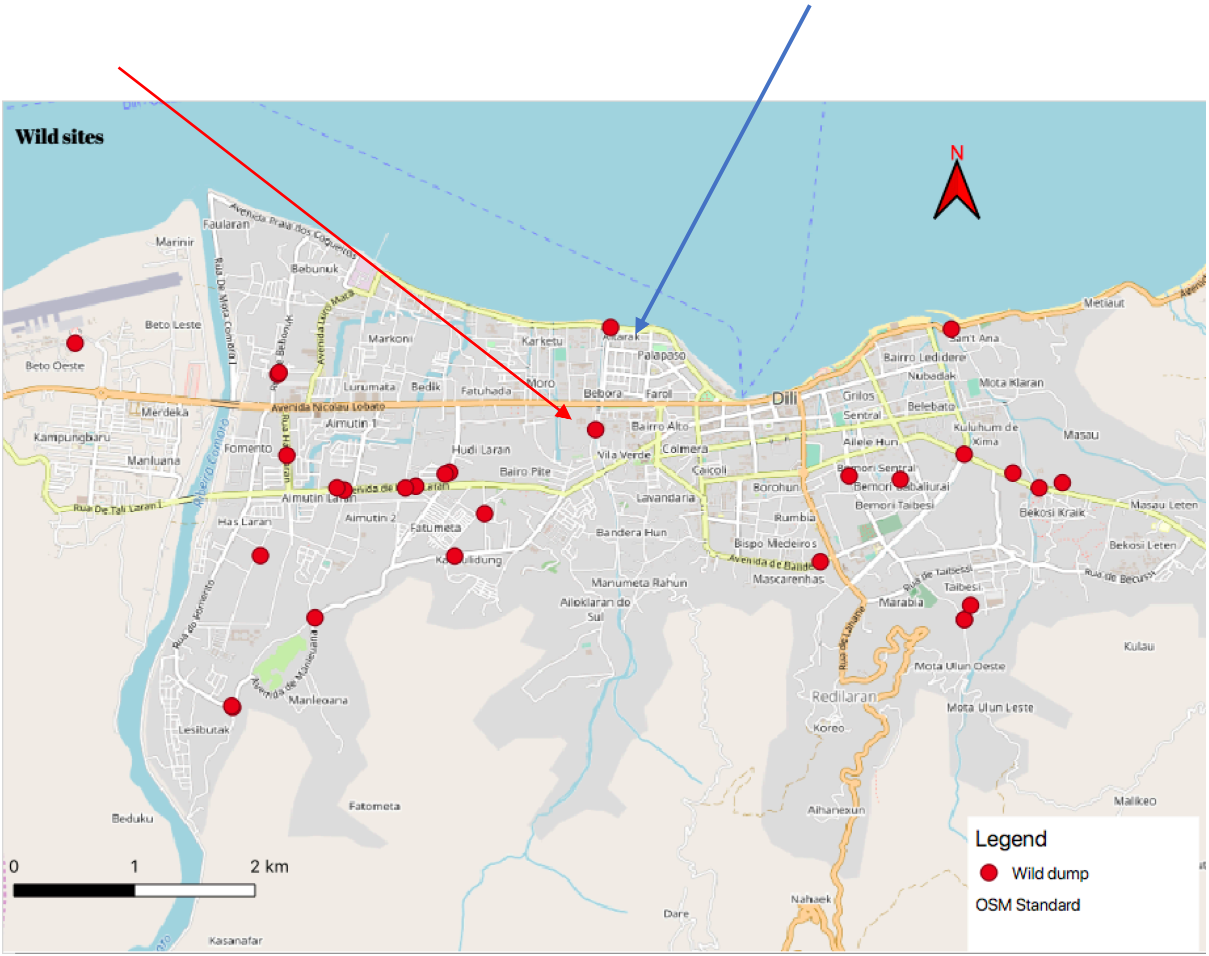


FIGURE 2-26: DISTRIBUTION OF WILD SITES [UNFILTERED POINTS]

c. Home collection service

As shown in Figure 2-27, waste collected by home collection service were also relatively spread out in the capital city. A large number of respondents who have access to this service expressed their satisfaction about the service. Meanwhile 23% expressed dissatisfaction. Unreliable collection was recorded as the main reason for dissatisfaction.

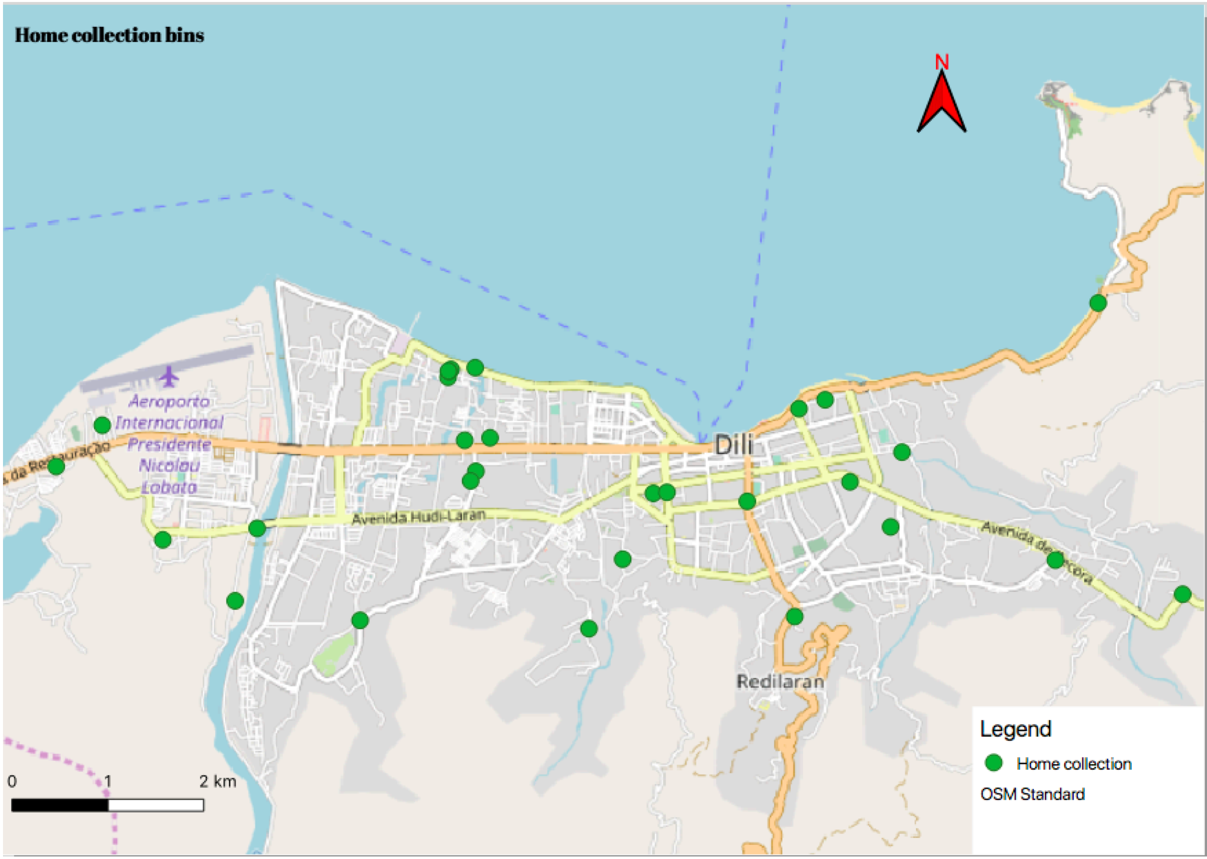


FIGURE 2-27: DISTRIBUTION OF HOME COLLECTION SERVICE [UNFILTERED POINTS]

d. Points of three collection sites combined (post filtering)

Figure 2-28 shows the locations of points recorded for all three types of collections sites post filtering (or after removing all inaccurate points). These points include the accurate, moderately accurate and vaguely accurate points from Table 5-4. It can be observed that bins/sites have been allocated by the municipality of Dili in almost all the main roads of Dili. The wild dumping sites (about 17%) were found located between the municipality's assigned bins. Lack of monetarisation and overflowing waste bins have been gathered from survey respondents as factors leading community to dispose of waste in open lands and rivers.

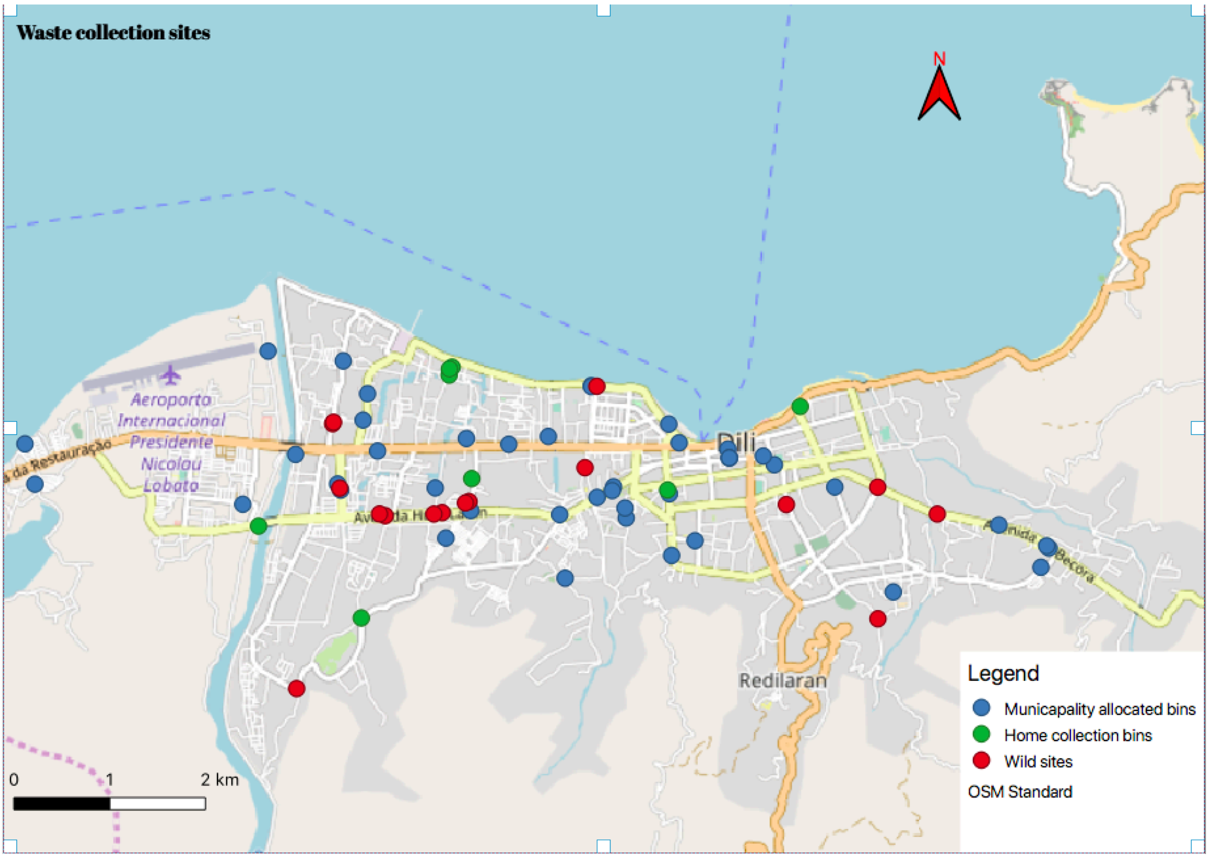


FIGURE 2-28: ALL COLLECTION SITES [FILTERED POINTS]

*. Filtered = clean data (accurate, moderately accurate, vaguely accurate)

Four points found were referring to the same collection site. These coordinates have been recorded by several people. An example of overlapping points (point 1, 2 and 3) is shown in image A Figure 2-29. These overlapping points were found by using the point cluster renderer in QGIS. The point cluster renderer allows the merging of nearby points into a single marker symbol based on a specified distance. For this study the distance was set to 0.003m. Point cluster renders nearby points so that they can be viewed easily.

Two points found to be the overlaps were removed manually by first checking against the corresponding image submitted by participants during the survey.

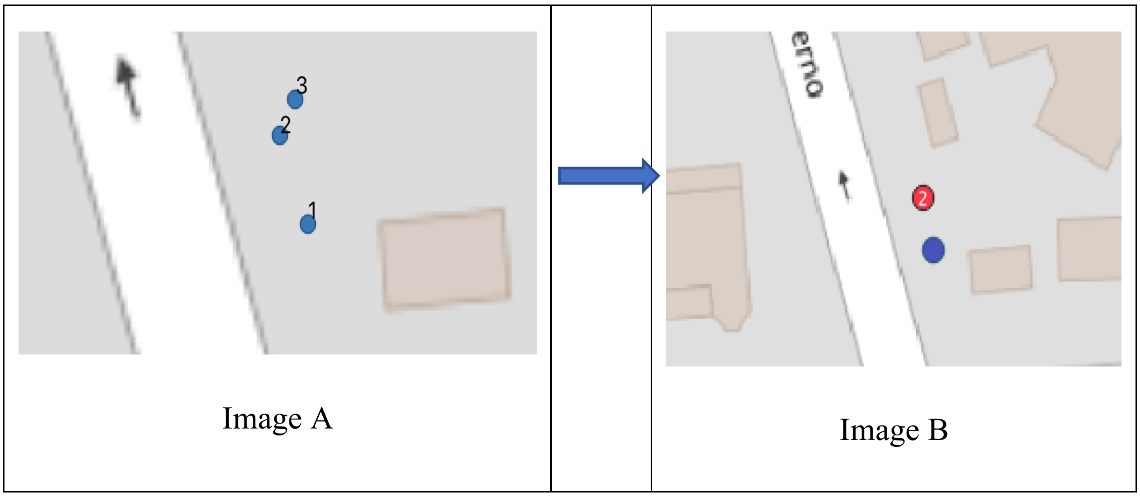


FIGURE 2-29: SAMPLE CLUSTERED POINTS

2.4.6.3 Temporal spread

All submissions were recorded during the survey period. The system recorded the 7th of November as the start date because one respondent completed the survey from the United States, which was one day behind. The highest number of responses were seen on the first and second day after the survey was launched. The number of responses decreased throughout the remaining month of November, slightly rose again in between the end of November and the first week of December and then dropped again throughout the month of December. Figure 2-30 provides the breakdown of responses received from November 8th to January, 12th.

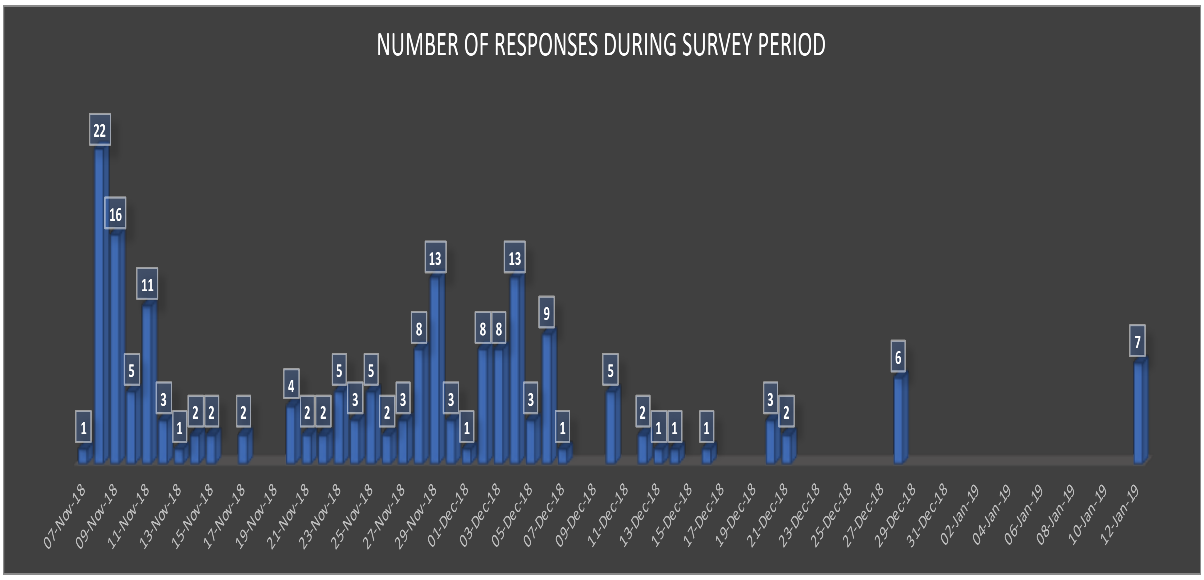


FIGURE 2-30: TEMPORAL DISTRIBUTION OF RESPONSES, BY DAY

Information about the temporal spread is important as it allows us to investigate the time respondents utilize to complete the survey and whether the survey was filled during leisure time or during office hours. This information is essential to analyse positional accuracy of the location data. It was assumed that if respondents complete the survey using a computer, they would mostly likely pinpoint the location accurately because the location is visible on the map. However, if smartphones were used to complete the survey while sitting in an office or in other places other than the actual collection site, the spatial coordinate would be inaccurate.

Figure 2-31 reveals that majority of the survey was completed between 6:43am and 11:31pm, with the highest submissions around 10am. The working hours in Timor-Leste are from 8am to 5pm. Hence, these result indicates that most respondents have most likely completed the survey during break time while at the office. A probable explanation is that this was the only time that most respondents have access to a computer and the Internet because the cost of internet is very high.

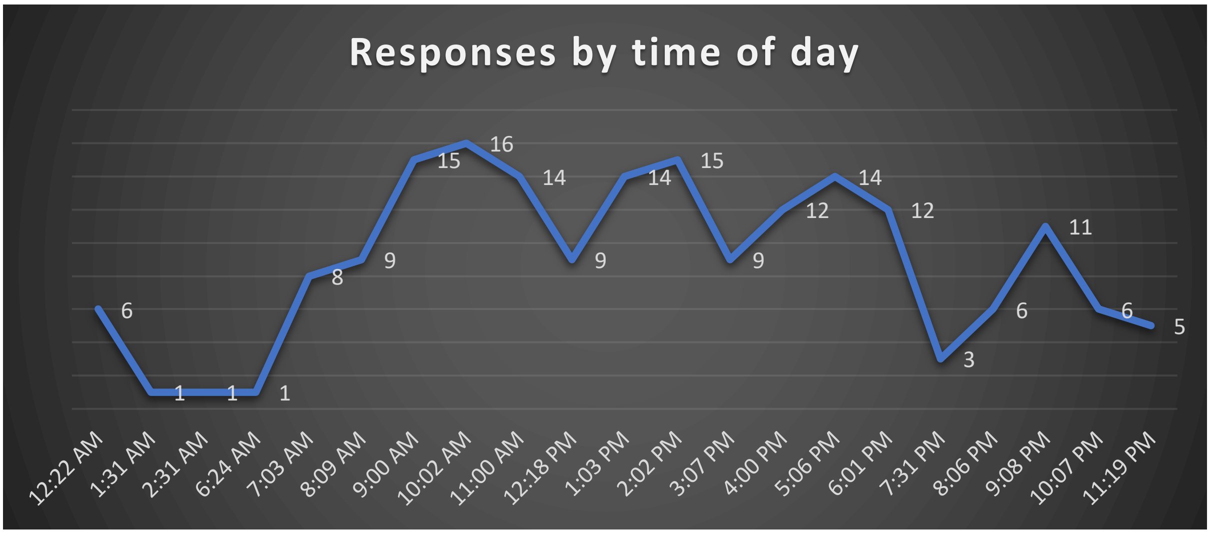


FIGURE 2-31: TEMPORAL DISTRIBUTION OF RESPONSES, BY TIME OF DAY

2.4.6.4 Volume of waste map

Figure 2-32 shows geographical distribution of collection sites by volume. The data consists of the bins the participants are currently using and the additional bins they identified. It can be viewed in the map that most of the sites identified have approximately more than two cart loads of waste. Eight sites reported to contain at least a truck load of waste. These sites are located in commercial areas, open lands and in relatively densely populated areas. Other volume of waste (points in purple) refers to either empty bins or bins with more than a truck load of waste.

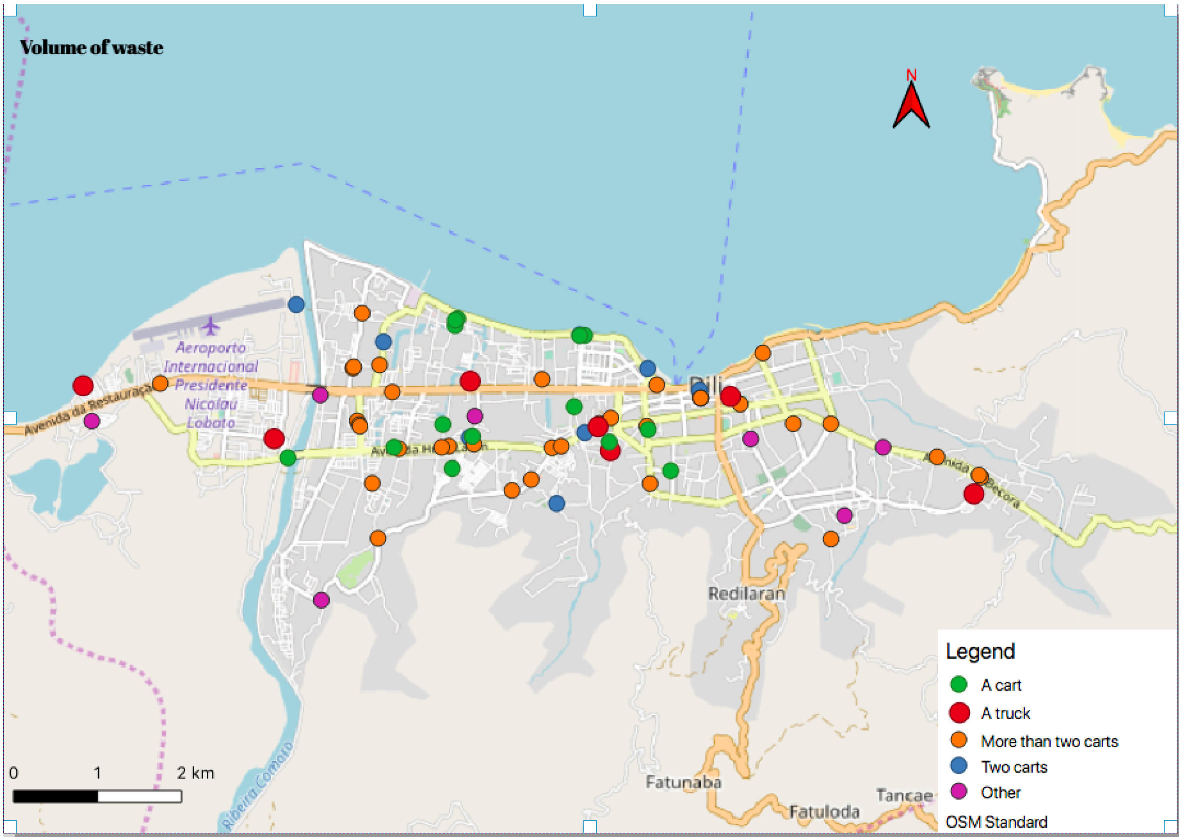


FIGURE 2-32: SPATIAL DISTRIBUTION OF COLLECTION SITES, BY VOLUME [FILTERED POINTS]

2.4.6.5 Responses satisfaction

Figure 2-33 illustrates the distribution of points where people are satisfied or not satisfied with the condition of the site they use to dispose of rubbish. The data shows that the majority of the respondents are not satisfied with their collection sites. Only a few people were satisfied with their collection sites.

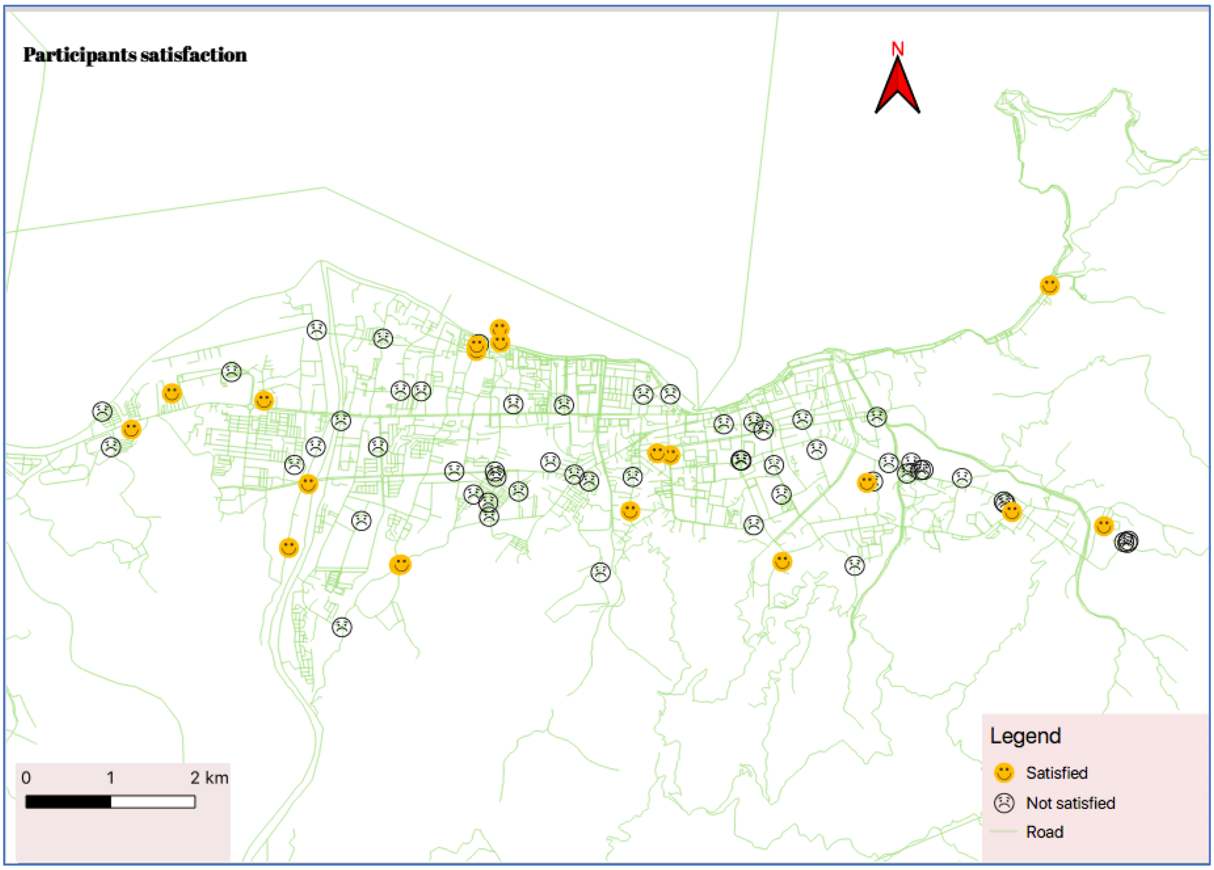


FIGURE 2-33: SPATIAL DISTRIBUTION OF SATISFACTION [UNFILTERED]

2.4.6.6 Collection frequency

Figure 2-34 provides geographic locations of where waste is collected every day, once a week, two times a week, three times a week, never, or whether participants are unsure. The result indicates that waste at a majority of the sites recorded are collected every day (points in green colour).

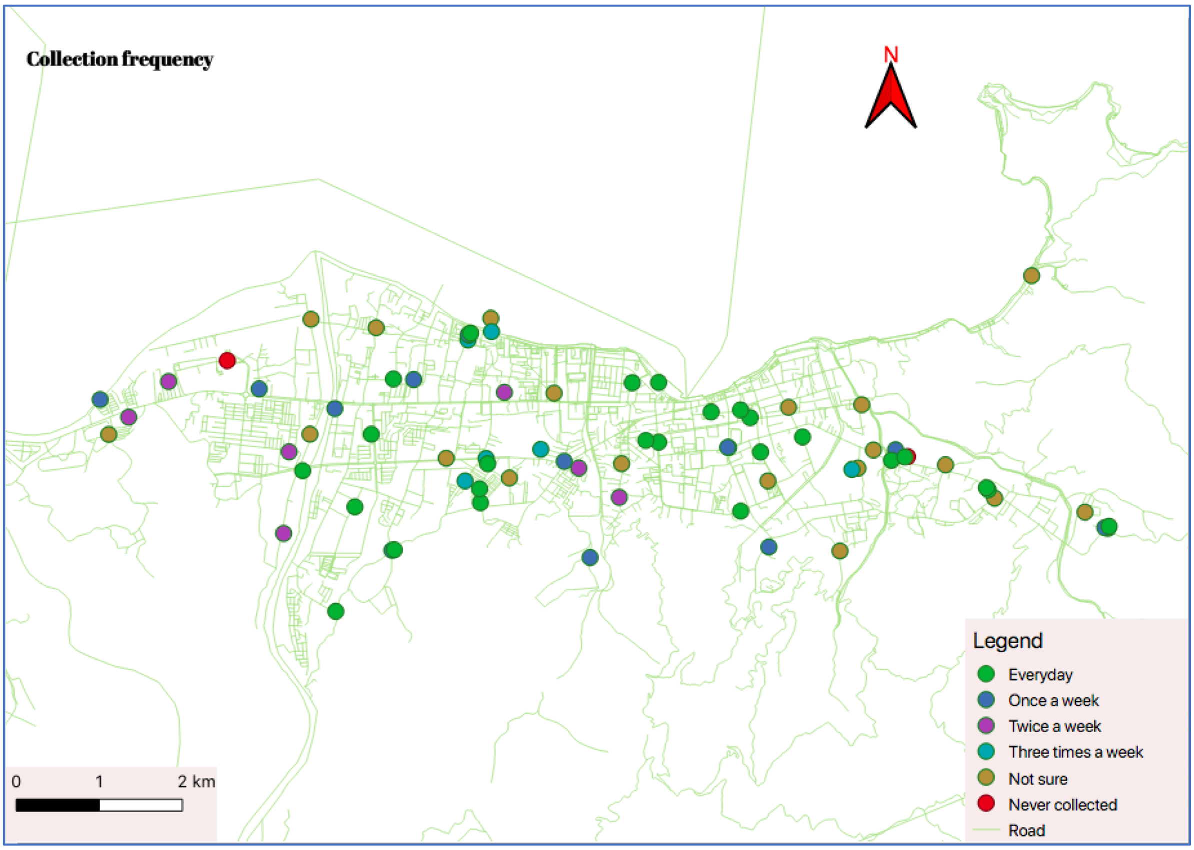


FIGURE 2-34: SPATIAL DISTRIBUTION OF COLLECTION FREQUENCY [UNFILTERED]

2.4.7 Additional issues identified and suggested improvements

In this survey, participants were asked to provide further comments about the overall solid waste management system in the municipality of Dili through an open-ended question. The responses for this question are categorized according to recurring themes identified across all responses, and are shown in Table 2.10. One or two responses were selected from the common responses and presented here in this section. The responses in English were quoted verbatim while the ones written in Tetun have been translated.

Bin management

At least twenty six respondents raised issues about the current bin management. The problems mentioned are insufficient bin allocation to cater for the area, bins too small causing overflowing and bins mainly located on the main roads.

"*Our bin is right on the ocean on a bit of beach that would otherwise be quite beautiful. It has always been a problem because it's not enclosed and the wind often blows the rubbish out of the area. It has always been bad but in the last year with the breakdown of the rubbish collection services it went for months without being collected which caused the rubbish to swell out onto the road at times almost blocking the road. The bins service a fairly large (and increasing) community. There should be smaller bins on every street which would prevent the huge build up on the beach. The bins also need to be enclosed so that animals can't get in to the rubbish."* **Respondent 2**

"I often see animals in the municipal waste sites, like pigs and dogs. The sites are often overflowing." **Respondent 59**

Negative					
Bin management		**Collection service**		**Disposal practice**	
Not enough	6	Not effective	4	Waste mixed	1
Too small - waste overflow	3	Limited number of collectors	3	Waste dumped illegally	10
Not enclosed	3	Limited number of collection trucks	3	**Total**	**11**
Far from households	11	Inappropriate collection trucks	2		

Too close to main roads	3	Collection done on main roads only	2		
Total	**26**	**Total**	**14**		
Awareness and education		**Policies and regulations**			
Lack of awareness about impact of waste	7	Lack of policies & regulation for proper waste disposal			2
Lack of information about proper disposal	9	Existing policies not enforced			2
Total	**16**	**Total**			**4**

Positive	
Waste management is in place	1
Government allocated budget for waste management every year	1
Government continually finding solution for improvement	1
Total	**3**

Recommendations	
Place small bins near households	4
Increasing number of bins	3
Provide properly enclosed bins	3
Place segregated waste bins	5
Collection conducted frequently	2
Education program about proper disposal practice	14
Education program about 4R practice	14

Fixed schedule for disposal	1
Tax collection service	3
Establish law proper disposal	4
Establish sanction for illegal dumping	3
Establish recycling industry	1
Total	**57**

TABLE 2-10: SUMMARY OF ISSUES IDENTIFIED AND RECOMMENDED IMPROVEMENTS

Awareness program

Positive comments were also made, indicating that solid waste management is in place, however, due to lack of awareness and lack of information, waste is still disposed of illegally.

"*Actually, the management system is in place but not efficient because there is no maintenance and regulator in place to monitor the waste being dump in municipality allocated bin. Still lack of contribution from Community because there is no informative information in each neighborhood or there is no collaboration from chief of village with neighborhood."* **Respondent 26**

"Every year the government allocates budget for waste management in the municipality of Dili that shows that the government is committed to improve waste management. In my opinion, this issue need to be thought at schools, starting from primary school, so that young people are informed early about how to dispose of rubbish properly. I am saddened by the fact that, today, even university students litter although bins have been provided all around Dili." **Respondent 48 (translated from Tetun)**

Policies and regulations

Several respondents stated that the lack of policies and regulations contributes to illegal disposal and dumping.

"*Waste is a significant issue for local government to deal with. However, a lack of supporting Government policy and action has constrained Administrasaun Munisipiu Dili's ability to address waste issues effectively."* **Respondent 7**

Recommendations

Recommendations were made to improve solid waste management in Dili. The suggestions include providing an education and awareness program about proper solid waste disposal and 4R (refuse, reuse, recycle, reduce) practices. Furthermore, the respondents suggested improvements in bin allocation and collection services and proper laws to regulate waste disposal and collection practices.

"*An education program about proper waste disposal is necessary to reduce waste production and prevent illegal dumping."* **Respondent 11** (translated from Tetun)

"Laws and regulations need to be established to prevent illegal dumping." **Respondent 86**

2.4.8 Summary

Overall, the participants in this study provide a reasonable representation of the Dili population, although lower responses were observed for some demographic groups, for example, those in the age group of 15 -24 and 45-64. Potential reasons for low responses could lie with factors such as level of education, social and economic background.

With regards to the current solid waste management, almost all participants hold the opinion that a proper solid waste management is important. The majority of the respondents also indicate willingness to segregate waste for collection purposes and are willing to pay if the collection service were taxed. The amount most are willing to pay are between $1 and $5. The majority of respondents also have access to municipality allocated collection sites, however, are not satisfied with the condition. Reasons for the dissatisfaction include insufficient number of bins, bin size (too small causing overflowing), bin not being properly enclosed (causing spillage and access by animals) and unreliable collection service.

CHAPTER 3 - SELECTION OF APPROPRIATE BACKGROUND FOR APPLICATION MAP

3.1 Introduction

This chapter outlines the study undertaken to select appropriate background for the application map utilized for this research study. The chapter begins by stating the aim of this study and then presents the review of the literature about maps and images. Furthermore, describes the overall design of the study including how data were collected and analysed. Lastly, the result of the study will be presented.

3.2 Objective

One of the objectives of this study is to map the location of solid waste collection sites in Dili. Achieving this objective requires a suitable map that allows participants to mark the location of the waste collection sites. This particular experiment was therefore conducted to identify an appropriate background map by investigating how well people recognize objects and how they can identify objects accurately on maps or images based on their map reading skills.

Thus, this experiment sought to answer the following questions:

- How well can objects be identified on satellite images at different resolutions?
- How well can humans find locations on maps?
- Do map reading skills affect the accuracy of the object location?

3.3 Literature Review

This section presents previous studies related to object identification using maps and satellite imagery. This section commences with an overview of maps and satellite imagery and how people interpret them, and whether people understand maps better than satellite images. Furthermore, it discusses how well objects can be identified on maps and satellite images at different resolutions.

3.3.1 Maps

A map is a representational drawing of the surface of the earth. Maps have three common features: scale, symbols, and grids. The scale shows the ratio of the distance on the map in relation to the actual distance on the earth. Symbols represent geographic features (for example, lines may represent boundaries, roads, rivers; cities may be represented by black dots and circled stars may represent capital cities). Grids display the latitude and longitude lines that help people to locate places on the map. To ensure readers can understand what each symbol represents, every map provides a map legend known as the dictionary of the symbols (Kraak & Ormeling, 2013).

3.3.2 Satellite imagery

Satellite imagery refers to the digital images taken by satellites orbiting the earth. A satellite image has four types of resolutions (Jensen, 2016):

- Spatial resolution – how much detail is visible to the human eye
- Spectral resolution – what can be seen within each pixel, what colour or band
- Temporal resolution – how far back in time the user can look and the currency of the image in terms of time/day/season/year

- Radiometric resolution (colour depth) - how well the differences in brightness (for example the contrast) in an image can be perceived

Optical satellite imagery as cited from the "Overview on High Resolution Optical Satellite Systems " (2018) is classified into four groups:

- Very high resolution (VHR): 1m - 4m spatial resolution
- High resolution: 5m - 30m spatial resolution
- Medium resolution: 80m - 180m spatial resolution
- Low-resolution optical satellite Data: 250m - some km

There are several distinct features in high-resolution imagery that separate it from lower resolution imageries (Huai, Wen, Gui-Song, & Gang, 2016). These special features include:

- Clear geospatial structure
- Distinct spatial layout
- Finer texture
- Entire image portrays a combination of multi-scale objects

3.3.3 Satellite images vs maps

Satellite imagery and maps are both utilized to visualize spatial data, however, the visualization process is carried out differently. Satellite images display the realistic appearance or the pictorial view of the objects on earth in the natural colour that human eyes are familiar with. Therefore, the level of details of an object is subject to the image resolutions (Jensen, 2016). Because images depict the physical surface of the earth, it is difficult to separate adjacent objects. Moreover, similar objects may appear differently on different surface materials. For example water is usually blue but if located in sand or mud, the colour appears brown. In addition, images can only display earth surface taken at a single moment of time (Liebe, Fischer, Logothetis, & Rainer, 2009).

Maps, on the other hand, are composed of symbols and labels. Maps are designed by map makers to model reality, and therefore, only provide selected information (Svatonova & Kolejka, 2017). Hence, maps can display both visible and invisible elements depending solely on the map makers. Maps are also structured, therefore, objects are visibly distinguishable from each other. Objects that are similar can be grouped and uniformly symbolized. For example, water and ocean are blue, plants and forest are green. The data source for designing a map are collected from multiple time periods (Kraak & Ormeling, 2013).

3.3.4 Visual interpretation of satellite imagery vs map reading

There are two ways to interpret satellite imagery, which are through human input (visual interpretation) or by an automated satellite sensor (computer interpretation). Visual interpretation of a satellite image often refers to as image interpretation or a process of examining photographic images to identify particular objects. Meantime, the interpretation of maps (cartographic representations) often is defined as *map reading* (Lloyd, 1997). Map reading as described by Head (1984) is similar to reading text because both use similar cognitive process, in which the ability to recognize objects is based on the information stored in the long-term memory. Therefore, factors such as knowledge, experience and cognitive efforts influences map reading efficiency (Mennecke, Crossland, & Killingsworth, 2000).

Unlike computers, people read maps and satellite images by visually interpreting them. The interpretation of variables vary between individuals (Van Coillie et al., 2014). Users visualize and interpret maps through symbols and labels whereas images are interpreted through various elements. These elements as listed by Jensen (2016) are:

- Colour – used to differentiate between objects
- Size - overall dimensions or measurements (length, area, perimeter, volume) of an object compare to others e.g. big buildings and small buildings
- Shape - physical characteristic of an object, e.g. buildings, roads, trees

- Shadow - sun’s inclination angle where the image was taken and in what point in the day the image was taken. Shadows help identify an object’s height and shape
- Texture – changes of colour from time to time. Texture helps to identify a single object.
- Pattern – spatial arrangements and spacing of multiple objects
- Site – the actual location of the remotely sensed image
- Association (signatures) – other objects associated with the object of interest

The elements of image interpretation from Estes et. al (1983) is broken down into a hierarchical level in which the interpretation difficulty increases as the order changes (Herold, Liu, & Clarke, 2003). Colour and tone are considered the primary elements and the secondary elements are the spatial arrangements of size, shape, and textures. The tertiary elements add context to differentiate the object of interest from the surrounding. The higher element encompasses site and association, thus requires the interpreter’s prior knowledge. Image interpretation by Estes et .al is illustrated in Figure 3-1.

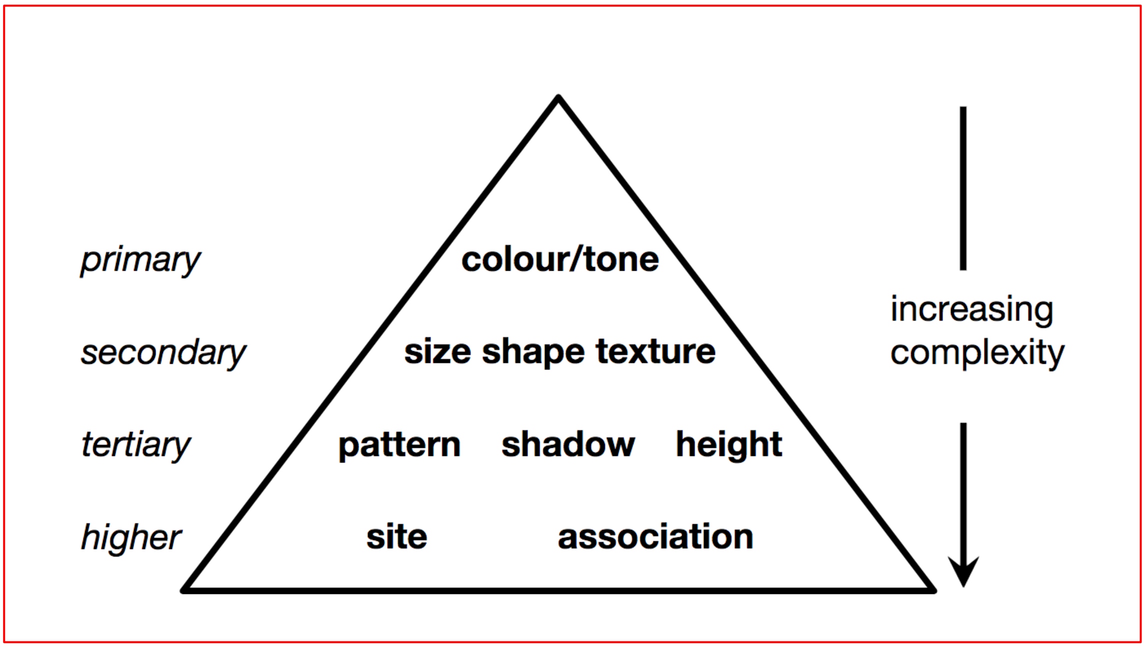


FIGURE 3-1: THE ELEMENTS OF IMAGE INTERPRETATION FROM ESTES ET. AL (1983)

Adapted from “Spatial metrics and image texture for mapping urban land use,” by Herold et al. (2003, p.991)

3.3.5 Object identification

To identify an object using either map or images, people often start by locating the familiar places such as roads, buildings (home, school, business places, tourist attractions such as parks, historical buildings, lakes, etc). If people are familiar with the area, they can immediately recognize the object. As noted by Golledge (1992), people can visualize the complete picture of an area once they have been exposed to the environment. Thus, they will be able to pinpoint the location of the object of interest even if they are not visible, however, the location may not be as accurate as when the object is visible.

Prior knowledge of the location of a certain object (local knowledge) is a powerful tool for interpreting map and satellite imagery hence identifying objects. Knowing certain changes that are happening in the area for example changes to the roads, forest fire, and landscape changes for urban expansion helps significantly in identifying certain features. As stated by Montello, Waller, Hegarty, and Richardson (2004), people record spatial information about their environment as they travel through the area. De Leeuw et al. (2011) investigated the ability of two different groups of community in Homa Bay, west Kenya, to classify road infrastructure using high-resolution imagery. These groups comprises people who are familiar with area the of study and people who are not familiar with the area. The study result indicates that the people who are familiar with the area classify roads more accurately than the other group.

In interpreting maps and low-resolution images where objects are invisible, factors such as prior knowledge and expertise, training level and expectations of what to see affect the accuracy level (Tapete & Cigna, 2018). A study by Svatonova (2016) on visual interpretation of images and maps shows that experts with prior knowledge and experience are faster in identifying an object. In terms of accuracy level, both experts and non-experts acquired the same result.

Humans also visualize images and maps and identify objects using colour cues. Colour enhances object identification in both maps and images (Liebe et al., 2009). However, in maps, objects are grouped and uniformly coloured. For example, water may be identified by blue colour, plants green and sand yellow. On the other hand, images are composed of multispectral colour, thus, provide more details for specific object visualization. For example, the change of tone in one colour displays the lightness or darkness (tint or shade) of a basic colour e.g. short plants have light green colour, while trees have dark green colour). Svatonova (2016) investigated the level of accuracy and correctness of interpreting satellite imagery based on the colour and depicted landscape. The experiment results revealed that the colourfulness of an object increases correctness and accuracy. Furthermore, a comparative study conducted by Svatonova and Kolejka (2017) on visual interpretation between aerial images and topographic maps also shows that object identification is carried out faster on images than maps.

Images are also interpreted through recognizing patterns, shapes, and textures (Jensen, 2016; Lillesand, Kiefer, & Chipman, 2014). The most obvious patterns are land covers, for example, with agricultural areas often being geometric shapes (circular or rectangle) that differentiate them from other random settings of nature. Likewise, geological features have visible textures (for example mountains have long or wavy lines, volcanos are circular and canyons often appears crooked and framed by shadow). Other obvious patterns are buildings that are polygonal in shape, roads linear in shape and trees random in shape. Meantime, water bodies such as rivers, lakes, and ocean can easily be identified through their unique shapes. Knowing these elements can help people to identify smaller objects associated with them.

Another important element that aids people to identify objects is referential information (Jensen, 2016). The referential information are features or objects associated with the object of interest. For example, a power station is identified by smoke from the chimney and the presence of water next to it.

3.3.6 Objects identification on satellite images at different resolutions

The spatial resolution of satellite imagery influences object identification. Spatial resolution shows how much detail is visible to the human eye (Jensen, 2016). The highs and lows of the resolution of an image are dependent on its element known as pixels (Hossain, 2016). Therefore, smaller pixel sizes produce higher resolution images while larger pixel sizes produce a lower resolution image. How images appear in different pixels are illustrated in Figure 3-2.

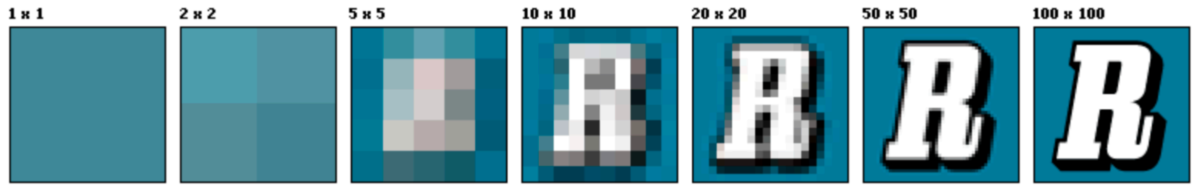


FIGURE 3-2: IMAGES DISPLAYED IN VARIOUS PIXELS

Image retrieved from "Remote sensing and image interpretation," by Hossain (2016, p.55)

The current commercial satellites that provide the highest resolution imagery is the Worldview4 (launched in 2016) by Digital Globe. Wordview4 provides panchromatic imagery at 30cm resolution, multispectral 1.24m. The image prices range from USD 14 – 55 per square kilometre (LandinfoWorldwideMapping, 2018). With the high-resolution spatial resolution, users can zoom in areas to see objects such as cars and houses in detail (See Figure 3-3, image A). With the lower resolution imagery, people may still be able to identify objects the same size as cars and boats, however, it would be difficult to identify smaller objects and pinpoint the location of such objects accurately (Figure 3-3, image B). In this situation, people need to rely on prior knowledge of the characteristic of the object and its location to enable them to pinpoint the exact location.

Image A - WorldView-4 Satellite Image of Santiago, Chili. Resolution 30cm natural color. Image taken on April 13, 2017 (DigitalGlobe)

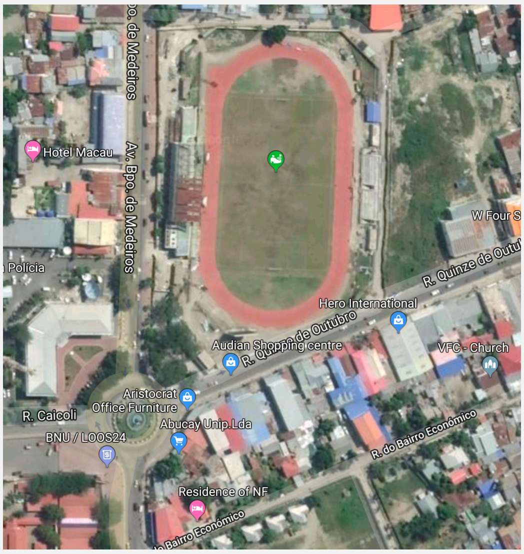


IMAGE *B* - AN AREA IN DILI, TIMOR-LESTE. RESOLUTION: GROUND RESOLUTION OF THE SOURCE DATA IS 0.5 METERS. ACCURACY: OBJECTS IN MAP ARE WITHIN 10.2 METERS OF TRUE LOCATION. IMAGE TAKEN ON JUL 8, 2012. (DIGITAL GLOBE)

FIGURE 3-3: SAMPLE IMAGES IN DIFFERENT RESOLUTIONS

3.3.7 Conclusion

Maps are designed to replicate reality and often designed to serve a purpose. Meanwhile, images displays reality with no descriptions, and therefore users are required to visualize and interpret the image based on elements such as colour, size, shape, pattern, site, association, etc. Successful interpretation of images is dependent on resolution of the image. Nevertheless, compared to maps, it is easier to read and identify objects on images because images display real landscape that human eyes are familiar with.

3.4 Methodology

This particular experiment was conducted to find a suitable map that allows participants to mark the location of the waste collection sites. Thus, the map of Massey University, Albany campus was selected for this experiment. Three samples of different maps with different resolutions were used. These maps are:

- OpenStreepMap (1464 x 1318 pixels)
- Low-resolution satellite image (resolution 10.2 meter, 1011 x 911 pixels)
- High-resolution satellite image (resolution 0.08 meters, 794 x 768 pixels)

The test was conducted using images and map of New Zealand because high-resolution images of Timor-Leste were not freely available. There are commercial images that are available to be purchased but expensive and requires a lengthy process to obtain. Meanwhile, the low-resolution images and OpenStreet map of Timor-Leste are freely available. Both the low-resolution image and the OpenStreetMap selected for the experiment are those that have similar resolution with Timor-Leste's.

3.4.1 Experiment

The experiment was conducted using Qualtrics[20]. This tool was chosen for this experiment due to its ability to store and visualize spatial information. Furthermore, Qualtrics was chosen because the software is available to this project at no cost.

In this experiment, participants were tasked to identify the location of an outdoor bench, the bus stop nearest a lecture theatre building and an outdoor table. Since the objects are only visible on the high-resolution image but not on the OpenStreetMap and the lower resolution map, the survey was conducted *in situ* (where the objects are located) on the Massey University campus, by physically pointing to the object and asking the participants to locate them on the maps embedded in the survey questionnaire. Questions with regards to object identification were constructed using heatmap feature. This feature was selected because it allows respondents to mark the object on the satellite image. Furthermore, the decision to conduct the experiment in situ was based on the fact that the object of interest was not unique but there are similar types of the objects located near them. The objects used for this study were a bench, a table and a bus stop (shown in Figure 3-4).

[20]https://idp.massey.ac.nz/idp/profile/SAML2/POST/SSO;jsessionid=FE1514A01C591537354475F795452E80?execution=e1s1

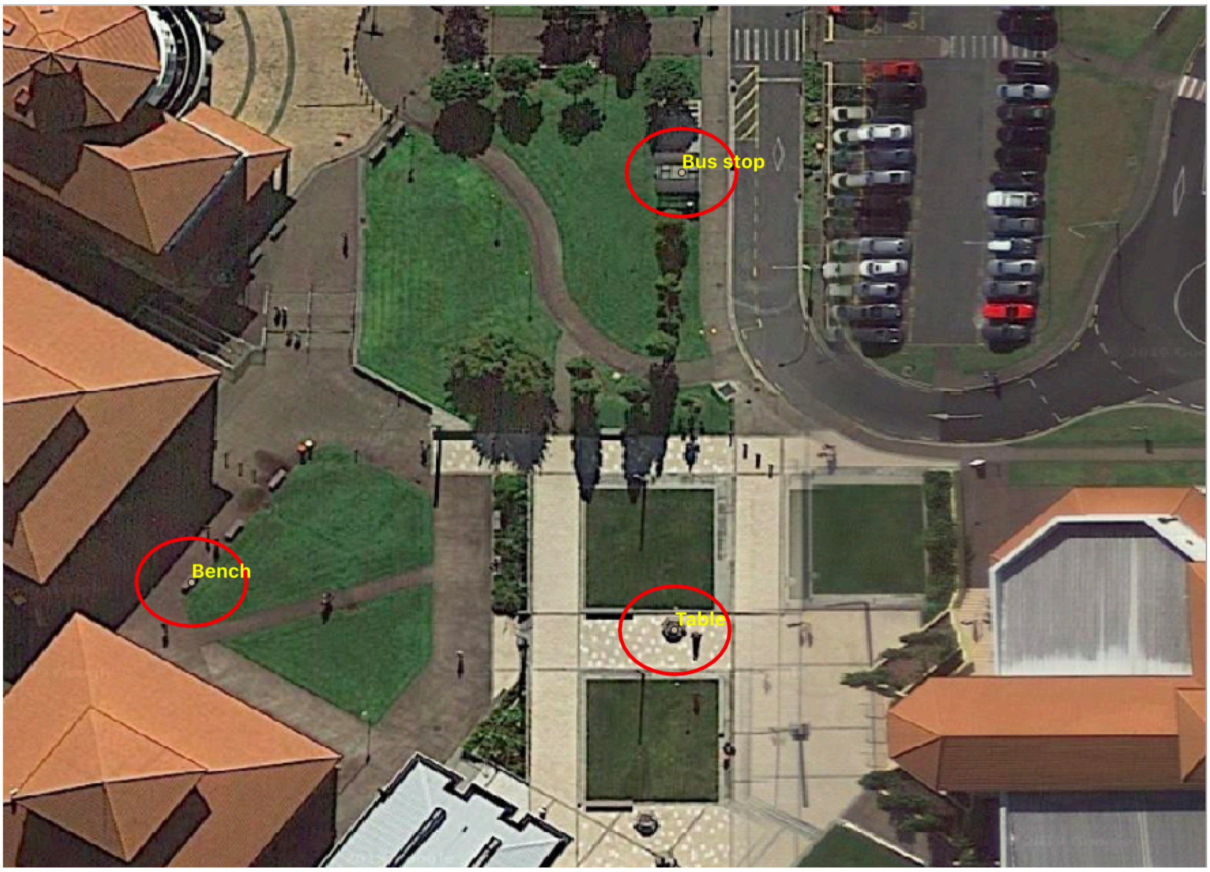


FIGURE 3-4: OBJECTS STUDIED

3.4.2 Participants

The participants for this project were students from Massey University and passers-by who voluntarily participated in the survey. Of 36 survey participants, 12 completed the survey using OpenStreetMap survey (Survey A), 12 completed the low-resolution image (Survey B) and 12 completed the survey using the high-resolution image (Survey C). Since the experiment was conducted at the campus, the majority of the participants were students and only two passers-by completed the survey using low-resolution satellite image (survey B). The passers-by were not familiar with the area which may affect the survey result.

3.4.3 Task

Three different maps were presented to the participants. The three maps from these experiments are presented in Figure 3-5, 3-6 and 3-7 are a Map (1464px x 1318px), low-resolution image (1011px x 911px), and high-resolution image (794px x 768px). For this experiment, the interpretation of the map and the images depend largely on the assumption that participants were able to read maps and able to identify objects they were tasked to identify. It was also anticipated that the objects in the image with high spatial resolution would be somewhat easy to identify. On the other hand, the image with low-resolution and the OpenStreetMap would likely be confusing and difficult thus forcing the participants to guess the location of the object of interest.

FIGURE 3-5: SURVEY A - OPENSTREETMAP

Image retrieved from https://www.openstreetmap.org/#map=17/-36.73255/174.70374

FIGURE 3-6: SURVEY B - LOW RESOLUTION IMAGE

Image retrieved from https://navigator.digitalglobe.com/projects/77a16b21-9b4c-4ecf-ae01-54ef17b2786b

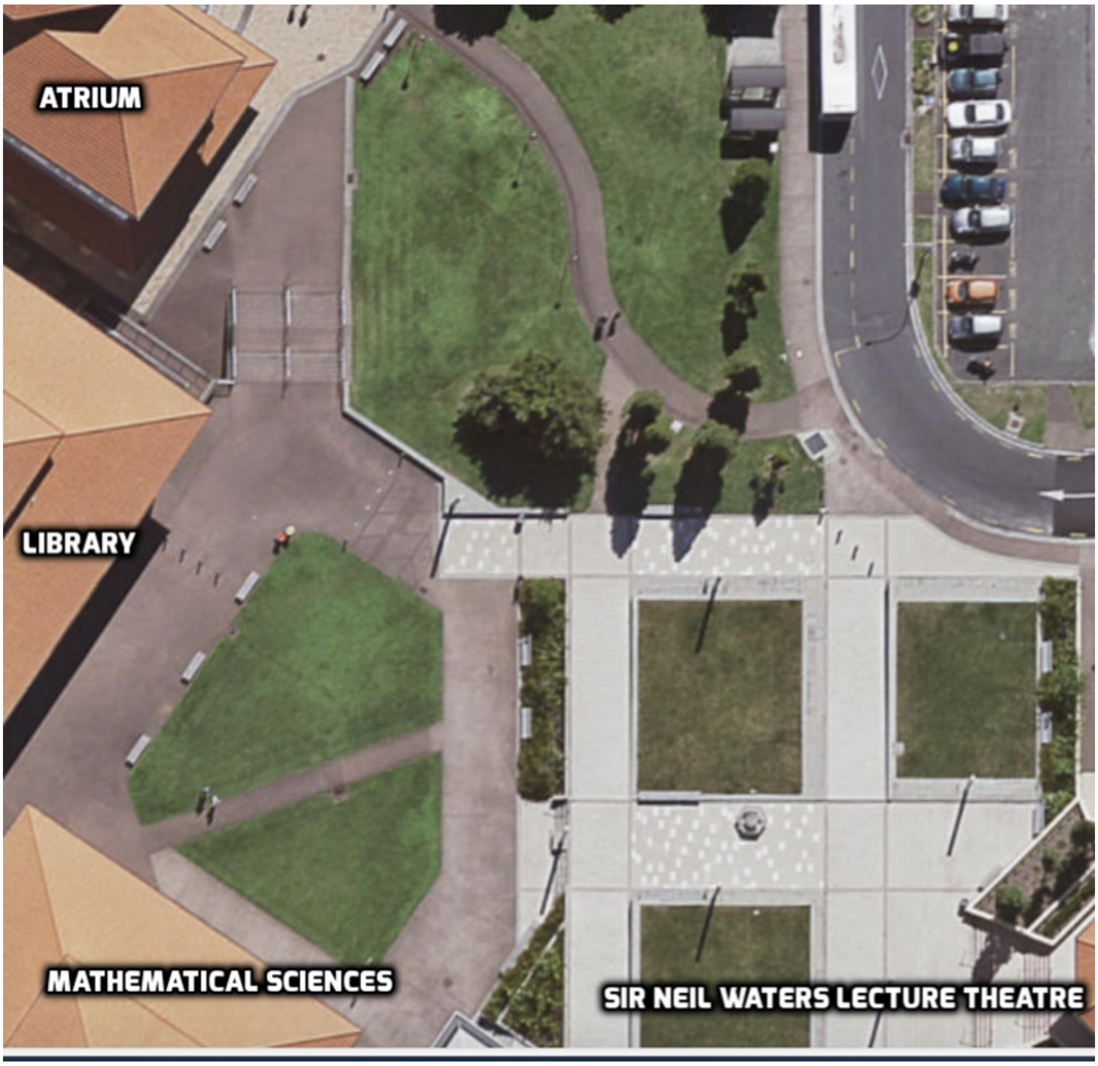


FIGURE 3-7: SURVEY C - HIGH-RESOLUTION IMAGE

Image retrieved from the Auckland Council (Auckland city 2016) imagery taken 2 years 8 months ago, on Friday, January 1, 2016. Resolution: ground resolution of the source data is 0.08 meters. accuracy: objects in map are within 999999 meters of true location

3.5 Data analysis

The interpretation of the results, particularly with the heat map questions was based on the success (positional accuracy) of the location of the objects. The positional accuracies are estimated by comparing the size of the map and the images (in pixels) that were utilized for the survey with the distance of the actual map (in meters): map size (712 x 626), low-resolution image (117.2 x 99.9), and high-resolution image (77.8 x 75.6). The dataset was downloaded in csv from Qualtrics and analysed with Excel and Minitab statistical software.

3.6 Results

The graphical representation of data collected from the heat map questions is shown by colours. Each colour represents the frequency of users' selections. The area that has been selected the most are shown in red. Qualtrics records two coordinates (x and y) during each selection. Both coordinates are located from the top left of the image and are measured in pixels. Figure 3-8, 3-9, and 3-10 show the heatmap for the three objects. The images shown are in the same scale.

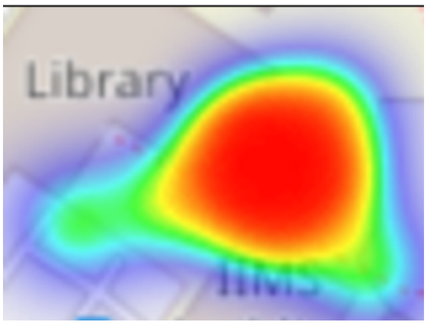
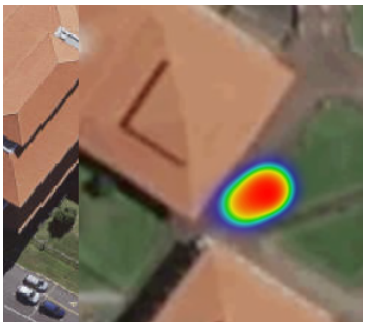
Map	Low-resolution image	High-resolution image
		

FIGURE 3-8: HEATMAP VISUALIZATION OF THE BENCH

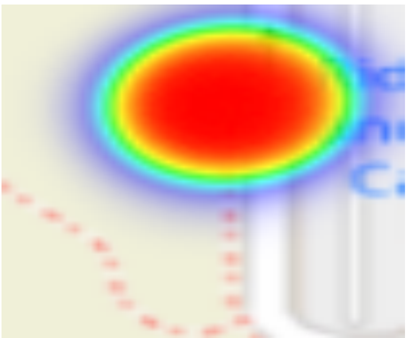
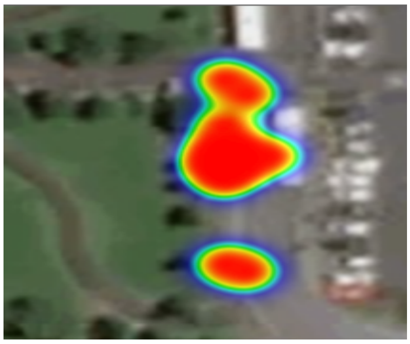
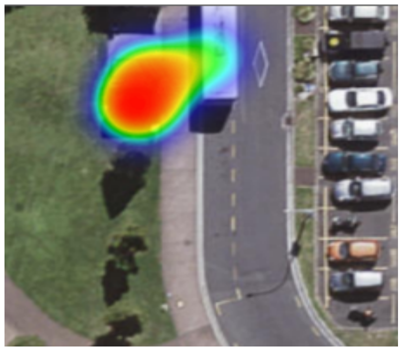
Map	Low-resolution image	High-resolution image
		

FIGURE 3-9: HEATMAP VISUALIZATION OF THE BUS STOP

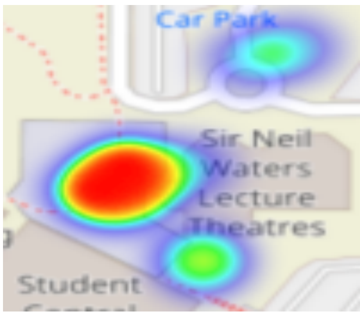
Map	Low-resolution image	High-resolution image
		

FIGURE 3-10: HEATMAP VISUALIZATION OF THE TABLE

3.6.1 Dispersion of data from the mean

The results of the experiment shows that objects were better identified on the high-resolution image. This is most likely attributed to the visibility of the objects of interest in the image. The outdoor table, in particular, had been easily pinpointed by most of the respondents (83%) which therefore reflected in a relatively small deviation (0.34). The data for the location of the bench deviates quite largely (at 4.38) compared to the bus stop and the table although it is visible in the high-resolution image. Table 3-1 provides the average standard deviation (in meters) for the three different maps. A more detailed statistical summary can be found in Table 3-2. Since the bench and the other objects were directly pointed at, respondents were expected to identify the location accurately. Indeed, at least 75% observations were within one standard deviation. However, several responses were a few meters away. These outliers contributed to the higher deviation. These anomalies suggest that the respondent misunderstood the object to select or the respondent has poor map reading skills.

Map type	Bench	Bus stop	Table	Average
High-resolution image	4.37	1.94	0.34	2.22
Low-resolution image	1.86	4.98	9.52	5.45
Map	12.69	29.6	24.09	22.13

TABLE 3-1: AVERAGE STANDARD DEVIATION (IN METERS)

Statistical summary for the map

Variable	Total Count	Percent	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum	Range	IQR	Mode	N for Mode	Skewness
Bench (x)	12	100	515.33	9.82	34.02	1157.7	435	505	519	541.5	561	126	36.5	545	2	-1.22
Bench(y)	12	100	896.5	5.42	18.76	352.09	867	883.5	894	909	935	68	25.5	891	2	0.57
Bus stop (	12	100	645.1	24.8	85.8	7363.4	608	619	619.5	627	917	309	8	619	4	3.44
Bus stop (	12	100	742.1	10.8	37.4	1395.4	710	727	734	736	857	147	9	736	3	3.08
Table (x)	12	100	659.3	12	41.5	1721.1	614	633	639	688	747	133	55	633	2	0.95
Table (y)	12	100	909.5	17	58.8	3452.3	792	905	917	930	993	201	25	905	2	-0.88

Statistical summary for the low-resolution image

Variable	Total Count	Percent	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum	Range	IQR	Mode	N for Mode	Skewness
Bench (x)	12	100	277.33	6.01	20.8	432.79	232	262	284.5	293.75	301	69	31.75	265, 290	2	-0.87
Bench(y)	12	100	607.58	3.49	12.09	146.27	589	598.5	606	618.5	627	38	20	*	0	0.35
Bus stop (	12	100	681.33	3.63	12.59	158.42	663	674.5	677	690.75	710	47	16.25	676, 677	2	1.01
Bus stop (	12	100	204.2	21.9	75.7	5733.6	91	157.8	197.5	221.8	346	255	64	209	2	0.74
Table (x)	12	100	655	21	72.6	5269.8	499	618.5	672.5	722	727	228	103.5	626, 727	2	-0.96
Table (y)	12	100	630.3	27.8	96.1	9244.7	375	605.3	657.5	669	755	380	63.8	l, 661, 669	2	-1.8

Statistical summary for the high-resolution image

Variable	Total Count	Percent	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum	Range	IQR	Mode	N for Mode	Skewness
Bench (x)	12	100	102	2.12	7.34	53.82	93	97.25	100	107	119	26	9.75	3, 100, 101	2	1.34
Bench(y)	12	100	514.3	23.6	81.8	6684.8	256	532.3	539.5	543.8	544	288	11.5	544	3	-3.4
Bus stop (	12	100	563.58	6.3	21.83	476.63	544	549.25	554	586.25	608	64	37	556, 593	2	1.2
Bus stop (	12	100	66.17	5.11	17.71	313.79	38	51	68.5	83	91	53	32	51, 83	2	-0.14
Table (x)	12	100	545.67	0.838	2.9	8.42	543	543.25	545	546.75	553	10	3.5	545	4	1.66
Table (y)	12	100	595.58	1.16	4.01	16.08	589	594	595	598	604	15	4	595	4	0.76

TABLE 3-2: STATISTICAL SUMMARY (IN PIXELS)

The identification of the bench on the low-resolution image is surprisingly better than the high-resolution (with the average standard deviation value of 1.85). This could be attributed to the fact that the object is located much closer to a building that all participants are likely to be familiar with (the library), therefore, it was easier to estimate the distance. The task of identifying the bus stop and the table showed large dispersion (at 4.98 and 9.51 respectively). The task of identifying the bus stop might have been difficult because the roof of the bus shelter appears to have the same colour tone and almost the same shape as the trees located nearby. Therefore, some respondents may have mistaken a tree as the bus stop. This suggests that the similarity of colour tones and shape makes recognition difficult.

The result of the object identification using the map showed substantially large variations. The reason could be that the objects are not visible, therefore, respondents need to guess where the location would be on the map. The bus stop was easily identified by most of the respondents (91.67%) because the map symbol was clearly visible on the map. Only one respondent pinpointed the location in an area that was of great distance from the bus stop. Meanwhile, the result from the identification of the bench and the table showed that several respondents pinpointed the location in areas located few meters away from the object. These few outliers contributed to the high values of the standard deviation.

3.6.2 Outlier exclusion

By using the interquartile range calculations, the data points that differ greatly from other values, particularly those that are beyond the 1.5 interquartile range (outliers) were identified and removed. Some changes were observed in the task of identifying all the bench, bus stop and table using the high-resolution image. For example, the average standard deviation values for these tasks decreased from 4.37 to 0.41, 1.94 to 1.65 and 0.34 to 0.27 respectively. Changes were also observed for the tasks of pinpointing the location of the bench and bus stop using the map. Drastic changes however were only observed in the task of identifying the bus stop using the map (from 29.60 to 3.49). This could be due to the fact that the outlier for that task lies an abnormal distance from the other values.

Nevertheless, not all observations have outliers. For example, there were no outliers found for the task of identifying the bench and table using low-resolution image and the task of identifying the table using the map (as shown in the unchanged standard deviation values). These changes are illustrated in Table 3-3.

Map type	Bench	Bus stop	Table	Average
High-resolution image	0.41	1.65	0.27	0.78
Low-resolution image	1.86	4.98	9.52	5.45
Map	10.32	3.49	24.09	12.63

TABLE 3-3: AVERAGE OF THE STANDARD DEVIATION WITHOUT OUTLIERS (IN METERS)

3.6.3 Dispersion of data from the median

Given the mean is skewed by outliers, the median and the interquartile range (IQR) were used to evaluate the central tendency and variability of sample distributions. The result as shown in the statistical summary in Table 3-2. The results revealed that the data accumulated for the task of locating the bench and table using the high-resolution image are fairly consistent as proven by the smaller IQR ranges (9.75 and 3.5 respectively). Similarly the task of identifying the location of the bus stop using the map also displays a significantly lower IQR value (at 8). These are most likely attributed to the visibility of the objects on the map. Astoundingly, the IQR value for the task of identifying the bus stop using the low resolution image is almost 50% lower (at 16.37) than the high-resolution (37). This implies that the data values are fairly closer to each other compared to the data values of the high-resolution image for this particular task. The task with largest IQR value is the task of locating the table using the low-resolution image (103.5) followed by the task of identifying the table using the map (55 IQR value).

Similar data distributions can be seen in the Figure 3-11, 3-12 and 3-13. These boxplots indicate the centrality and the spread of the data and provides a visual display of the minimum value, the lower quartile (lower 25% of observations), the median, the upper quartile (upper 25% of observations), the maximum value from the data sets and the extreme values (outliers). It can be observed from both x and y datasets, the width of the boxplots for the tasks of identifying the bench and the table using the high-resolution image are more condensed despite each having few outliers. This indicates that the data points for both tasks are relatively close. A rather similar trend can also be seen in the task of identifying the bus stop using both map and images, however, the boxplot for the map appears to be much more condensed compared to boxplot for the images.

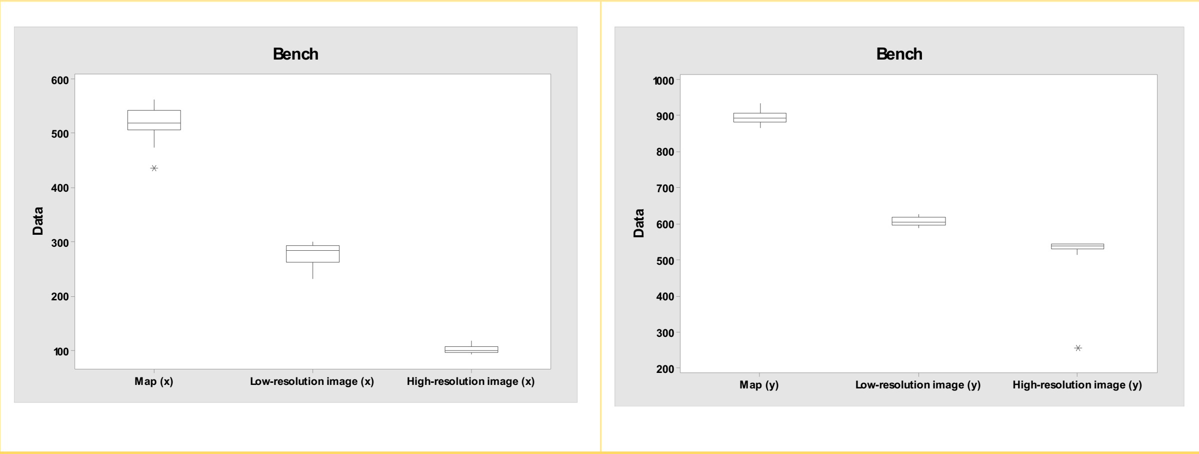


FIGURE 3-11: BOXPLOTS DISPLAYING DATA DISTRIBUTION FOR THE TASK OF IDENTIFYING THE BENCH

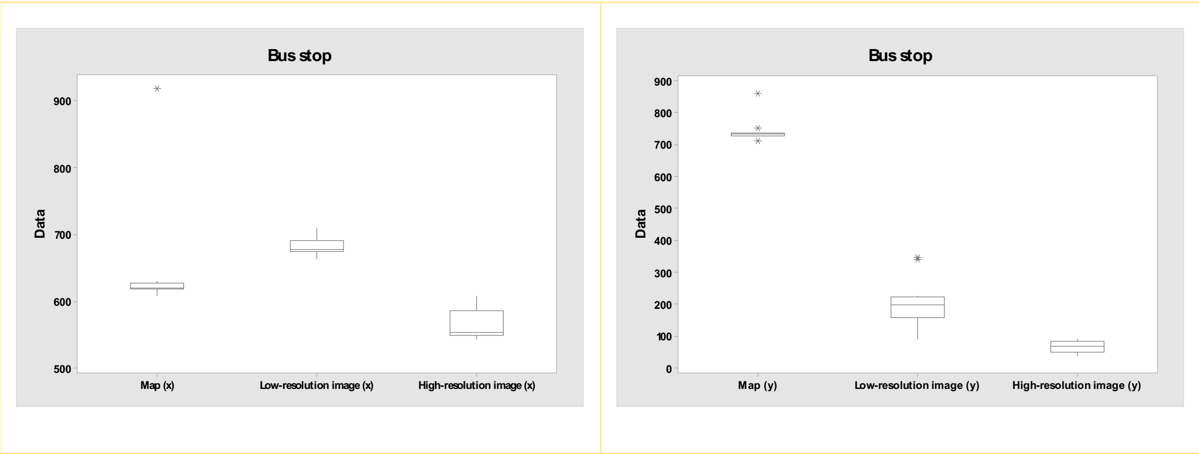


FIGURE 3-12: BOXPLOTS DISPLAYING DATA DISTRIBUTION FOR THE TASK OF IDENTIFYING THE BUS STOP

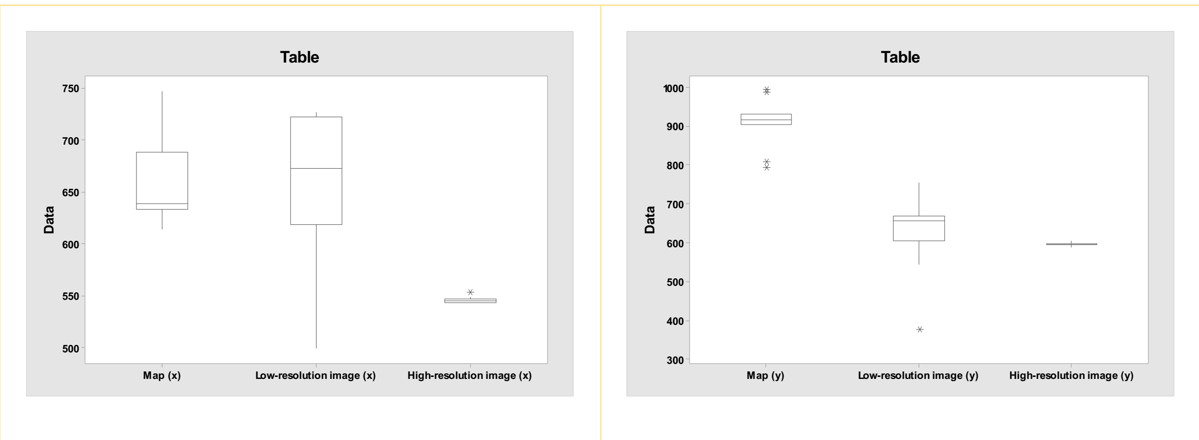


FIGURE 3-13: BOXPLOTS DISPLAYING DATA DISTRIBUTION FOR THE TASK OF IDENTIFYING THE TABLE

The data recorded for the task of identifying the bench using the map, appears to have a symmetrical distribution given the median line is roughly closer to the centre of the box and the whisker lengths (the lower quartile and upper quartile) are almost the same (see Figure 3-11). On the other hand, the data for the task of locating the bench by using the low-resolution image appears to be left-skewed (negatively skewed) as shown by much longer whisker at the bottom compared to the top whisker. The left-tailed distribution signifies that the 25% of the data above the median value (smaller box) are more closely together than those below the median line. Similar appearance (skewness) is observed for the boxplot representing the table on the low-resolution image. However, the median line for the low-resolution image is somewhat closer to the centre. This means that the middle 50% of the observations closer to the median value (those within the inter-quartile range) have less variability.

As for the task of pinpointing the location of the table using the map, a right-skewed (positively skewed) distribution has been observed, which signifies that the data points that lies below the median line are closer together than those above.

3.7 Discussion and conclusion

This study was conducted to identify an appropriate background map by investigating how well people recognize objects and how they can identify objects accurately on maps or image based on their map reading skills.

The result of the experiment revealed that survey participants can identify objects quicker in a high-resolution image. This is because the object is visible. However, map reading skills are required for them to mark the location accurately. The participants could also quickly identify objects that are clearly represented by symbols or labels (for example for the case of identifying the bus stop using the map). Moreover, the result of the study shows that participants were able to pinpoint the location of an object despite it not being visible, if they are familiar with the object and the location, however, the coordinates may not be as accurate as when the objects can be seen (for example the task of identifying objects using low resolution image). Hence, factors such as knowing what the object looks like and the familiarity with the area are essential in the process of interpreting both images and maps. Map reading ability is also important because the task of identifying an object requires the reader to be able to search and locate the objects. The result of this study shows that map reading ability differs between each individual and their spatial skills affect the accuracy of object location.

This study poses several questions and a summary of the findings pertaining to each of these questions are provided below.

1. *How well can objects be identified on satellite images at different resolutions?*
   The result of the experiment indicated that people can identify the location of an object more accurately and quickly using a high-resolution image. People can also pinpoint the location of objects using the low-resolution image, however, the location is not as accurate as compared to the high-resolution image.

2. *How well can humans find locations on maps?*
   People can pinpoint the location of an object more accurately if the object is represented by a symbol. The reason could be that map symbols represent exactly what the object looks like in real life. In this experiment, for example, most respondents were able to rapidly and accurately identify the location of the bus stop because it was displayed with a symbol.

3. *Does map reading skill affect the accuracy with which an object is located?*
   Yes, map reading ability does influence the result because unlike images, objects on maps are represented by symbols and labels. Understanding what each symbol represents can help users to identify the precise location of an object.

Based on the result, this study concludes that the best background map would be a high-resolution image. The second option was to use a map as it has symbols and labels. These features help people to navigate the area they are familiar with and allow them to mark the location of solid waste collection sites. The prefer option was a high-resolution image. However, it was difficult to obtain a high-resolution image for Dili due to financial constraints. Therefore, the study proceeded to use the OpenStreetMap.

CHAPTER 4 - PROPOSAL FOR THE OPTIMIZATION OF WASTE COLLECTION SITES

4.1 Introduction

This chapter presents a proposal for optimising waste collection sites in two subset areas in Dili by using the data collected from this research study. The section commences by describing the objective of this study and then discussing previous work related to this project. Finally, the chapter details the optimization model as well as various associated schemes.

4.2 Objective

The objectives of the optimization are to optimize ease of collection, convenience (closeness) to households and to ensure that the right size of bins is placed according to the volume of waste generated. The optimal locations are determined based on various factors including population distribution, the quantity of waste generation, collection transport accessibility and proximity to households. The selection of the optimised locations are carried out using geographic information system (GIS) technique.

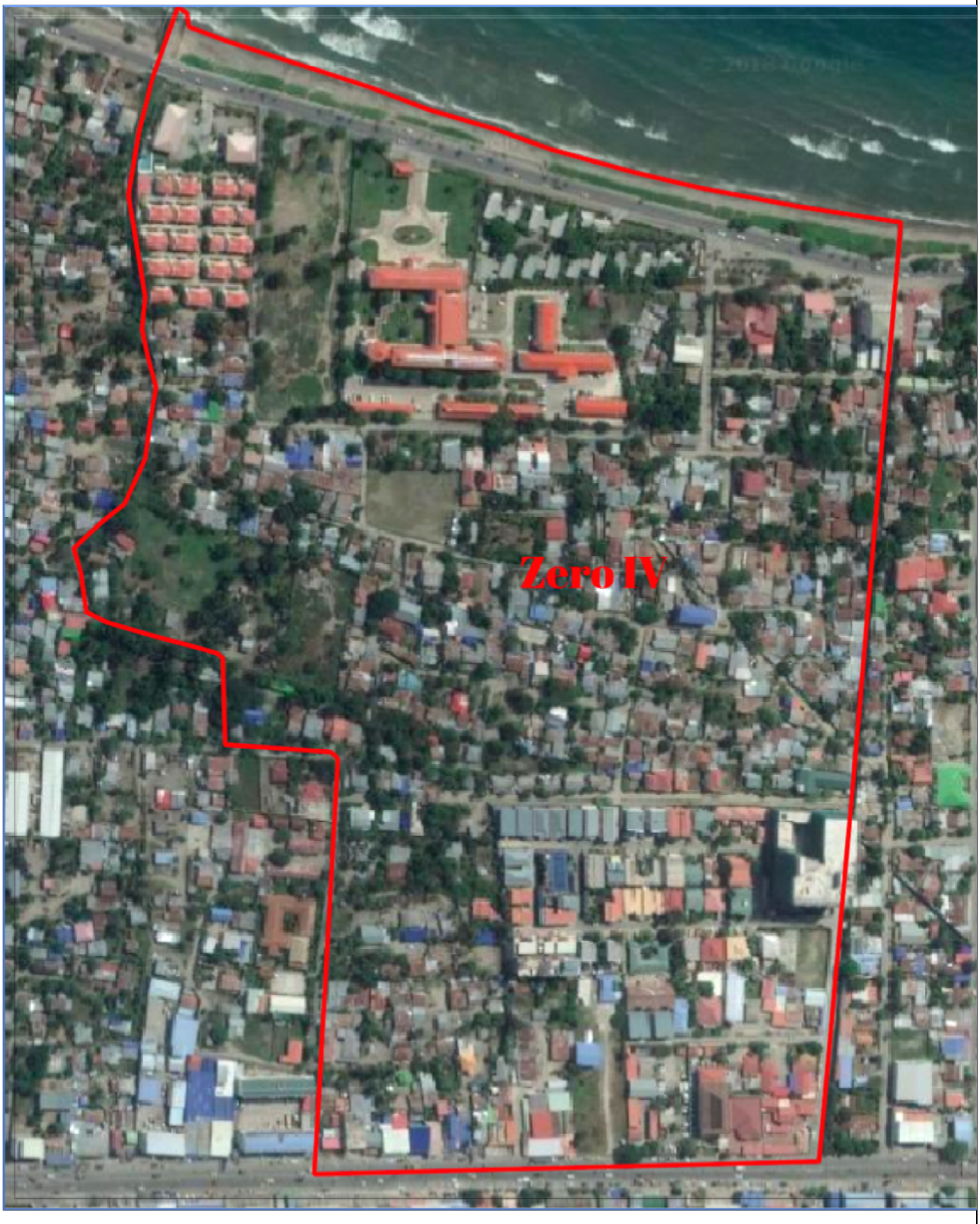
The number of bins to be provided is based on the volume of waste produced. The types of the bins and their storage capacity studied are the ones specified in the Decree-law number 2/2017 (Government of Timor-Leste, 2017). These are:

- 4,000 liters or four cubic meter (for main roads (primary roads) and collector roads (secondary roads)
- 1,200 liters (in smaller streets for household waste)
- 240 liters

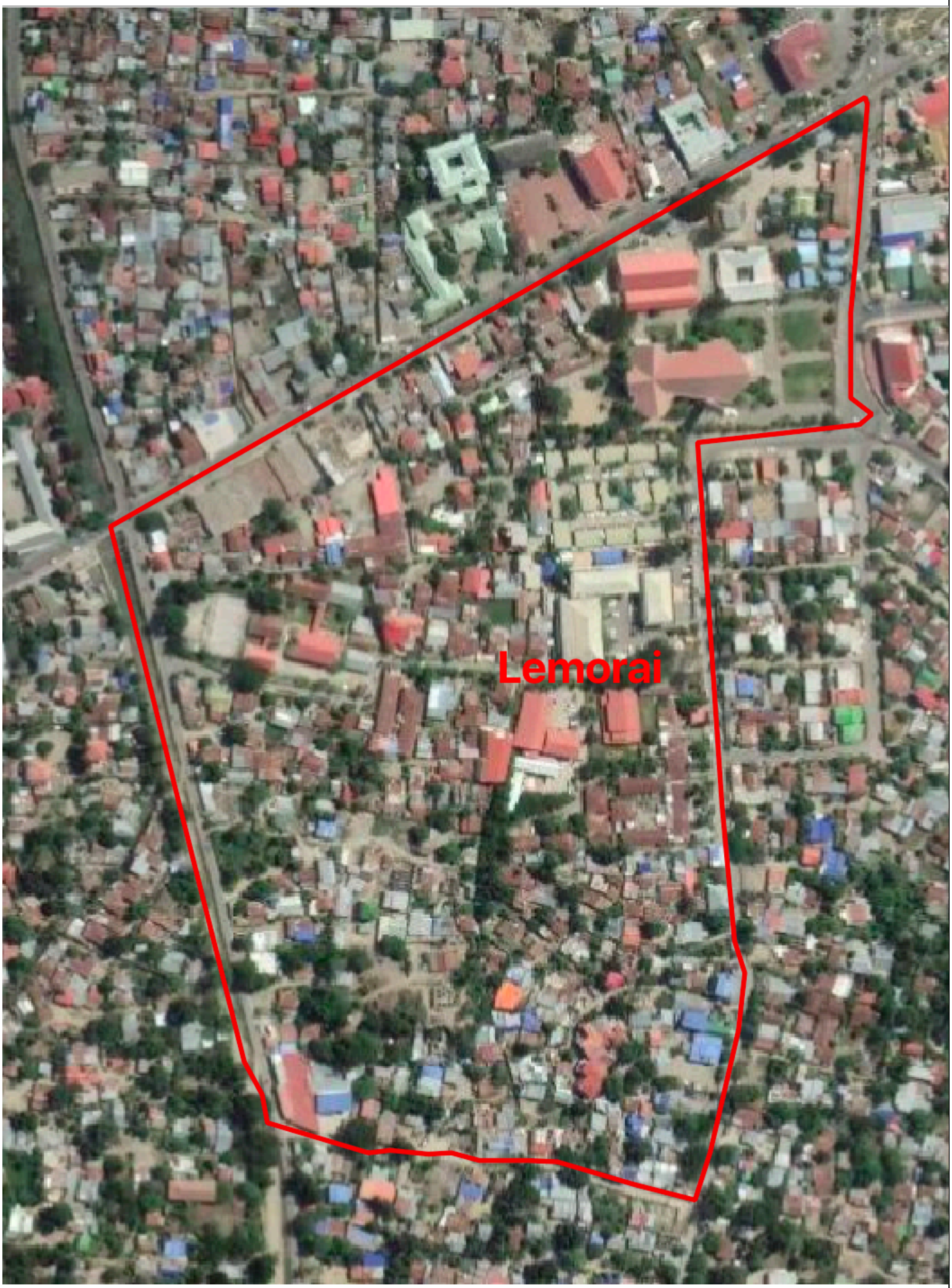
- 120 liters
- 60 liters

For this experiment, two flood-prone villages were selected. These villages are Aldeia Zero IV which is located centrally around latitude -8.5471 and longitude 125.5573 and Aldeia Lemorai which is located around latitude -8.5589 and longitude 125.5668. The reason these two villages have been chosen for this study is that both villages are located in low lying areas with a poor drainage system causing them to encounter frequent flooding during heavy rainy seasons. Improper solid waste disposal contributes to flooding as waste creates a blockage in waterways and drainage systems. Moreover, waste left uncollected in flooded areas could create additional problems such as the spreading of diseases. Hence, this kind of study may be particularly important in these areas. Hence, this kind of study may be particularly important in these areas as it proposes optimal locations based on waste generated in these areas. Having adequate bins placed in convenient locations for both residents and collectors can potentially improve the collection services as well as reduce flood risks. The study areas are shown in Figure 4-1.

The residents of the study areas comprise of low to middle-income families. The low-income families are more at risk of flood as they live in poor housing conditions. Aldeia Lemorai, in particular, suffers more as it more densely populated while there is no proper drainage system in place.



Study area 1- Aldeia Zero IV



Study area 2 – Aldeia Lemorai

FIGURE 4-1: OPTIMAL BIN LOCATION STUDY AREA

4.3 Literature review

Given its uniqueness and its ability to digitally store, retrieve, manipulate, analyse, and display geographically referenced data, GIS has been used as a valuable decision-making tool in many areas including solid waste management. One of its applications in waste management is for optimising bin locations and optimising transportation routes.

Several optimisation modules have been developed and applied in various areas. These studies, however, have mainly utilized ArcGIS tools. For example, Ahmed, Muhammad, and Sivertun (2006) used the buffering method to verify the location of existing bins and relocate those located in close proximity with buildings such as schools, hospitals, religious buildings and environmentally sensitive areas (for example streams). In addition, the study focuses on allocating new bins in areas that have a limited number of bins and proposes recycling bins for areas deemed to generate more recyclable waste such as theatres, offices, marriage halls, and educational institutions. Buffer analysis of 20m radius was used to create boundaries for institutional buildings, 15m for environmentally sensitive areas and 100m for allocating the new bins. The study was conducted in Aurangabad city, India. This study, however, did not take into account factors such as bin storage capacity and collection frequency.

A similar study was conducted by Nithya, Velumani, and Senthil (2012). The authors also investigated the adequacy and the location of existing bins in Sidhapudur, Coimbatore, India and then proposed new locations of bins in areas that require them. The number of bins proposed is based on the amount of per capita waste generated. Three different proximity distances were tested, that is 50m, 75m and 100m buffer zone around existing bins to find the optimal convenience distance. The result of their study shows that the 75m buffer zone was found to be ideal.

Meanwhile, in the Municipality of Nikea, Athens, Greece, Chalkias, and Lasaridi (2009) focus on replacing existing 240 liter bin with 1100 liter bins and reschedule collection using GIS routing method with the aim to minimize time spent for collection and reduce the distance traveled. A buffer zone of 60m was used for allocating the new 1100 liter bins. The result of the study shows that the optimised model provided savings compared to the existing model. The saving for the collection time increased from 3.0% to 17.0% and travel distance savings increased from 5.5% to 12.5%.

This study adopted a similar method of using the buffering system. However, the optimal number of bins were proposed based on the amount of waste generated the area, bin storage capacity and the collection frequency. Furthermore, this study differs from previous works in that it utilized Quantum GIS (QGIS) platform. QGIS is an open source geographic information system that supports the creation, management, and analysis of geospatial data[21].

[21] https://qgis.org/en/site/

The present work is distinctive considering this method, to the best of the researcher’s knowledge, is yet to be explored in Dili or any other areas in Timor-Leste.

4.4 Methodology

4.4.1 Data preparation

Various data required for the analysis include the size of population, population density, waste generation rate (mixed waste), the current positions of waste collection bin/sites, type of bins (capacity) and road networks. The data on the existing collection sites are taken from the result of the survey conducted by this study (detail in Chapter 2) while data on the population currently residing in Dili are derived from the 2015 housing and population census (Statistics Timor-Leste, 2016). Spatial data on administrative divisions were obtained from the Cartography Department, Ministry of Finance while the road network is obtained from the OpenStreetMap (OSM) database[22]. The conceptual framework of spatial data analysis is shown in Figure 4.2

[22] https://www.openstreetmap.org/.

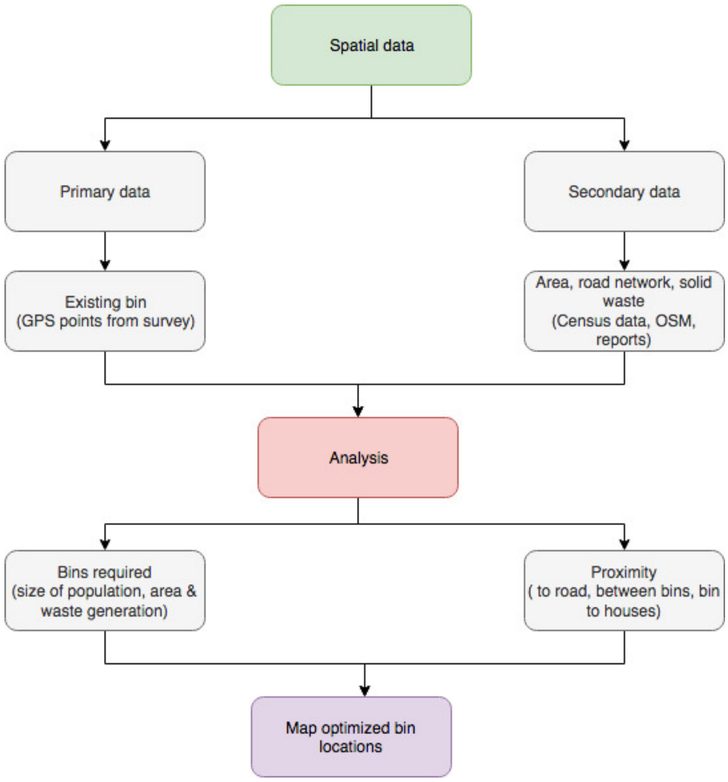


FIGURE 4-2: CONCEPTUAL FRAMEWORK

4.4.2 Proposed model for optimal location

To ensure the right number and types of bins are placed in each area, the volume of waste produced is investigated. The number of bins required is calculated on the basis of per capita waste generation and the size of the population. Dili has an average of 6 persons per household and is estimated to generate waste at the rate of 0.79kg/head/day or 4.32kg/house/day (JICA, 2016). The average Figure for solid waste density (weight) is not available, therefore, the calculation of bins placed in each area are based on the amount of waste generated.

Currently, bins are placed mostly on the main roads, therefore, people have to walk a fair distance to dispose of waste. The inconvenience led people to dump rubbish in open spaces and rivers. This study, therefore, aims to propose optimal bin location that would minimize the distance they need to walk to encourage the use of bins rather than wild dumping.

The optimal locations of bins are identified based on the following criteria:

i. Population distribution
ii. Quantity of waste generation
iii. Collection transport accessibility (on road network)
iv. Distance from households
v. Proximity relative to point of reference or the existing bin

4.4.2.1 Total waste generation

To calculate total waste generation the following formula is used:

$$Tw = Pw.Tp$$

Where

Pw = Per capita waste generation

Tw = Total waste generation per village

Tp = Total population per village

This calculation is based on the assumption that each individual generates the same amounts of waste.

4.4.2.2 Number of bins required

The number of bins and the sizes required for each area are determined based on daily and weekly waste generation. For this experiment, the types of bins specified in the Decree-law number 2/2017 are used as the reference. Larger bins are favoured since the survey result revealed waste overflowing as the common issue of the current collection system. The use of larger bins can prevent waste overflow as well as decrease the number of bins and collection stops. However, people will have to walk further to reach the bins.

By using the formula mentioned above, it was found that both villages may not require daily collection service. Based on the waste each generates each day, ideally, the collection can be carried out once a week using either 1200 or 240 liter waste bin (highlighted in yellow in Table 4-1). The number of bins required between daily collection and weekly collections are presented below in Table 4-1.

Number of bins required																	
Village	Population	Area (sq.km)	Population density (sq.km)	Waste generation rate/pear head/per day	Total waste generation (per day)	Total waste per week	Number of bins (collect every day)					Number of bins (collect once a week)				
							4000 liter	1200 liter	240 liter	120 liter	60 liter	4000 liter	1200 liter	240 liter	120 liter	60 liter
Aldeia Zero IV	2,181.00	0.344	6,340	0.79	1,722.99	12,060.93	0	1	7	14	29	3	10	50	101	201
Aldeia Lemorai	1,926.00	0.168	11,464	0.79	1,521.54	10,650.78	0	1	6	13	25	3	9	44	89	178

TABLE 4-1: NUMBER OF BINS REQUIRED

4.4.2.3 Spatial data of the existing collection sites

In order to propose optimised bin locations, particularly for ease of access, the existing bin locations were also investigated. A ground truth dataset was therefore collected from Rua Hudilaran (starting from the roundabout at Elem Loi), Rua Martires da Patria, Rua dom Luis dos Reis Noronha and Rua da Circumvalacao (refer to the lines populated with points in pink color – in Figure 4-3) after the survey to verify whether the survey has managed to capture all the existing locations of the bins. These roads were selected because they are connected with each other and lie right in the middle of the city. The ground-truthing points were collected using GPS by two relatives of the researcher of this study.

The ground truthing result revealed that there are 21 bins located on the above-mentioned roads while the survey managed to identify 8 locations (points in brown). Based on this result, we assume that the survey managed to collect approximately 38 % of bin locations. However, there is a possibility that this estimate is inaccurate because more people collected data on some of the roads.

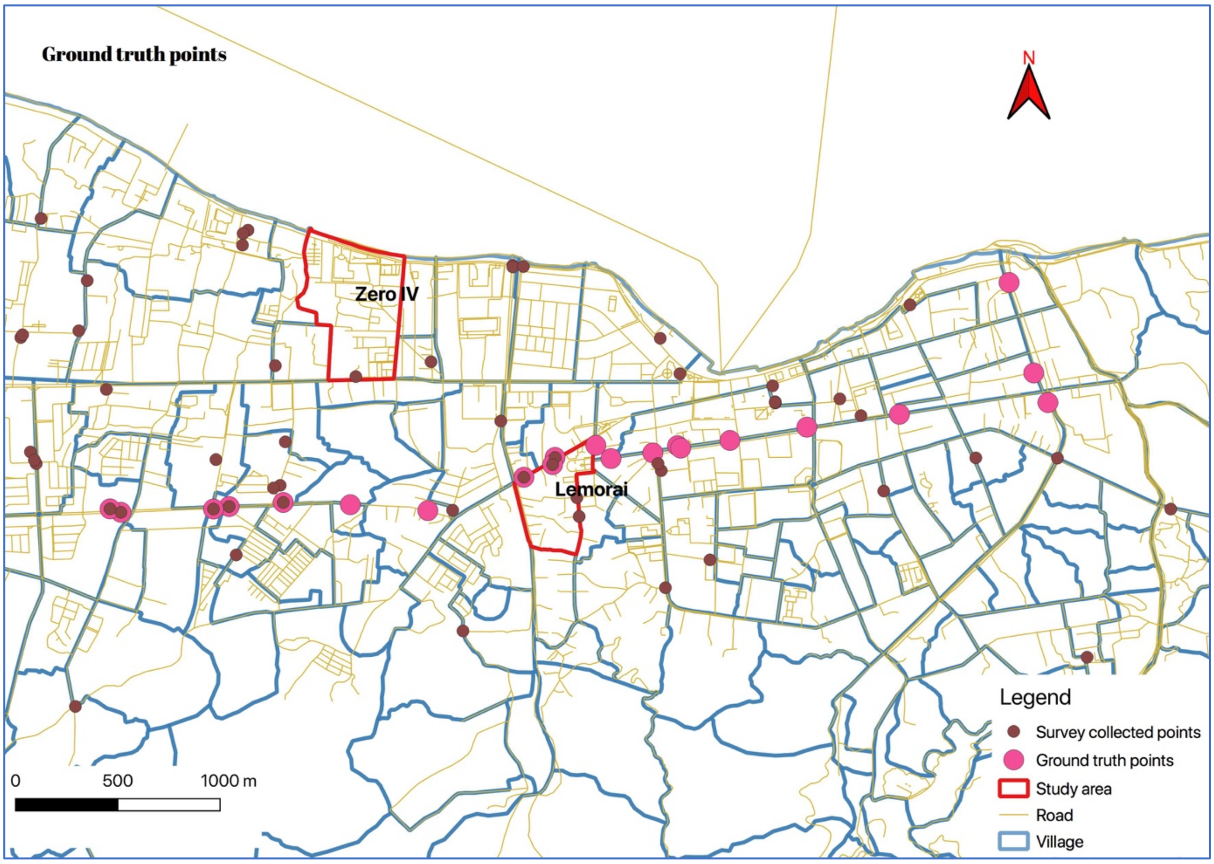


FIGURE 4-3: GROUND TRUTH POINTS (IN PINK COLOR)

Furthermore, a measurement was conducted using the 'measure line' tool in QGIS to investigate the distance between the bins. The datasets of the groundtruth points and the points identified through the survey were given specific identification as follows:

- Ground truth points (GT)
- Point collected during survey (CB)

There are several points that are not located precisely alongside the road. These coordinates may have been shifted due to weak GPS signals caused by taller buildings around the area or clouds. The rainy season in Dili starts from December to March and these areas often covered with thick clouds. There is also possibility that the data may not be accurate because more people collected data on these streets. Therefore, the measurements results are approximate only. Table 4-2 shows the result of the measurement.

Manual measurement		
Input	Target	Distance (in km)
Rua Hudilaran		
CB58	CB55	0.062
CB55	CB54	0.512
CB54	CB50	0.087
CB50	CB21	0.297
CB21	GT1	0.379
GT1	GT2	0.430
Average distance		0.295
Rua Martires da Patria		
CB26	CB25	0.173
CB25	CB20	0.039
Average distance		0.106
Rua Dom Luis dos Reis Noronha		

GT14	GT13	0.233
GT13	GT12	0.158
GT12	GT10	0.276
GT10	GT9	0.429
GT9	GT8	0.519
Average distance		0.323
Rua da Circumvalacao		
GT5	GT6	0.570
GT6	GT7	0.184
Average distance		0.377
Total average distance		**0.275**

TABLE 4-2: DISTANCE BETWEEN EXISTING COLLECTION SITES

The result indicates that the average distance between collections sites located alongside the main roads in the groundtruthing area is 0.275km. Meanwhile, the length of the main road in study area 1 – Aldeia Zero IV is approximately 2.882km and village 2 – Aldeia Lemorai is at least 2.55km (refer to Figure 4-4). Based on this information, we assume that study area 1- should have approximately 10.48 existing bins and village 2 has 9.28 bins. However, the groundtruthing results indicated that there are only about 38% (3 - 4) bins in these areas.

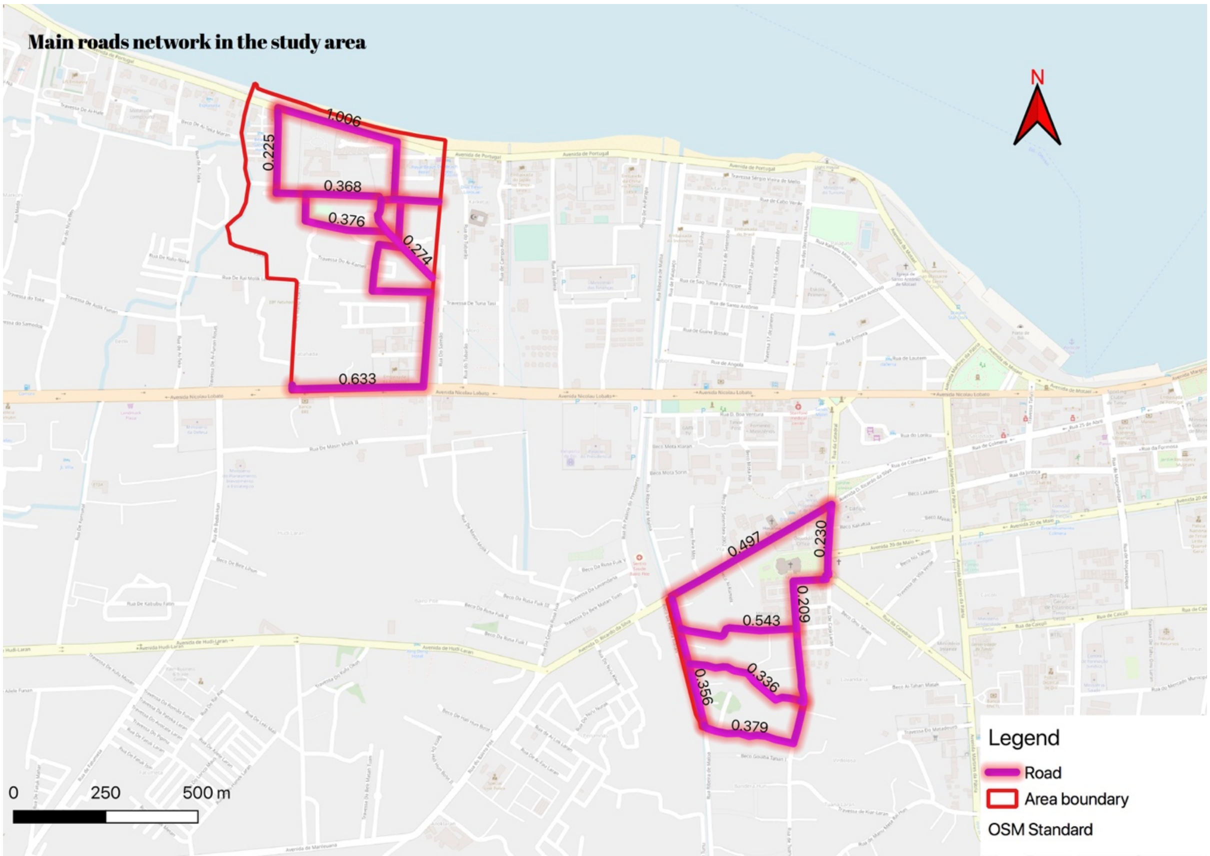


FIGURE 4-4: MAIN ROADS NETWORK IN THE STUDY AREAS

Meanwhile our calculation shows that Aldeia Zero IV needs at least ten (10) 1200 liter bins and Aldeia Lemorai needs approximately 9 bins of the same storage capacity to cater for waste generated in these areas. This indicates that there are not enough bins in these areas.

Based on this information, this study attempts to provide possible optimal locations for the two areas. The following sections outlines the process, the results obtained as well estimating the costs associated with selections.

4.4.2.4 Optimal locations

The computation process for determining the optimised locations was conducted using the QGIS. Due to incomplete data collected during the survey, the spatial locations for the bins required by each village were randomly generated using random '*points in layer bounds tool*'. The random points are relocated alongside the road network using '*snap points to the line*'. Self-judgment was applied for the placement of the optimised location to ensure bins are located alongside a road to allow easy pickup and transportation. The location of the recorded existing bin was used as a reference. Spatial analysis was conducted using the buffering method. By using the circular buffer the area covered (service area) by each bin was measured. The area covered refers to the distance people have to walk to the bin to dump their rubbish. This information is essential to understand whether the bins allocated are sufficient and easily accessible. The area covered is calculated using the formula:

$$Ab = \pi r^2$$

Where

Ab = Area covered by a bin (service area)

r = proximity distance used for buffer creation

To satisfy the requirement that bins should be accessible to households and are placed closer to a road to allow ease of collection, buffer zones were created around the optimised bin locations to assess the coverage level. The buffer zones tested included a 100m radius for the 1200 liter bin, and 50-meter radius for the 240-liter bin. Each buffer zone represents the area serviced by each bin.

4.5 Result

This section provides detailed information about the placement of optimised bin locations in the two selected study areas.

4.5.1 Study area 1 – Aldeia Zero IV

Aldeia Zero IV has a total area of 0.344 square kilometres and a total population of 1,926. The total amount of waste generated in this area is 1,722.99kg per day and 12,060.93kg per week. Based on the total per capita waste generated, the village needs at least 10 bins with the storage capacity of 1200 liter bin or 50 bins (240 liter) for once a week collection.

4.5.1.1 Aldeia Zero IV - 1200 liter bin - 100m buffer zone

Figure 4-5 shows the service area covered by each 1200 liter bin in Aldeia Zero IV. After creating 100m buffer zones around each bin, at least 0.231 sq.km out of the total area, 0.344 sq.km is covered. The remaining 0.113 sq.km area that is not covered consists of a number of community houses located in areas with no accessible roads, open lands, government offices, and private residential properties (Figure 4-6). Several overlaps are also observed between the points. This is due to the structure of the housing distribution. Ideally, the p-median or p-centre model as proposed by Vijay, Gautam, Kalamdhad, Gupta, & Devotta (2008) can be applied to find the optimum location, hence, eliminate location overlaps. However, due to time constraints, this method was not investigated in this study.

FIGURE 4-5: 1200 LITER BIN SERVICE AREA (100M BUFFER ZONE)

Total area boundary: 0.344 sq.km

Total area covered : 0.231 sq.km

Area not covered: 0.113 sq.km

FIGURE 4-6: AREA COVERED (100M BUFFER ZONE)

4.5.1.2 Aldeia Zero IV - 240 liter bin – 50m buffer

If smaller bins with storage capacity around 240 liters were used, the village needs at least 50 bins to cover the whole village. Figure 4-7 illustrates the service area with a 50m buffer zone. By applying the same criteria in which bins are placed alongside roads and closer to the residential areas, the 50 bins would cover at least 0.270 sq.km of the total village area. Details can be seen in Figure 4-8. The advantage of having smaller bins is that people will not have to walk far to dispose of their rubbish.

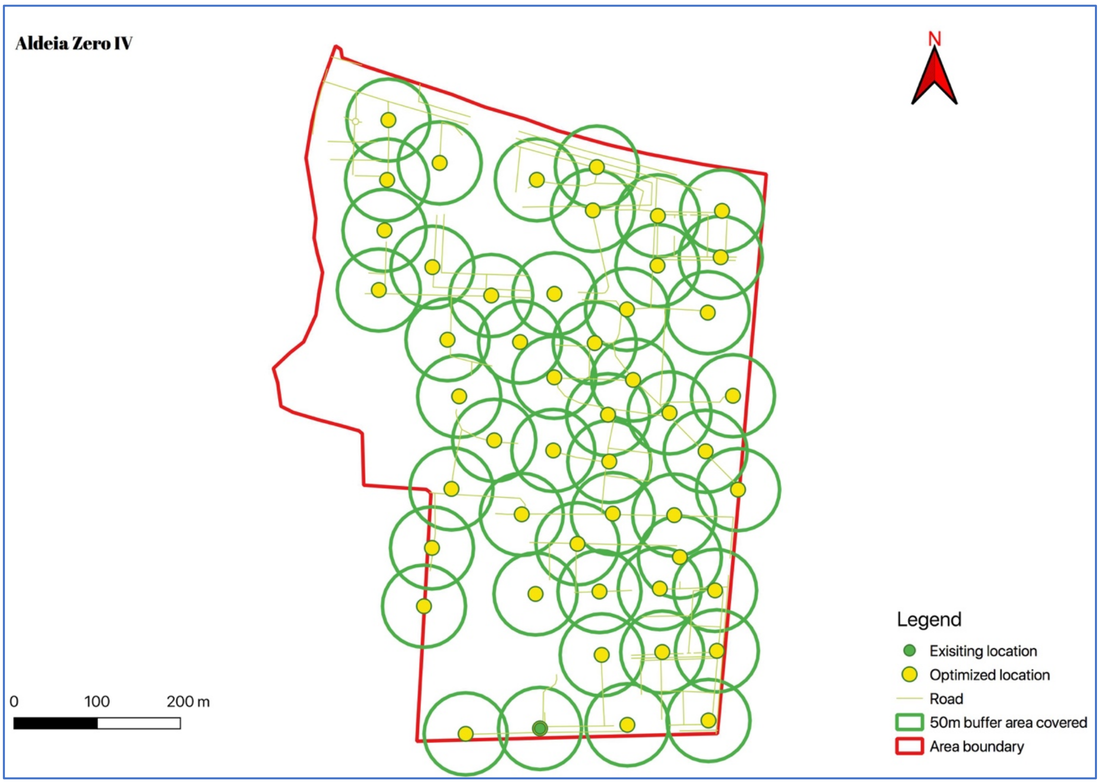
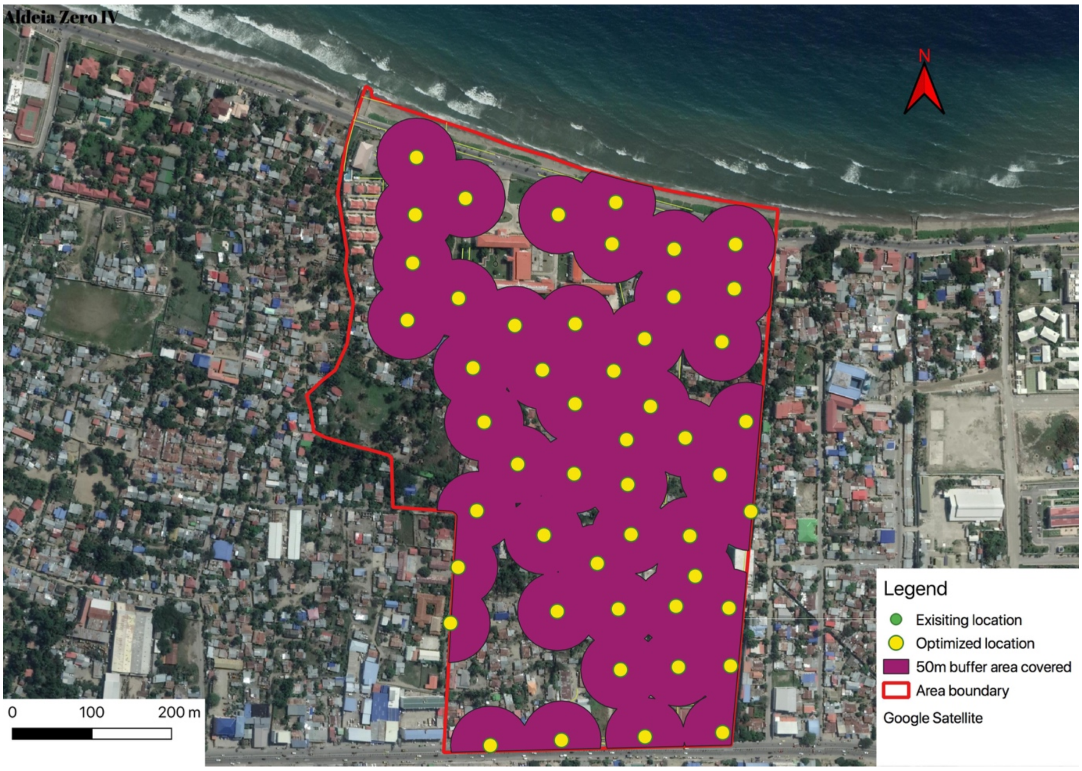


FIGURE 4-7: 240 LITER BIN SERVICE AREA (50M BUFFER ZONE)



Total area boundary: 0.344 sq.km

Area covered: 0.270 sq.km

Area not covered: 0.074 sq.km

FIGURE 4-8: AREA COVERED (50M BUFFER ZONE)

4.5.2 Study area 2 – Aldeia Lemorai

Aldeia Lemorai has a total area of 1,649 sq.km and a total population of 2,181. The total amount of waste generated in this area is 1,521.54 kg per day and 10,650.78 kg per week. Based on the total per capita waste generated, ideally, the village would need at least 9 bins with the storage capacity of 1200 liter or 44 smaller bins (240 liter) for once a week collection. A religious area is located at the edge of this village right on the main road. Religious areas are considered sacred places, therefore, to ensure household waste is not dumped in the religious area, a 100m buffer (shown in red circled) is placed around it.

4.5.2.1 Aldeia Lemorai - 1200 liter bin - 100m buffer zone

Figure 4-9 shows the 1200 liter bins service area for Aldeia Lemorai. To ensure that the distance between bins is approximately located at a 100m radius for optimal efficiency, the existing points that are located very close to each other are relocated to a new location. For example in Figure 4-9 (red arrow). The buffer analysis shows that the nine bins can cover around 0.136 sq.km area out of 0.168 sq.km total area. The remaining 0.032 sq.km area that is not covered is mainly the religious area which has been deliberately excluded. Details are displayed in Figure 4-10.

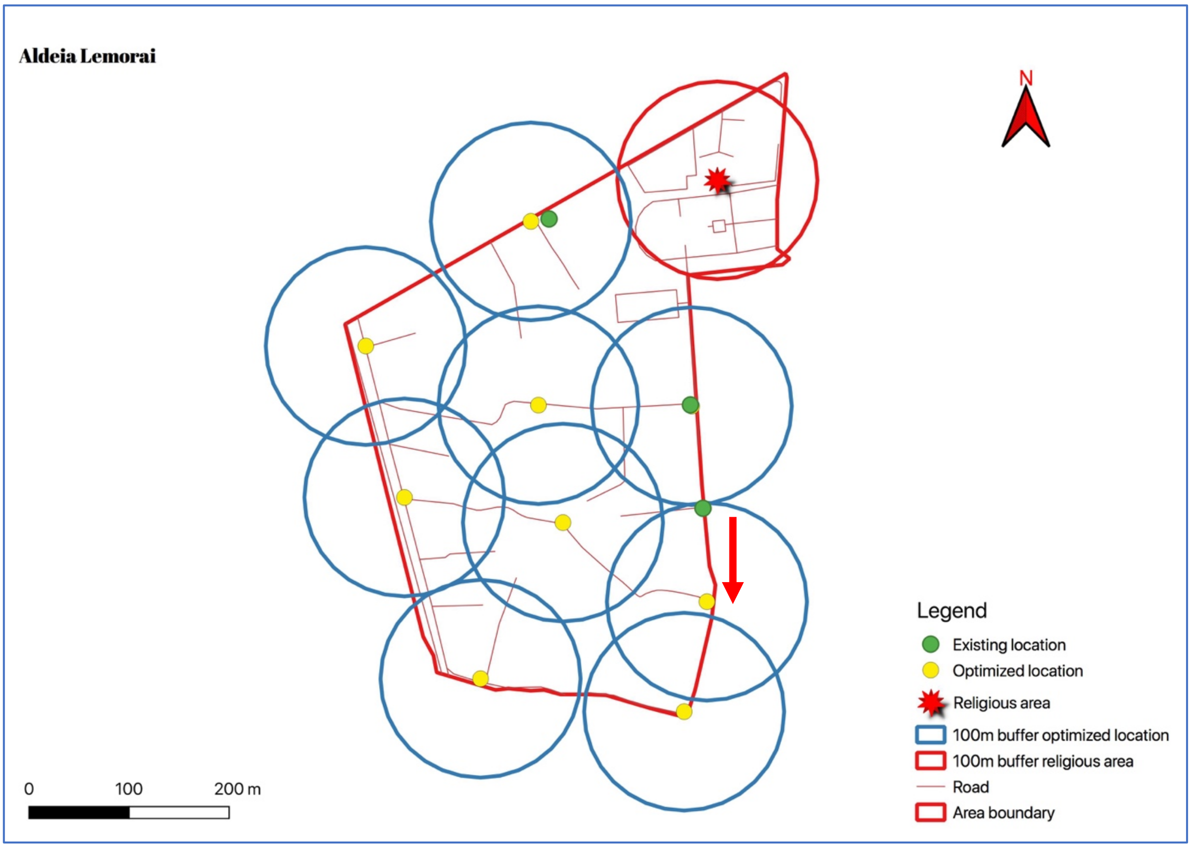
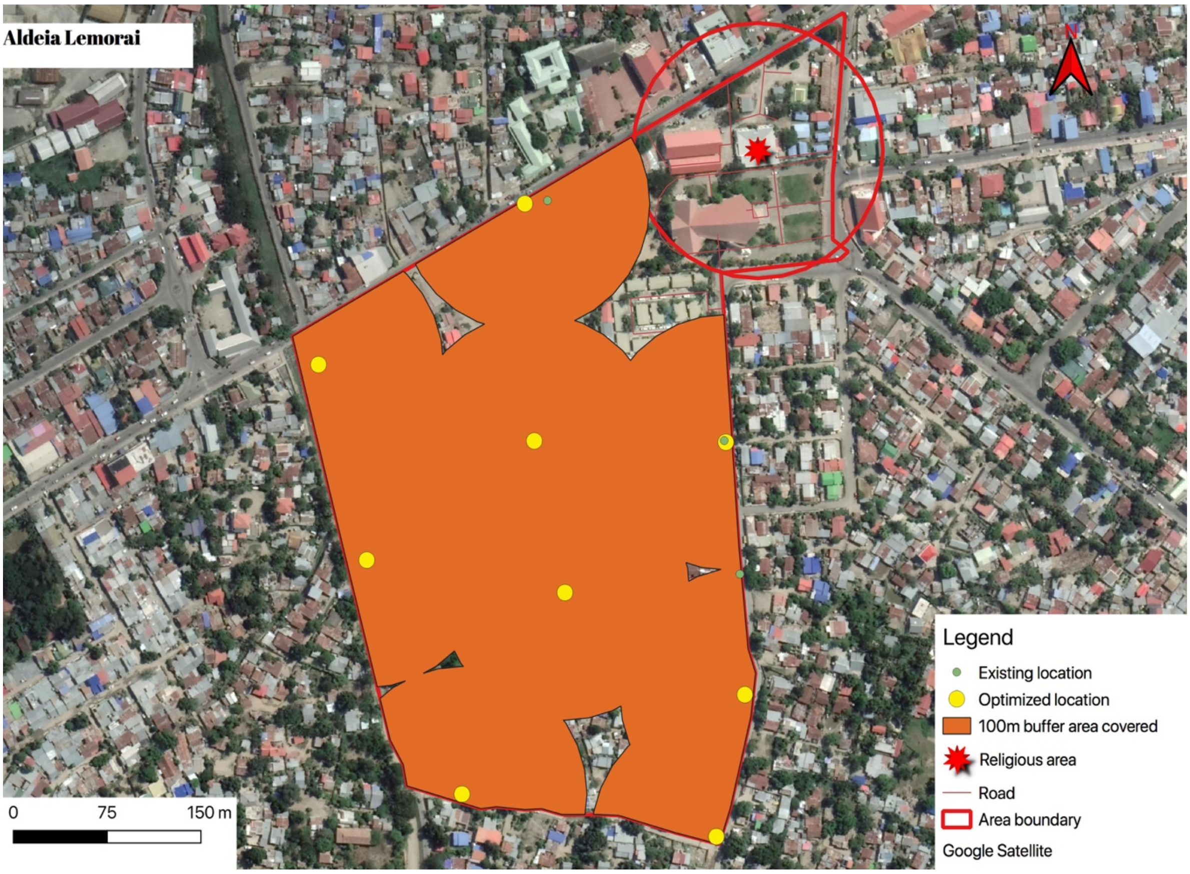


FIGURE 4-9: 1200 LITER BIN SERVICE AREA (100M BUFFER ZONE)



Total area boundary: 0.168 sq.km

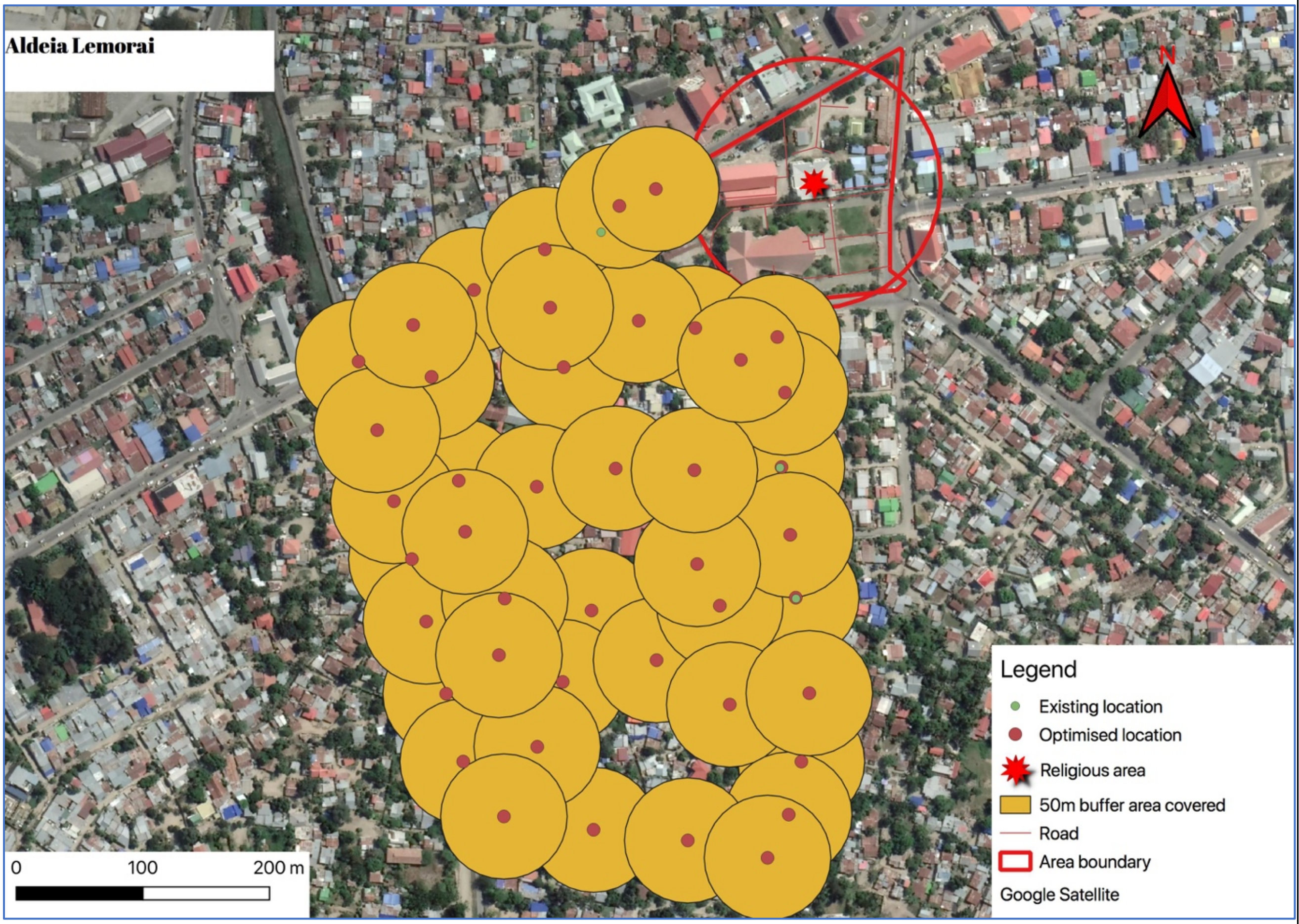
Area covered: 0.136 sq.km

Area not covered: 0.032 sq.km

FIGURE 4-10: AREA COVERED (100M BUFFER ZONE)

4.5.2.2 Aldeia Lemorai 240liter – 50m buffer zone

A 50m buffer zone was also applied for Aldeia Lemorai for the placement of the 44 bins. However, given the area is much smaller, almost 70% buffer zones were found to have overlapped (see Figure 4-11). Therefore, a 35m radius is instead created around the 44 optimised locations. The result indicates that at least 0.108 sq.km area is covered. The remaining area that is not covered (0.061 sq.km) largely belongs to the religious area and roughly about 40 houses that are located far from streets (approximately). Details illustrated in Figure 4-12 and Figure 4-13.



Total area boundary: 0.168 sq.km

Total area covered: 0.139 sq.km

Area not covered: 0.0029 sq.km

FIGURE 4-11: 240 LITER BIN SERVICE AREA (50M BUFFER ZONE)

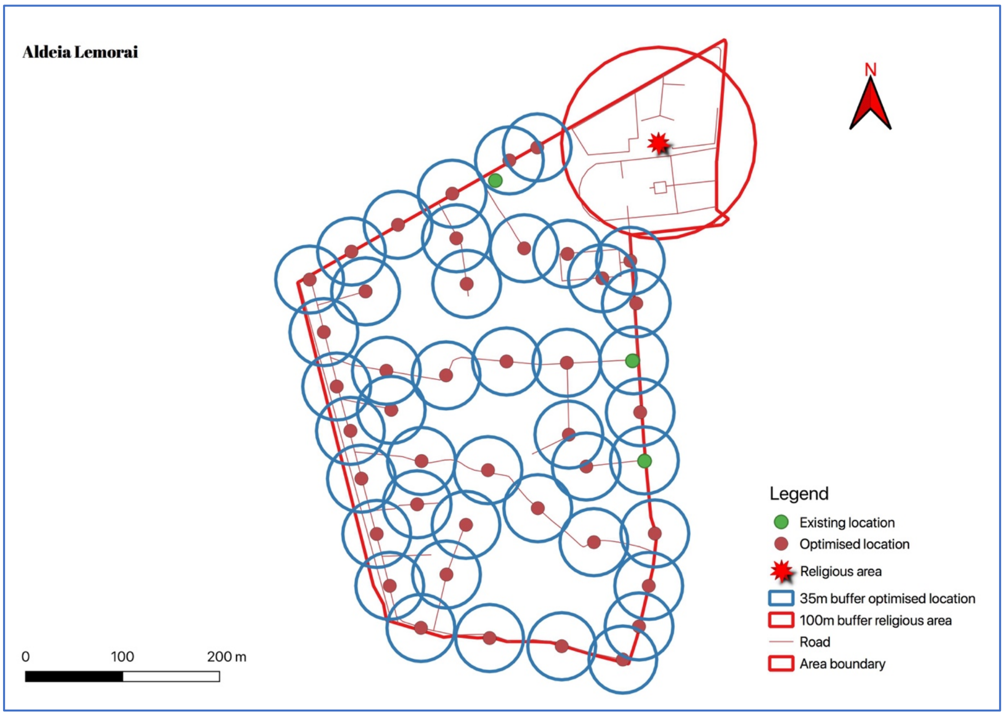
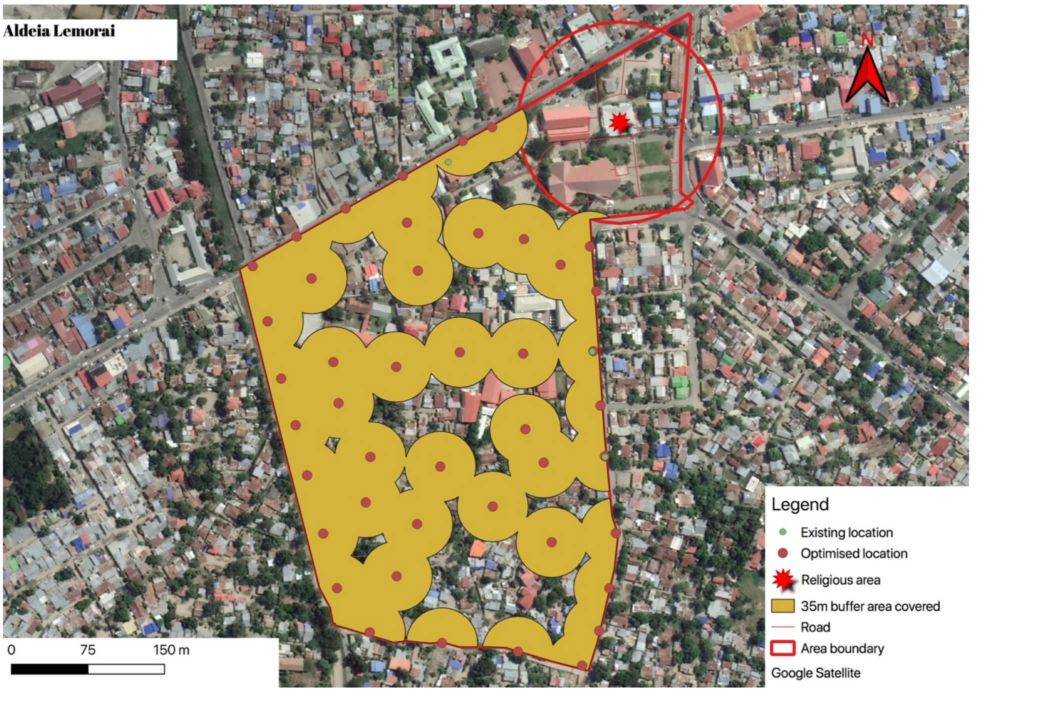


FIGURE 4-12: 240 LITER BIN SERVICE AREA (35M BUFFER ZONE)



Total area boundary: 0.168 sq.km

Total area covered: 0.108 sq.km

Area not covered: 0.061 sq.km

FIGURE 4-13: AREA COVERED (35M BUFFER ZONE)

4.6 Cost estimates

In addition to considering the benefits to households of optimal bin location, the possible schemes presented above may vary in the cost for collection. The cost of collection of the different schemes is estimated by calculating the distance from where the bins are located to Tibar landfill as well as the fuel and the time needed. The calculation is based on the model adopted from Sonesson (2000). The only difference is that the Sonesson (2000) model is based on the Hauled Contained System (HCS) collection whereas this study focuses on the collection using the Stationary Container System Collection (SCS) method. In the SCS system, collection bins remain at the collection point and are emptied either manually or mechanically to collection vehicles. On the other hand, the HCS transports containers to the disposal site (either transfer station or a landfill) and returns the containers after emptying.

Fuel consumption and time needed are calculated based on the distance travelled by the collection trucks following the collection routes proposed in Figure 4-14 to Figure 4-17. The routes were planned using OSM tools in QGIS. OSM tools perform routing as well as generating the distance and drive time along the routes.

Proposed collection routes

The routes are generated according to the location of the bins. Each bin is numbered according to the quantity of bins required in the area. Collection is carried out sequentially according to the number assigned to the bins. Number 1 indicates the collection start point.

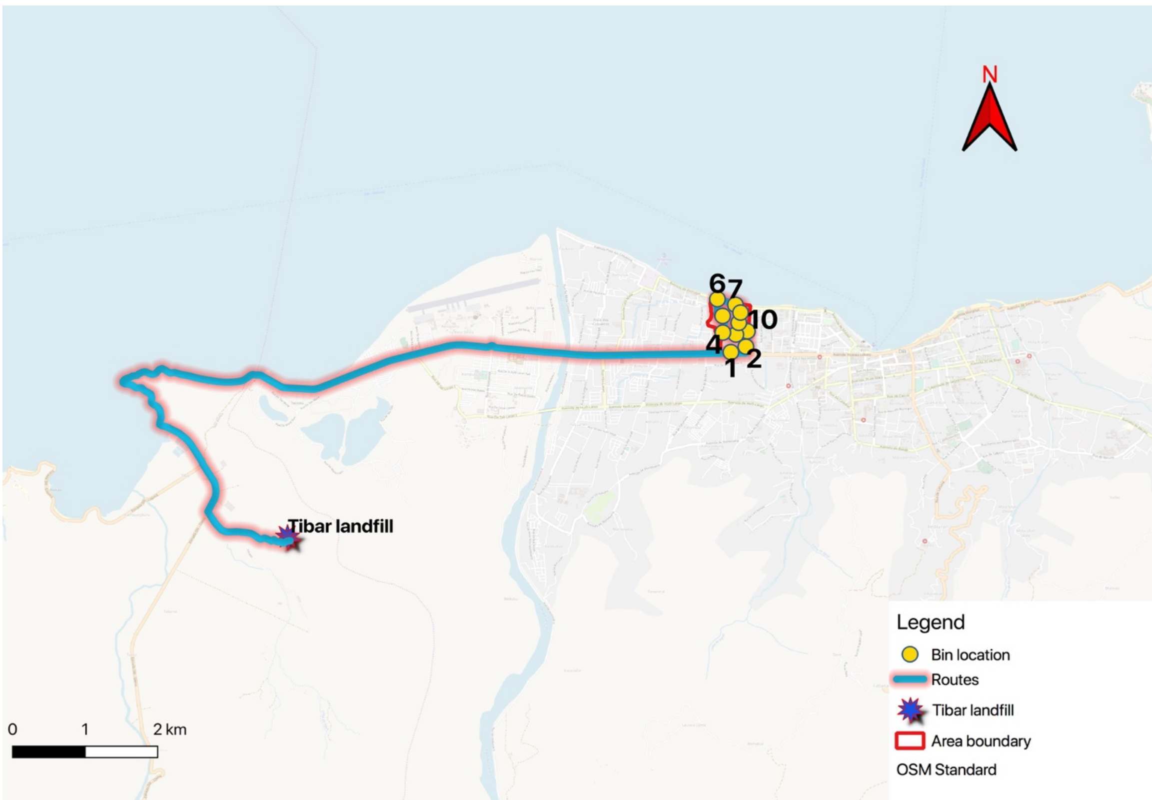


Figure 4-14: Proposed collection route, Aldeia Zero IV, 1200 liter bin

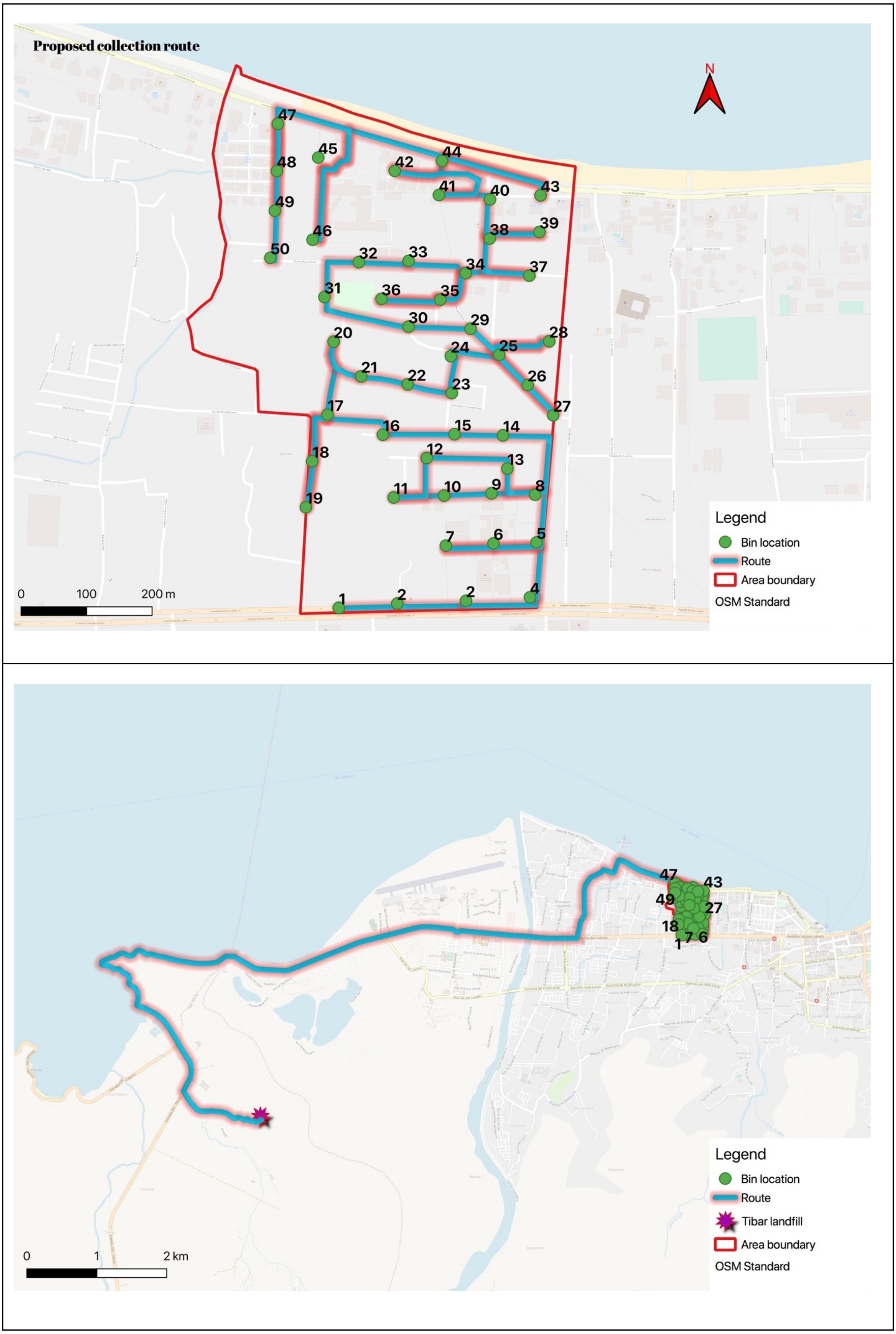


FIGURE 4-15: PROPOSED COLLECTION ROUTE, ALDEIA ZERO IV, 240 LITER BIN

FIGURE 4-16: PROPOSED COLLECTION ROUTE, ALDEIA LEMORAI, 1200 LITER BIN

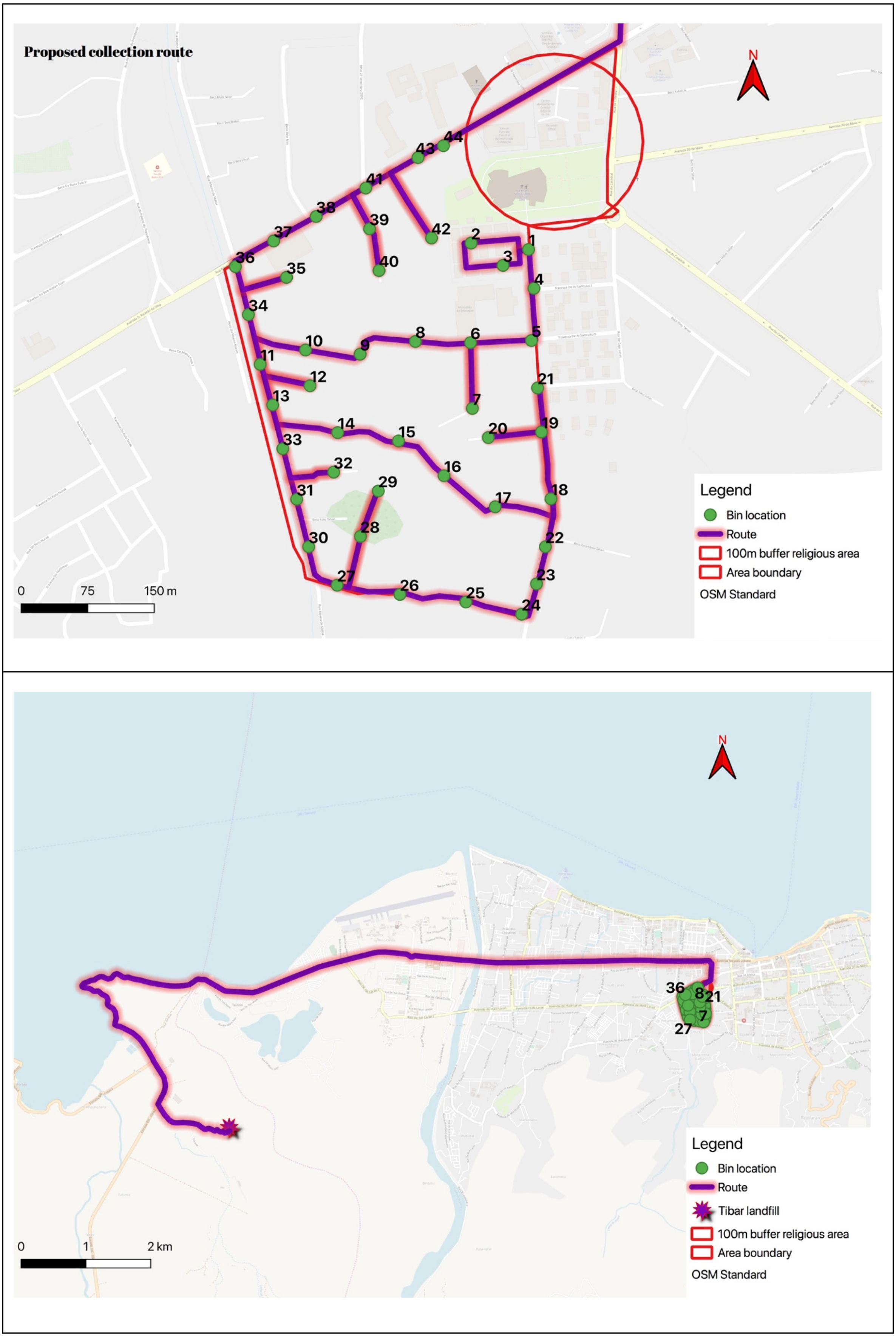


FIGURE 4-17: PROPOSED COLLECTION ROUTE, 240 LITER BINS

Based on the routes planned, the total driving distance for the collection of the 1200 liter bins from Aldeia Zero IV is approximately 14.906 km with total driving time including stops of 3.76h. Meanwhile, the average distance for the collection of the 240 liter bins reaches almost 20km. For Aldeia Lemorai, the distance travel for collection of the 1200lt bin in total is around 16.145km, with total driving time of 3.573h. The total driving distance and time for the collection of the 240 liter bins are 17.937km and 22.396 respectively. Details can be found in Table 4-4 and Table 4-5.

The cost estimation is made based on the assumption that all bins are always full and the total amount of waste does not change. Also, the bins are equipped with wheels. Waste is collected and transported using either a rear-end loaded or side loaded 16 tonne sealed compactor with self-lifting and emptying capability with a maximum load of 15000 liters. This type of vehicle was selected due to its ability to lift above 1000 liters of waste.

The data used for the calculation is a combination of statistics, previous studies and our own estimation. Time for driving during collection and speed often vary between areas and the time to stop and pick up the bins are dependent on the skill of the crews. Moreover, fuel consumption varies between trucks and fuel types.

In this experiment, the default fuel consumption and time required for each stop in the study areas are considered the same. The estimated time per stop to pick up and empty each larger bin is 0.015h and 0.010h for small bins (based on own estimation). Fuel required per stop is 2.5 liters per 10 kilometres (Wang & Richardson, 1996). The average speed is assumed to be 50 km/h across all areas (own estimation). Parameters and the data required for calculation is presented in Table 4-3. The collection frequency is based on the total amount of waste and the collection vehicle's carrying capacity. Traffic congestion is not taken into account in this calculation.

Parameter	**Description**
Number of stops	Based on the number of bins
Distance between stops (km)	Obtained from map with GIS
Average speed	50 km/h (own estimation)
Time per stop (h)	0.015 hr and 0.010hr (own estimation)
Energy/fuel required for driving and per stop	2.5 liters/10km or 0.25liter/km (Wang & Richardson, 1996)
Amount of waste	1200lt, 240lt (based on bin storage capacity)
Average load on truck (tonnes/load)	15000liter (known Figure from contractor)
Distance between service area and landfill	Obtained from map with GIS
Cost of fuel (diesel)	USD 0.96 (based on current price)

TABLE 4-3: PARAMETERS USED FOR ESTIMATION

The following formulas were used for calculating energy/fuel consumption and time consumption.

Calculation of energy consumption

$$\boldsymbol{E}tot \quad = \quad \boldsymbol{E}drivecollect + \boldsymbol{E}stopcollect$$

$$\boldsymbol{E}drivecollect = \boldsymbol{d}stop * \boldsymbol{no}stop * cf * \boldsymbol{fc}drive$$

$$\boldsymbol{E}stopcollect = \boldsymbol{no}stop * cf * \boldsymbol{fc}stop$$

Calculation of time consumption

$$\boldsymbol{T}tot \quad = \quad \boldsymbol{T}drivecollect + \boldsymbol{T}stopcollect$$

$$\boldsymbol{T}drivecollect = \boldsymbol{d}stop * \boldsymbol{no}stop * cf / \boldsymbol{as}collect$$

$\boldsymbol{T}stopcollect = \boldsymbol{no}stop * cf$

Where

Etot = total energy consumption for collecting waste

Edrivecollect = energy consumption for driving during collection

Estopcollect = energy consumption due to stops

Tdrivecollect = time consumption for driving during collection

Tstopcollect = time consumption for driving

fcdrive = fuel consumption for driving

fcstop = fuel consumption for stops

ascollect = average speed during collection (km/h)

Tstop = time consumption for stops

Al = average load (tonnes)

Wa = waste amount (tonnes)

dstop = distance between stops

nostops = number of stops (=bins) in the area

cf = collection frequency

The results of the calculations for both villages show that the driving distance and time needed to collect waste using 240lt bins are about four times higher than the small bins (refer to Table 4-4 and 4-5). Thus increases the driving time and fuel consumptions as well as the costs.

Fuel consumption estimate									
Area	Bin storage capacity (lt)	Distance driven (km)	Average speed (km/h)	Number of stops	Fuel consumption (lt)	Total amount of waste (tonnes)	Collection frequency	Total fuel consumption (lt)	Total fuel consumption (USD$)
Aldeia Zero IV	1200	14.906	50	10	37.264	12000	1	37.264	**$37.26**
	240	19.566	50	50	244.575	12000	1	244.575	**$244.58**
Aldeia Lemorai	1200	16.145	50	9	36.32625	10800	1	36.326	**$36.33**
	240	17.937	50	44	197.307	10560	1	197.307	**$197.31**

TABLE 4-4: ESTIMATED FUEL CONSUMPTION

Collection time estimate								
Area	Area	Distance driven	Number of stops	Average speed (km/h)	Collection frequency	Time driving (h)	Time per stop (h)	Total collection time (h)
Aldeia Zero IV	1200	14.906	10	50	1	0.36	0.015	3.76
	240	19.566	50	50	1	0.49	0.010	25.2
Aldeia Lemorai	1200	16.145	9	50	1	0.38	0.015	3.573
	240	17.937	44	50	1	0.49	0.010	22.176

TABLE 4-5: ESTIMATED COLLECTION TIME

4.7 Summary

The topology of an area and its road network fundamentally affect the coverage level of different bin layout schemes. As observed in the analysis for Aldeia Zero IV, for the placement of 1200 lt bin, the areas not covered are about 20% higher than for the 240 lt bins. On the other hand, in Aldeia Lemorai, the area covered by 1200 lt bins is much higher than for the 240 lt bins.

In terms of cost of collection and transportation, larger 1200 lt bins are four times cheaper than the smaller bins. However, households residing 100m away from the bin may find it inconvenient to take their waste to the bin on a regular basis, increasing the likelihood of poor disposal practices. These households could be provided small wheeled bins that would allow them to transport waste to the communal bin. Another possible solution is to employ informal waste pickers to transfer household waste from smaller bins to the nearest communal bins. In contrast, the smaller bins are more accessible by households, as they are on average much closer to individual homes. However, the cost of the collection and transportation is significantly higher than for larger bins. Thus, there is a trade-off between the cost of collection and convenience for households.

In this proposal, the optimized locations for the bins were estimated using buffer system at 100m radius for the 1200 liter bin, and 50-meter radius for the 240-liter bin. Each buffer zone represents the area serviced by each bin. Another method that can be explored for this purpose is to calculate the walking distance/time along the street networks.

CHAPTER 5 - DISCUSSION AND CONCLUSION

5.1 Introduction

By employing the crowdsourcing data collection method, this research study has aimed to assess whether this method can effectively obtain data for solid waste management in a developing country like Timor-Leste. Solid waste disposal and collection practices in Dili, the capital city of Timor-Leste were used as the case study. The findings of this study reveal that crowdsourcing can effectively be used to obtain data for solid waste management. However, there are some limitations, particularly in obtaining location-specific data. This section provides details of the lessons learned by first discussing the main findings of solid waste disposal and collection practices in Dili. Several practical recommendations on how to improve current practices will be presented. Lastly, ways to improve the use of crowdsourcing methodology in collecting location-specific data in a developing country will be explored.

5.2 Solid waste disposal and collection practices in Dili

5.2.1 Waste collection service

The study found that the municipality waste collection service covers almost all areas in Dili. This confirmed the Asian Developments Bank's report which indicates that almost 90 % of the total Dili area is serviced by a municipal collection facility (Asian Development Bank, 2015). However, there are four significant issues that the study identified in the current solid waste disposal and practices in Dili. These are ineffective bin management, infective collection service, lack of awareness among citizens about proper solid waste disposal and lack of law enforcement units.

The amount of waste generated is increasing as the population increases but there are inadequate bins available to cater for the ever increasing amount of waste. The survey results indicated that waste bins provided are either too small or quickly filled, often overflow with waste before collection or are located far away from residential areas. Overflowing mixed waste creates unpleasant odours, attracting animals, as well as pollutes the air. In some areas, larger bins are available, however, they are not enclosed and often placed far from the households. Unenclosed bins attract animals to scavenge, resulting in poor hygiene. Consequently, waste is scattered around the bins and on the streets. The inconvenience of larger distances to the nearest bin cause people to dump waste in nearby open lands or rivers. This suggests that a proper bin allocation plan is required. An effective way to ensure correct bin allocation is to identify how much waste is generated in the area and then allocate bins accordingly.

Another issue that the survey identified in the current disposal and collection practice is the ineffectiveness of the collection service. Waste collection in Dili is scheduled to be carried out every morning between 4 am and 7 am (Quintão, 2018). However, the study revealed that the collection frequency varied from once a day, once a week, twice a week to three times a week. In some areas, waste is often not collected for days particularly in areas where wild dump sites are used due to the absence of the municipality bins. Respondents of the survey attested inadequate collection services such as limited human resources and collection facilities as factors contributing to ineffective collection services. Although this may be true, the variations noted in the collection frequency in areas (Figure 2-34, in chapter 2) suggests that the problem could lie in route planning, scheduling, and monitoring. Poor routing and monitoring can be improved by optimising bin locations and establishing a proper monitoring and scheduling system. A model for optimising bin placement has been proposed by this study. The study focuses on two villages in Dili, however, this model can be adopted for other villages. Detailed information can be found in chapter 4.

In addition to inadequate collection facilities, an inactive collection service, lack of education and awareness, and weak enforcement of laws prohibiting illegal dumping have been reported as factors contributing to inadequate solid waste collection services in Dili. Survey respondents indicated that due to lack of information and absence of a control system, waste is often not placed inside the bin and instead is dumped outside and waste is dumped illegally in open areas. When the collection service is delayed, waste is scattered by animals causing a nuisance to the people living nearby. This issue can be addressed through waste education and awareness programs. Furthermore, establishing policies and regulations such as fines and penalties for improper disposal and illegal dumping, and reward systems for reporting illegal dumping (for example, paying the reporter 10% of fines charged to the violator) may also help improve waste disposal behaviour.

5.2.2 The type of waste found

Recyclable and organic waste was found to contribute to more than 50% of the total amount of waste in Dili. Organic waste is known to be the biggest contributor, with methane (CH4) and carbon dioxide (CO2) creating greenhouse gases in landfill (Hilgifer & Humer, 2003). Treating these types of waste at the source of generation through activities such as composting and recycling could potentially bring economic, health and environmental benefits as well as reduce collection costs.

Toxic and soil (hospital waste) have also been found among other waste generated. Although lower in quantity than organic and recyclable waste, these types of waste poses risks to health and environment. Lack of laws to regulate the disposal of medical and household hazardous waste and lack of facilities could be the reason this stream of waste ends up mixed with other household waste. The key to improving the management of toxic and soil waste is to provide better methods of storage and educate society to segregate hazardous waste from other general waste.

5.2.3 Recycling knowledge, attitudes, and practices

The study found that there is a positive attitude towards waste segregation, recycling and paying for a waste collection service. This demonstrates the willingness of the public to improve the waste management system in Dili. The local authority may use this opportunity to encourage improved R4 (refuse, reuse, reduce and recycle) practices and introduce a payment scheme for waste collection as a way to motivate society to reduce waste. For example establishing pricing policies such as ‘pay-as-you-throw’ or a flat rate monthly payment scheme for collection and disposal service to motivate the community to reduce waste, and establish a recycling incentive scheme to encourage the public to recycle. Nonetheless, it must be noted that the majority of survey participants are employed, therefore, most likely have a steady income. Further study is needed to investigate the perceptions of people who have low and no income.

5.3 Recommendations

To improve solid waste disposal and collection practices in Dili, the following recommendations are proposed for consideration by policymakers in charge of solid waste collection services in Dili:

- The local authority should conduct an assessment of the current bin locations in every area in Dili and allocate bins according to the waste generated. The model and the optimised locations recommended in this study for Aldeia Zero IV and Aldeia Lemorai can be used as an example. It should be noted, however, that this method has several limitations. Details of the drawbacks are discussed in section 5.4.
- Establish proper operational scheduling, vehicular routing, and monitoring systems for collection and transportation to improve collection services. Technological solutions such as GPS tracking can be used to monitor and control collection trucks.
- Establish a control mechanism to monitor waste disposal practices. Several possible solutions include assigning a control officer in the area or adopting modern technological solutions such as installing monitoring cameras or establishing an information system that allows people to report illegal dumping in real-time. For the latter initiative to work, it may be necessary to establish a reward system for reporting

illegal dumping. For example, paying the reporter 10% of fines charged to the violator.

- Establish a payment system for the collection services to prevent illegal dumping. For example a 'pay-as-you-throw' or a flat rate monthly payment scheme.
- Address the public's lack of information about proper disposal practices and lack of awareness towards proper solid waste disposal practices through education and awareness campaigns. Educational institutions, non-government organizations, and civil society organizations can be involved to disseminate information.
- Provide necessary infrastructure to encourage 4R (refuse, reuse, reduce and recycle) as well as reducing the amount of waste going to the landfills. A recycling incentive scheme should also be established to encourage the public to recycle
- Consider engaging the private sector through Public-Private Partnership (PPP) to handle waste collection and transportation.

5.4 Limitations in the proposed bin location optimisation model

The major obstacle in the process of developing the optimization model was the incompleteness of spatial data on the existing bin locations in the two areas investigated. If more complete data were obtained, the study may have been able to better determine areas of uneven distribution or gaps. Due to the limited data, assumptions needed to be made based on responses and information obtained from the ground-truthing for the optimization process.

Another limitation of this model is that the study only focuses on placing the bins at locations that would allow ease of collection, convenience for the community and adequate storage capacity to cater for waste generated in the area. Therefore, factors such as land availability and proximity to private properties were not investigated.

5.5 Research questions examined

The purpose of this study was to investigate whether crowdsourcing can be an effective method for collecting data about solid waste disposal and collection practices in a developing countriy such as Timor-Leste. Furthermore, the study sought to identify the opportunities and barriers to crowdsourcing in developing countries compared with developed countries and how this affects the design of crowdsourcing projects. The following research questions were assessed.

1. *Is crowdsourcing an effective method for collecting data about solid waste disposal and collection practices in Timor-Leste?*

The results of the survey demonstrated that crowdsourcing is an effective method for collecting real-time data about solid waste disposal and collection practices in Timor-Leste. However, its effectiveness relies on the availability of the technical tools, knowledge, and skills of respondents and the size of the participation pool.

A total of 186 submissions were received from ninety-nine people who participated in the two month study period. Each participant submitted on average 2.27 responses. This demonstrated that data collection for solid waste management could be collected quickly through crowdsourcing. This process was faster and cheaper as the survey was carried out online through a free open-source platform that allowed data to be collected using smartphones, tablets, as well as with computers. The quantity, however, although it was sufficient to conduct analysis and to develop solutions for optimising the collection sites, the data gathered was much less than the study had expected. The survey aimed to collect a greater quantity of responses particularly on the geographical locations of the waste collections sites/bins to conduct a detailed analysis of the current locations. However, only 183 location specific responses were received. Lack of spatial data in some areas prevented the study from designing a more comprehensive optimization proposal.

There are several possible reasons contributing to low responses. Firstly, it could be that many people were not aware of the survey. The survey was advertised mainly through social media, printed fliers that were posted at three universities and through direct contact via emails to various organizations dealing with environmental awareness programs. Only three non-government organizations and a local radio station responded. A possible reason for the lack of response could be that the subject being investigated was not seen as a priority.

Secondly, people may be aware of the survey, however, may not be able to participate due to a lack of access to the technical tools required to complete the survey. Access to a smartphone with a GPS device or a computer and the Internet were a prerequisite. However, many people in developing countries may not have financial ability to access these devices (Giff & Coleman, 2002; Newman et al., 2010). Others may have the means but lack digital experience particularly with regard to completing an online survey in relation to geographic locations. The digital divide is prominent in crowdsourcing projects (Haklay, 2013). Evidence shows that participation in VGI projects is higher in developed countries than in developing countries due to the digital divide (Sui, Goodchild, & Elwood, 2013). A strategy to address these issues could be to provide participants with technological devices and the skills required (for example, providing participants with smartphones and conducting face-to-face training on how to complete the survey). This, however, requires financial resources.

The third reason for the decline in the response rate could be related to the motivation to participate. People are more inclined to participate if they feel that the study will benefit them in some way (Parker, 2014). For this study, participants were informed about the overall aims of the project and that they would be provided a summary of the study upon request. However, they may not see the study to be of relevance to them. A strategy to encourage participation as proposed by Hossfeld, Keimel, and Timmerer (2014) is to provide incentives. Thus, a monetary reward incentive of being entered into a draw to win $100 cash was offered. However, people may have felt that there was little chance that they would win, therefore, chose not to participate. Another approach could be through providing small prepaid reward such as a $2 gift cards to every individual who participates in the study. This would attract more people to participate, particularly people with less money may find working for these gift cards worthwhile. However, it may be difficult to ensure people are not making erroneous mistakes at home.

This study also found that people lose motivation to participate over time. This is in line with the study of (Haklay, 2013; Zeng, Tang & Wang, 2017). Thus, gamification has been proposed as another technique that can be used to engage participants, for example using games that allow users to authenticate others responses (Composto et al., 2016; Mordechai Haklay, Antoniou, Basiouka, Soden, & Mooney, 2014; See et al., 2016). This technique, however, may not be effective in developing countries due to slow internet connections.

2. *Is crowdsourcing an effective method for raising awareness of the impact of waste disposal practices among the public?*

There is no conclusive evidence to suggest if crowdsourcing has raised people's awareness about the impact of solid waste. However, based on observations, talks about improving solid waste management have intensified on social media since the survey conducted by this study was released. People taking time to post on social media and engage in conversations regarding solid waste disposal and collection practices in Dili suggest that they are more aware of the impact of solid waste. Furthermore, since the survey was released, campaign and informal activities related to cleaning Dili waste have intensified. In addition, on January 30th, the government of Timor-Leste reaffirmed commitment to reduce the use of plastic in Timor-Leste by approving a proposal for the implementation of zero waste policy. Details on this can be found on http://timor-leste.gov.tl/?cat=10&lang=en. These changes suggest that in some way this study has contributed to raising awareness of improving solid waste management in Dili, Timor-Leste.

3. Can crowdsourced data be used for optimising the location of solid waste collection sites?

This research study demonstrated that with sufficient data and the availability of proper decision support tools, optimised locations of solid waste collection sites can be designed using crowdsourced data. The accuracy of the location of the collection sites is of particular importance for designing an optimised model.

The survey form used for this study allowed participants to mark the location of the collection sites accurately using their smartphones, a tablet or a computer. The form had a map functionality which could be accessed through a computer, allowing users to mark the precise geographic locations of the solid waste collections sites. Participants who choose to use their smartphones could use the GPS in their phones to collect a location automatically. However, the smartphones users are required to stand as close as possible to the site/bin when marking the location. This may have been a challenge for many participants since access to the Internet is expensive and without an incentive guaranteed, people may be reluctant to carry out the task. Consequently, among the 186 response submissions, only 48 locations were correctly marked by the respondents while 18 were moderately accurate and 7 were vaguely accurate. A significant number of coordinates (83 in total) were inaccurate. Those that have not marked the locations correctly may have used a smartphone to complete the survey from a location other than where the bin is located.

Despite the above-mentioned issues, by using GIS tools and accurate data obtained from the survey, this study was able to propose the optimised locations for solid waste collection sites in two villages. However, the method adopted is not scalable as it involves manual processing owing to limited data. The process can be automated if the datasets required were complete.

4. Is crowdsourced data of sufficient quality and quantity to enable the government to evaluate the effectiveness of the current waste collection system?

Quality or fitness of use is highly dependent on the accuracy and reliability of data provided and the characteristics of the respondents. The participants for this study were people who reside in Dili and are familiar with the subject area. Furthermore, the majority of the participants were working in the government sector. Thus, it can be concluded that the respondents have appropriate knowledge and more likely to have provided accurate and reliable information. However, social bias or the tendency of providing answers that are viewed favourably by others may exist (Podsakoff, MacKenzie, & Podsakoff, 2012). For example, in the answer to the questions about whether respondents thought proper solid waste management is important, respondents may have selected ‘yes’ because this answer is perceived as the response that most would favour.

The issue of bias and data accuracy are often examined by comparing with the authoritative data (Goodchild & Li, 2012), however, official data on the subject being studied is not available. Therefore, the findings of this study can only be viewed as a preliminary exploratory work that can be used as a base for designing strategies to improve the current waste collection systems.

5. What are the opportunities and barriers of crowdsourcing in developing countries compared with developed countries and how does this affect the design of crowdsourcing projects?

From the result of the study, it can be concluded that crowdsourcing is a feasible method for collecting data in a developing country like Timor-Leste. Opportunities for crowdsourcing exist as the Internet and smartphone use is constantly growing. However, a lack of knowledge and skills and access to appropriate technology have been found as significant barriers to the use of the crowdsourcing method. To overcome these barriers, methodologies can be improved. Several strategies include finding the right incentive mechanism to attract wider participation and ensuring that the technology used is accessible by all levels of socio-economic groups.

5.6 Conclusion

This thesis investigated the effectiveness of crowdsourced geographic information for solid waste management in developing countries. Using the Municipality of Dili, the study evaluated the effectiveness of crowdsourcing to obtain data about solid waste disposal and collection practices and explored the potential of using crowdsourced data to optimize the location of solid waste collection sites. In addition, the study assessed whether crowdsourcing is an effective method for raising awareness of the impact of solid waste, and evaluated whether crowdsourced data is of sufficient quality and quantity to enable the government to evaluate the effectiveness of the current waste collection system.

The study result demonstrated that crowdsourcing is a viable method for collecting solid waste data. Challenges such as collecting accurate location-specific data still remain, hence, the crowdsourced dataset may not entirely substitute for the usual traditional dataset. At this stage, however, the collected data can still be utilized as a supplementary data source. In the future, by improving data collection methodologies, such as using smaller rewards or providing necessary facilities, a crowdsourcing-based data collection method could be utilized as an adequate substitute for traditional data source because of its ability to collect data in real- time with lower operational costs. This approach is feasible for a developing country such as Timor-Leste where critical area such as waste management has less priority for funding.

The findings also showed that with the support of technical tools like GIS, crowdsourced data can be used to design and optimize location of waste collection bins. In this study, the process of designing the optimum location was carried out using a combination of a manual and automated processes due to incomplete data. However, this process can be automated if the datasets required were complete.

Despite the limitations, the study provides some practical solutions that can be used to improve solid waste disposal and collection practices in Dili. The study also provides useful insights into obtaining information on general solid waste management in a developing country through crowdsourcing which could inform future studies.

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APPENDICES

Appendix 1 – Survey questionnaires (English version)

Questionnaire 1

KoBoToolbox

Choose Language English

Dili Waste Mapping Survey

This research study aims to investigate whether crowdsourcing can be an effective method for collecting data about solid waste disposal and collection practices in developing countries. Moreover, the study seeks to identify the opportunities and barriers of crowdsourcing in developing countries compared with developed countries and how this affects the design of crowdsourcing projects. Using Dili, the capital city of Timor-Leste as a case study area, this research aims to obtain data about solid waste disposal and collection practices in Dili, evaluate the effectiveness of the current waste collection system, and to investigate whether citizens are aware of the impact of waste disposal practices.

This survey is anonymous and your participation is voluntary. Completion and return of the questionnaire imply consent. You will be asked if you would be willing to be contacted for further clarification regarding your responses by email. If you choose to provide your email address, your survey responses may no longer be anonymous to the researcher. However, no names or identifying information will be included in any publications or presentations based on these data, and your responses to this survey will remain confidential.

The procedure involves filling an online survey that will take approximately 15 minutes. By completing it before the end of December 2018, you will be entered into a draw to win $100 cash prize. It is anticipated that the information obtained from this study could help to influence current and future policy on solid waste management in the Municipality of Dili. A copy of the summary of findings will be available on request.

For more information, please contact Elizabeth Baptista (researcher) at [redacted] or [redacted] or Prof. Kristin Stock (supervisor) at +64 (09) 414 0800 ext. 43719 or k.stock@massey.ac.nz.

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher named in this document is responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director (Research Ethics), email humanethics@massey.ac.nz.

Thank you.

If you have read this form and agree to take part in this survey, please click the "Proceed to the survey" button. *

- (●) Proceed to the survey
- ( ) I do not wish to participate

Participation

Have you completed this survey before? **Note: If this is your first time accessing this survey, please select 'no'. If you have completed this survey before, please select 'yes' to complete another survey.** *

- ( ) Yes
- (●) No

Demographics

Please indicate your age. *

- ( ) 16-24 years old
- ( ) 25-34 years old
- ( ) 35-44 years old
- ( ) 45-54 years old
- ( ) 55-64 years old
- ( ) 65-74 years old
- ( ) 75 years or older
- ( ) Prefer not to answer

Please indicate your gender. *

- ( ) Male
- ( ) Female
- ( ) Prefer not to answer

Are you currently in employment? *

- ( ) Yes
- ( ) No

Which of the following type of the organization do you work for? *

- ( ) Public sector (government)
- ( ) Private sector (company, self-employed)
- ( ) Voluntary sector (Charity)
- ( ) Other

Which of the following describe your current occupation? *

- ( ) Out of work and looking for work
- ( ) Out of work but not currently looking for work
- ( ) In full-time education
- ( ) Retired
- ( ) Other

Including yourself, how many people live in your household? (Example: 1, 2, 3 ....etc)

Recycling

Have you ever heard about the importance of recycling? *

- (•) Yes
- ( ) No

Do you think recycling is important? *

- (•) Yes
- ( ) No

If a recycling program was set up, would you be willing to separate materials into separate bins for collection purposes? *

- ( ) Yes
- ( ) No

If the collection sites were taxed, would you be willing to pay for the service? *

- ( ) Yes
- ( ) No

How much would you be willing to pay? *

- ◯ Less than USD$1 per month
- ◯ Between USD$1 - $5 per month
- ◯ Between USD$5 - $10 per month

What is your combined annual household income?

- ◯ Less than $2000
- ◯ $2000 - $4999
- ◯ $5000 - $6999
- ◯ $7000 - $9999
- ◯ $10000 and above
- ◯ Prefer not to answer

Awareness of solid waste and its impact

Solid wastes refers to any waste generated by every day human activities. Solid waste may be in the form of household garbage, leftovers of food and other wastage that include old house hold items such as papers, plastic waste in the form of kitchen equipment or any other products that are consumed during every day activities.

Do you think its important to have a proper solid waste management system? *

- ◉ Yes
- ◯ No

Which of the following do you think would happen if solid waste were improperly managed? NOTE: You may select more than one.

- ☐ Soil contamination
- ☐ Climate pollution (harmful greenhouse gases)
- ☐ Air contamination
- ☐ Water contamination
- ☐ Harm towards animal and marine life
- ☐ Human health hazards
- ☐ All of above
- ☐ Other

Waste collection site

How does your household dispose of rubbish? Please select the site/facility you use the most. *

- (•) Municipality allocated bin/site


- ( ) Wild dump site

- ( ) Home collection (collected from home)

Are you satisfied with the overall condition of the "Municipality allocated bin/site" facility (service)? *

- ( ) Yes
- ( ) No

What are the reasons of your satisfaction? NOTE: You may choose more than one. *

- [ ] Convenient
- [ ] Reliable collection service
- [ ] Spacious bin
- [ ] Bin properly enclosed
- [ ] Other

What are the reasons of your dissatisfaction? NOTE: You may choose more than one. *

- [ ] Inconvenient
- [ ] Unreliable collection service
- [ ] Bin quickly full
- [ ] Bin not fully enclosed
- [ ] Other

Which of these types of waste have you ever seen in this collection bin/site? NOTE: You may select more than one.

☐ Organic waste: kitchen waste, vegetables, flowers, leaves, fruits.

☐ Toxic waste: old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish.

☐ Recyclable: paper, glass, metals, plastics.

☑ Soiled: hospital waste such as cloth soiled with blood and other body fluids.

☐ E-waste: electrical devices such as electronics, mobile phones, television sets, and refrigerators

☐ All of above

☐ Other

How often is the waste picked up by the collectors? *

- ◯ Every day
- ◯ Once a week
- ◯ Twice a week
- ◯ Three times a week
- ◯ Never collected
- ◯ Not sure

The last time you visited this site, how must waste did it contain?

- ◯ About a cart load
- ◯ About two cart loads
- ◯ About more than two cart loads
- ◯ About a truck load
- ◯ Other

Please upload a photo of this collection bin/site.

Click here to upload file. (< 10MB)

Please identify the location of this collection bin/site your household is using on the map. ***For laptop and PC users, please search for the location by entering the address on the*** *'search for place or address, for example* **becora, dili.** ***Then, please find and click the location as accurately as you can. For phone users, please stand as close as possible to the waste collection site and then click on GPS icon (⌖) to allow the Internet to automatically collect the exact latitude and longitude coordinates of the collection site.*** *

latitude (x.y °)
-75.677995

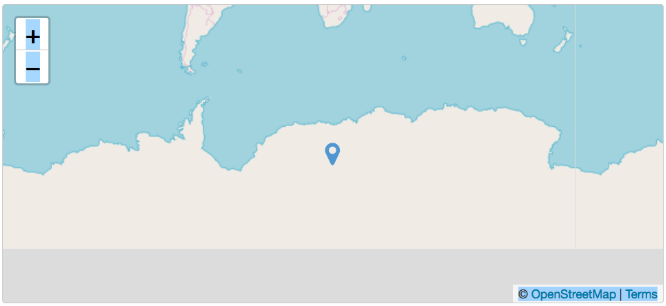
longitude (x.y °)
23.390579

altitude (m)

accuracy (m)

search for place or address

[



Please describe in your own words precisely where this bin/site is located. This detail information will help us to study the location of the site. *

Have you located the collection site accurately? *

- ◯ Yes
- ◯ No
- ◯ Not sure
- ◯ Other

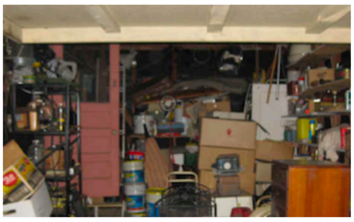
Which of the following garbage elimination practices does your household still do? NOTE: You may choose more than one.

☐ Burned

☐ Buried

☐ Composting

☐ Keep at home



☐ Other

Comments and feedback

Do you have any comments or feedback about the overall waste management system in the Municipality of Dili?

May we contact you if we have additional questions?

- (•) Yes
- ( ) No

If yes, please provide your email here:

If you would like to be entered into a draw to receive $100 cash price, please enter your email below.

Thank you for completing this survey. We would like to ask your help to locate other waste collection sites in Dili. To proceed please submit this survey and complete another one.

✔ Submit

Questionnaire 2

Participation

Have you completed this survey before? **Note: If this is your first time accessing this survey, please select 'no'. If you have completed this survey before, please select 'yes' to complete another survey.** *

- (•) Yes
- ( ) No

Which of these types of waste have you found in this collection bin/site? NOTE: You may select more than one. *

- [ ] Organic waste: kitchen waste, vegetables, flowers, leaves, fruits.

- [ ] Toxic waste: old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish.

- [ ] Recyclable: paper, glass, metals, plastics.

- [ ] Soiled: hospital waste such as cloth soiled with blood and other body fluids.

- [ ] E-waste: electrical devices such as electronics, mobile phones, television sets, and refrigerators

- [ ] All of above
- [ ] Other

The last time you visited this site, how must waste did it contain? *

- ◯ About a cart load
- ◯ About two cart loads
- ◯ About more than two cart loads
- ◯ About a truck load
- ◯ Other

Please upload a photo of the collection site you have identified.

Click here to upload file. (< 10MB)

Please identify the location of this collection bin/site your household is using on the map. ***For laptop and PC users, please search for the location by entering the address on the*** *'search for place or address, for example* ***becora, dili. Then, please find and click the location as accurately as you can. For phone users, please stand as close as possible to the waste collection site and then click on GPS icon (⌖) to allow the Internet to automatically collect the exact latitude and longitude coordinates of the collection site.*** *

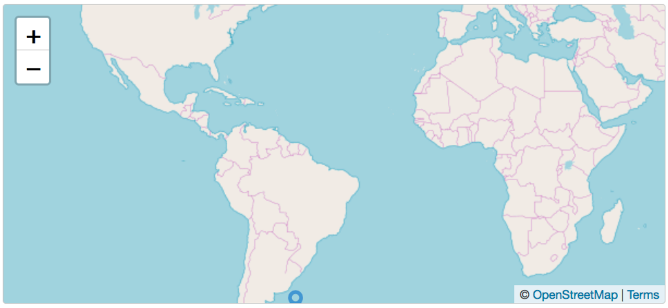
latitude (x.y °)
-40.891375

longitude (x.y °)
-55.359421

altitude (m)

accuracy (m)

search for place or address



Please describe in your own words precisely where this bin/site is located. This gives us more detailed information that will help us study the location of the site. *

Have you located the collection site accurately? *

- (•) Yes
- ( ) No
- ( ) Not sure
- ( ) Other

If you would like to be entered into a draw to receive $100 cash price, please enter your email below.

Thank you for completing this survey. We would like to ask your help to locate other waste collection sites in Dili. To proceed please submit this survey and complete another one.

✔ Submit

Appendix 2 – Survey questionnaires (Tetun version)

Questionnaire 1

KoBoToolbox

Choose Language Tetun

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Dili Waste Mapping Survey

Peskiza ida ne'e halao ho objetivu atu investiga karik *'crowdsourcing'* ou *'colaboração coletiva'* bele sai hanesan metodu ida ne'ebe efetivu ba koleksaun dadus kona ba eliminasaun resíduos sólidos no pratika koleksaun lixu iha nasaun sira ne'ebe sei dezenvolve. Nune'e mos, estudu ida ne'e buka atu identifika oportunidade no barreiras ne'ebe nasaun sei dezenvolve sira enfrenta kompara ho nasaun dezenvolvidu sira, no buka hatene oinsa fatores sira ne'e afeta prosesu dezenvolvimentu projetu *'crowdsourcing'*. Foti Dili, cidade capital Timor-Leste nian nudar area de estudu, peskiza ida ne'e buka atu atinji objetivus atu kolekta dadus kona ba resíduos sólidos no pratika koleksaun lixu iha Dili, avalia eficácia sistema koleksaun lixu atual, no Investiga cidadaun sira nia konsciência kona ba lixu sólidu no nia impaktu.

Survey ida ne'e anônima no ita boot nia participasaun voluntária. Se ita boot kompleta no submete kestinariu survey ida ne'e nian, hatudu katak ita boot konsiente atu participa. Ami sei husu ita boot atu fornece ita boot nia email karik ita boot hatân atu ami kontaktu kuandu ami precija informasaun adisional. Se ita boot hili atu fornece ita boot nia email, ita boot nia resposta sei la anônima ona ba peskizadores sira. Maibe, laiha naran ou informasaun ne'ebe identifika pessoal ruma sei fo sai iha publikasaun ka apresentasaun baseia ba dadus ne'ebe kolekta husi peskiza ida ne'e, no ita boot nia resposta ba survey sei permanece confidencial.

Procesu atu kompleta survey ida ne'e sei foti mas-a-menus minute 15. Kompleta survey ida ne'e antes fim de Dezembru 2018, ita bot sei tama iha sorteio hodi hetan prêmiu ho osan montante $100. Ami espera katak, informasaun sira ne'ebe kolekta husi estudu ida ne'e bele tulun atu influencia politika atual no futuru kona ba jestaun lixu iha cidade municipal Dili. Resumu resultadu peskiza nian sei disponivel liu husi solicitasaun.

Karik precija informasaun adicional, favor kontakta Elizabeth Baptista (peskizadora) iha [redacted] ka [redacted] ka Prof. Kristin Stock (supervisor) iha +64 (09) 414 0800 ext. 43719 or k.stock@massey.ac.nz.

Projetu ida ne'e avaliadu liu husi dalan 'peer review' no konsidera nudar projetu ho risku mínimu. Tamba ne'e, la precija avaliasaun husi Komitê de Ética Ema nian iha Universidade Massey. Peskizador nomeadu iha dokumentu ida ne'e mak sei responsabiliza kona ba konduta étika ne'ebe iha relasaun ho pesquiza ida ne'e. Se ita boot iha dúvidas ruma kona ba realizasaun peskiza ida ne'e, no hakarak atu levanta ba ema ruma ne'ebe laos peskizador (es) estudu ida ne'e nian, favor kontakta Professor Craig Johnson, Diretor (Ética de Pesquiza), email humanethics@massey.ac.nz. Obrigada.

Se ita-boot le'e ona informasaun ida ne'e no aceita atu participa iha survey ida ne'e, favor klik iha butaun "participa survey". *

- (•) Participa survey
- ( ) Hau lakohi atu participa

Participasaun

Ita bo'ot antes ne'e partisipa ona survey ida ne'e ka seidauk? **Nota: Se itaboot foin primeira vez assesu survey ida ne'e, favor hili 'lae'. Se karik ita boot priense tiha ona survey ida ne'e, favor klik "sim" atu kompleta tan survey seluk.** *

- ( ) Sim
- (•) Lae

Demográfiku

Favor indika ita boot nia tinan/idade. *

- ( ) 16-24 anos
- ( ) 25-34 anos
- ( ) 35-44 anos
- ( ) 45-54 anos
- ( ) 55-64 anos
- ( ) 65-74 anos
- ( ) 75 anos ka liu
- ( ) Prefere la hatan

Favor indika ita boot nia jeneru. *

- ( ) Mane
- ( ) Feto
- ( ) Prefere la hatan

Atualmente ita boot serbisu ka lae? *

- (•) Sim
- ( ) Lae

Atualmente ita boot serbisu ka lae? *

- (•) Sim
- ( ) Lae

Ita boot serbisu iha organizasaun husi setór ida ne'ebe? *

- (•) Setór Publiku (Governo)
- ( ) Setór Privadu (empresa, kiosk, nsst)
- ( ) Setór Voluntário (Caridade, NGO)
- ( ) Seluk

Favor indika ita boot nia status okupasaun agora. *

- (•) La serbisu no buka hela serbisu
- ( ) La serbisu maibe la buka serbisu
- ( ) Escola full-time
- ( ) Reformadu
- ( ) Seluk

Inklui ita boot, iha ema nain hira mak hela iha ita boot nia umakain? (Ijemplu, 1, 2, 3 .....nsst)

Resiklajen (daur ulang)

Ita bo'ot rona ona kona ba importansia hosi resiklajen (daur ulang)? *

- (•) Sim
- ( ) Lae

Tuir ita boot nia hanoin resiklajen (daur ulang) ne'e importante ka lae? *

- (•) Sim
- ( ) Lae

Se karik programa resiklajen iha, ita boot prontu atu separa lixu iha kaixa ket-ketak ba procesu koleksaun nian ka lae? *

- (•) Sim
- ( ) Lae

Se karik iha futuru estadu estabelese sistema pagamentu/taxa ba fatin koleksaun lixu nian, ita boot prontu atu selu ka lae? *

- (•) Sim
- ( ) Lae

Montante hira mak ita boot prontu atu selu? *

- ( ) Menus husi USD$1 kada fulan
- ( ) Entre USD$1 - $5 kada fulan
- ( ) Entre USD$5 - $10 kada fulan

Total rendimentu annual iha ita boot nia uma kain kada tinan hira?

- ( ) Menus husi $2000
- ( ) $2000 - $4999
- ( ) $5000 - $6999
- ( ) $7000 - $9999
- ( ) $10000 ba leten
- ( ) Prefere la hatan

Konsciencia kona ba lixu sólidu no nia impaktu

Resíduos sólidos refere ba lixu oin-oin ne'ebe resulta husi atividades ema nian iha lor-loron. Resíduos sólidos bele mai husi lixu doméstiku, hahan restu no sasan antigo/la uja ona husi uma laran hanesan surat tahan, lixu plástiku, ekipamentus dapur nian no produtu seluk neebe konsume durante atividades lor-loron.

Tuir ita boot nia hanoin, sistema jestaun ba lixu sólidu ne importante ka lae? *

- (•) Sim
- ( ) Lae

Tuir ita boot nia hanoin, saida mak sei akontese se ita la jere lixu sólidu ho diak? NOTA: Bele hili liu ida

- [ ] Kontaminasaun ba rai
- [ ] Polusaun klimatika (gas sira neebe perigu ba meiu ambiente)
- [ ] Kontaminasan ba ar (kontaminasi udara)
- [ ] Kontaminasaun ba bé
- [ ] Perigozu ba animais no marinha nia vida
- [ ] Perigozu ba saude humana
- [ ] Sira leten ne hotu (All of above)
- [ ] Seluk

Kaixa/Fatin rai lixu nian

Oinsa ita boot nia umakain hamenus lixu husi uma? Favor hili sitiu/facilidade ne'ebe ita boot uja bebeik? *

- Kaixa/fatin aloka husi Municipiu


- Fatin butuk lixu iha estrada ninin

- Koleta diretamente husi uma

Ita boot satisfaz ho kondisaun fasilidade "Kaixa/fatin aloka husi Municipiu" nian? *

- Sim
- Lae

Razaun saida mak halo ita boot satisfaz? NOTA: Bele hili liu ida *

- Estratejíku/fasil atu asesu
- Kolektores sempre foti lixu tuir horas
- Kaixa/fatin rai lixu nian boot (espaçoso)
- Kaixa/fatin rai lixu nian iha matan hodi taka
- Seluk

Razaun saida mak halo ita boot la satisfaz? NOTA: Bele hili liu ida *

- La estratejíku/susar atu asessu
- Kolektores foti lixu la tuir horas
- Kaixa/fatin rai lixu nakonu lalais
- Kaixa/fatin rai lixu nian la iha matan hodi taka
- Seluk

Tipu lixu saida deit mak ita boot hare ona iha kaixa/fatin kolekta lixu refere? NOTA: Bele hili liu ida

- [ ] Resíduos (lixu) orgânicos: resíduos husi cozinha, modo tahan, aifunan, ai tahan, ai fuan, nsst

- [ ] Resíduos (lixu) tóxicos: aimoruk prazu liu, tinta, produtu químicos, lâmpadas, lata, lata fertilizantes no pesticidas, baterea, graxa sapato, nsst

- [ ] Lixu Reciclável: Surat tahan, vidro, metais, plásticos, nsst

- [x] Resíduos (lixu) hospital nian: Lixu husi materiais hospital nian hanesan hena ho ran, no fluidos sira seluk

- [ ] E-waste: dispositivos elétricos, hanesan sasan eletrôniku, telefone celular, televisaun, geleira, nsst

- [ ] Sira leten ne hotu (All of above)
- [ ] Seluk

Kolektores sira kolekta lixu husi fatin ne'e dala hira? *

- ( ) Lor-loron
- ( ) Semana ida dala ida
- ( ) Semana ida dala rua
- ( ) Semana ida dala tolu
- ( ) Nunka kolekta
- ( ) La hatene

Iha tempu ikus liu ita boot visita lixu fatin ne'e, mas a menus volume (kuantidade) lixu hira mak ita boot hare iha neba?

- ◯ Gerobak ida
- ◯ Gerobak rua
- ◯ Liu gerobak rua
- ◯ Trek ida
- ◯ Seluk

Favor upload foto husi kaixa/lixu fatin ba koleksaun lixu ida ne'e. Klik iha "click here to upload file' hodi anexa photo.

Click here to upload file. (< 10MB)

Favor identifika fatin alokasaun kaixa/sitiu lixu nian ne'ebe itaboot nia umakain uja iha mapa. ***Ba sira neebe uja laptop ka PC,*** ***atu identifika fatin alokasaun lixu besik ita nia uma, favor ketik endereco lixu fatin ne iha*** *'search for place or address, por ijemplu* ***becora, dili. Depois, buka no klik iha fatin ne'ebe kaixa/fatin lixu ne'e iha ba. Ba sira ne'ebe uja telemovel, favor hamrik besik iha lixu fatin, depois klik iha icon GPS (⌖) nian hodi permite internet atu automatikamente identifika latitude no longitude husi lixu fatin ne'e.*** *

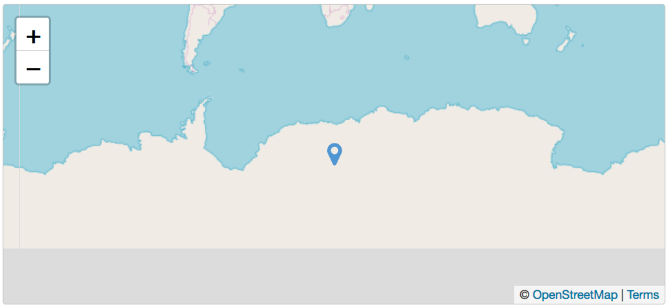
latitude (x.y °)
-75.677995

longitude (x.y °)
23.390579

altitude (m)

accuracy (m)

search for place or address



Favor descreve ho ita boot nia liafuan rasik area kaixa/fatin lixu ida nee nian. Informasaun ida nee sei aijuda ami hodi estuda sitiu ida ne'e. *

Itaboot identifika ona lixu fatin ne ho los? *

- ◯ Sim
- ◯ Lae
- ◯ La certeza
- ◯ Seluk

Husi lista tuir mai ne'e, métodu hamenus lixu ida neebe mak ita boot nia umakain sei prátika? NOTA: Bele hili liu ida.

- ☐ Sunu

- ☐ Hakohi

☐ Compostagem

☐ Rai iha uma

☐ Seluk

Komentáriu no feedbacks

Ita boot iha komentariu ka feedback ruma kona ba sistema jestaun lixu nian iha Municipiu Dili?

Bele ga lae ami kontaktu ita boot sekarik ami presija tan informasaun ruma?

◉ Sim
○ Lae

Se bele, halo favor hakerek ita boot nia email iha ne'e:

Se ita boot hakarak tama iha sorteio hodi hetan prêmiu ho osan montante $100 , halo favor hakerek ita nia email iha okos:

Obrigado ba ita bo'ot nia partisipasaun hodi kompleta survey ida ne'e. Ami hakarak husu ita boot nia ajuda atu identifika tan kaixa/fatin kolekta lixu nian iha Dili laran. Atu kontinua favor submete survey ida ne'e depois hatan tan survey ida.

✔ Submit

Questionnaire 2

Participasaun

Ita bo'ot antes ne'e partisipa ona survey ida ne'e ka seidauk? **Nota: Se itaboot foin primeira vez assesu survey ida ne'e, favor hili 'lae'. Se karik ita boot priense tiha ona survey ida ne'e, favor klik "sim" atu kompleta tan survey seluk.** *

◉ Sim
○ Lae

Idenfika kaixa/fatin rai lixu sira seluk

Opsaun ida ne'ebe mak representa kaixa/fatin lixu ida ne'e? *

◉ Kaixa/Fatin aloka husi Municipiu


○ Fatin butuk lixu iha estrada ninin

○ Koleta diretamente iha kada umakain

Tipu lixu saida deit mak ita boot hetan ona iha kaixa/fatin kolekta lixu refere? NOTA: Bele hili liu ida *

☐ Resíduos (lixu) orgânicos: resíduos husi cozinha, modo tahan, aifunan, ai tahan, ai fuan, nsst

☐ Resíduos (lixu) tóxicos: aimoruk prazu liu, tinta, produtu químicos, lâmpadas, lata, lata fertilizantes no pesticidas, baterea, graxa sapato, nsst

☐ Lixu Reciclável: Surat tahan, vidro, metais, plásticos, nsst

☐ Resíduos (lixu) hospital nian: Lixu husi materiais hospital nian hanesan hena ho ran, no fluidos sira seluk

☐ E-waste: dispositivos elétricos, hanesan sasan eletrôniku, telefone celular, televisaun, geleira, nsst

☐ Sira leten ne hotu (All of above)

☐ Seluk

Iha tempu ikus liu ita boot visita lixu fatin ne'e, mas a menus volume (kuantidade) lixu hira mak ita boot hare iha neba? *

◯ Gerobak ida

◯ Gerobak rua

◯ Liu gerobak rua

◯ Trek ida

◯ Seluk

Favor upload foto husi kaixa/fatin kolekta lixu ida ne'e nian. Klik iha "click here to upload file' hodi anexa photo.

Click here to upload file. (< 10MB)

Favor identifika fatin alokasaun kaixa/sitiu lixu nian ne'ebe itaboot nia umakain uja iha mapa. ***Ba sira neebe uja laptop ka PC,*** ***atu identifika fatin alokasaun lixu besik ita nia uma, favor ketik endereco lixu fatin ne iha*** *'search for place or address, por ijemplu* ***becora, dili.*** ***Depois, buka no klik iha fatin ne'ebe kaixa/fatin lixu ne'e iha ba.*** ***Ba sira ne'ebe uja telemovel,*** ***favor hamrik besik iha lixu fatin, depois klik iha icon GPS (⌖) nian hodi permite internet atu automatikamente identifika latitude no longitude husi lixu fatin ne'e.*** *

latitude (x.y °)
-40.891375

longitude (x.y °)
-55.359421

altitude (m)

accuracy (m)

search for place or address

Favor descreve ho ita boot nia liafuan rasik area kaixa/fatin lixu ida nee nian. Informasaun sira nee sei aijuda ami hodi estuda sitiu ida ne'e. *

Itaboot identifika ona lixu fatin ne ho los? *

- (●) Sim
- ( ) Lae
- ( ) La certeza
- ( ) Seluk

Se ita boot hakarak tama iha sorteio hodi hetan prêmiu ho osan montante $100 , halo favor hakerek ita nia email iha okos:

Obrigado ba ita bo'ot nia partisipasaun hodi kompleta survey ida ne'e. Ami hakarak husu ita boot nia ajuda atu identifika tan kaixa/fatin kolekta lixu nian iha Dili laran. Atu kontinua favor submete survey ida ne'e depois hatan tan survey ida.

✔ Submit

Appendix 3 – Survey advertising material

English version

HELP US IDENTIFY SOLID WASTE COLLECTION SITES IN DILI

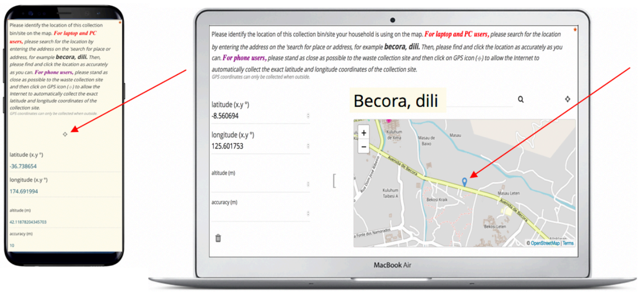
Participate in our survey (in Tetun or English) using your computers or mobile phones via the link below:

https://ee.humanitarianresponse.info/::BIb27ofk

Or scan the QR code

To answer the question about the *GPS location*:

- For desktop users: Please identify the location of the bin/site using map
- For mobile phone users: please stand as close as possible to the waste collection site and then click on GPS icon (⌖) to allow the Internet to automatically collect the exact latitude and longitude coordinates of the collection site.



Participate and submit many surveys for the opportunity to win a $100 cash price.

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher named in this document is responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director (Research Ethics), email humanethics@massey.ac.nz.

For more information, please contact Elizabeth Baptista, [redacted] / [redacted]

MASSEY UNIVERSITY

Research project

Master of Information Sciences (Information Technology)

Tetun version

AIJUDA AMI IDENTIFIKA LIXU FATIN IHA DILI LARAN

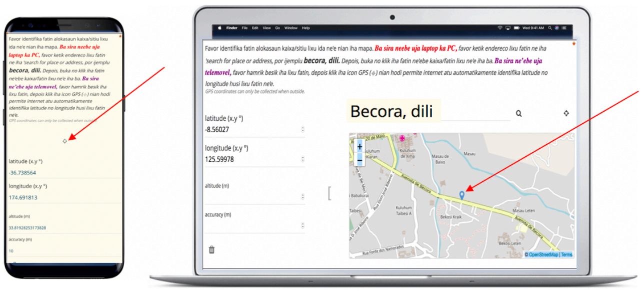
Participa iha ami nia survey (ho lian Tetun ka Inglés) uja komputador ka telemovel, liu husi link ida ne'e:

https://ee.humanitarianresponse.info/::BIb27ofk

ka scan kodigu QR iha okos

Atu hatan pergunta kona ba *GPS location*:

- Ba sira nebe uja dekstop: favor identifika fatin alokasaun lixu nian iha mapa
- Ba sira nebe uja telemovel: favor hamrik besik kaixa/sitiu lixu nian, depois klik iha icon GPS (⌖) nian hodi permite internet atu automatikamente identifika *latitude no longitude* husi lixu fatin ne'e.



Participa no submete survey barak, ba opportunidade atu tama sorteu hodi hetan premiu osan cash $100.

Projetu ida ne'e avaliadu liu husi dalan 'peer review' no konsidera nudar projetu ho risku mínimu. Tamba ne'e, la precija avaliasaun husi Komitê de Ética Ema nian iha Universidade Massey. Peskizador rasik mak sei responsabiliza kona ba konduta étika ne'ebe iha relasaun ho pesquiza ida ne'e. Se ita boot iha dúvidas kona ba realizasaun peskiza ida ne'e, no hakarak atu levanta ba ema ruma ne'ebe laos peskizador (es) estudu ida ne'e nian, favor kontakta Professor Craig Johnson, Diretor (Ética de Pesquiza), email humanethics@massey.ac.nz.

Atu hetan informasaun adisional, favor kontaktu Elizabeth Baptista, [redacted]/ [redacted] Dili Waste Mapping

MASSEY UNIVERSITY

Projeto Peskiza

Mestrado em Ciência da Informação (Tecnologia da Informação)

Instruction about how to fill the form using KoboCollect

1. Install KoboCollect from Google Play
2. Open **:** General Setting
3. Select Server
4. Enter the server URL **https://kc.humanitarianresponse.info** and your username: **ebaptista** and password: **1234567e**
5. Open **"Get Blank Form**" and select Dili Waste Mapping Survey to download the form
6. Click on **'Fill Blank Form'** to respond to the questionnaire
7. Click on 'Save and Exit'
8. Go back to the main page then click on 'send finalized form'