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Abstract

Zanzibar, just like many countries around the world is experiencing the continuous rise of electronic waste (e-waste). Apart from e-waste originating from fresh and new imported electronic and electrical equipment (EEE), Zanzibar is also experiencing a major influx of second hand EEE being imported to the island. Data from Tanzania Revenue Authority (TRA), indicates the rising of EEE importation in Zanzibar from estimated 3000 tonnes in 2012-2013 to over 5200 tonnes in 2013-2014. It is still unclear how many tonnes of the total imported EEE are becoming waste at the end of the year. Author estimated just 10% of the imported EEE are becoming waste at the end of the year, which means almost 520 tonnes are estimated to be generated in the year 2013-2014 only which is quite a threatening statistic. In addition to the electronic waste that was generated from the previous years in a country which lacks collection, dismantling and disposing facilities more waste is accumulated in streets and informal landfills as seen in the developed mass flow model.

The main objective of this project is to formulate desired and operational e-waste business models that will fit best in Zanzibar context. The business models will open new business opportunities and will help in reducing accumulations of e-waste in landfills and streets. After intensive literature review, analysis and interview feedback from stakeholders, PPP business model is selected to be the preferred business model. This is because in PPP business model, the involvement of a public sector is crucial in supporting the model in terms of risk sharing, resources such as land, security and labour support, policy issues, investment refunds but only if the government agrees during the contract agreements. An ICT collection strategy is innovated to support the selected viable business model by ensuring the availability of sufficient waste and reducing the transaction cost of recycling firms.

This research also analyzed consumer's willingness to support the collection strategy and the adoption rate of the proposed ICT collection strategy. Using Theory of Planned Behavior and Roger's Diffusion Theory, 400 questionnaires were distributed in 4 different streets. Consumer's intention towards the behavior of using mobile application to sell e-waste is at promising average of 6,895 (out of 7) and an adoption rate to the proposed innovation of mobile is also excellent at 6,9228 (out of 7).

With PPP business model integrated with the innovated ICT collection strategy that consumers showed high intentions towards the behavior of using it and high adoption rate of the proposed innovation, e-waste problem in Zanzibar will be solved by great extent and will open e-waste business opportunities with the help from ICT.

When uploading this document to Digital Exam each group member confirms that all have participated equally in the project work and that they collectively are responsible for the content of the project report. Furthermore each group member is liable for that there is no plagiarism in the report.

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Chapter 1: Introduction

Zanzibar is an island located on the coast of East Africa and together with Tanzania Mainland it forms The United Republic of Tanzania. Zanzibar have a population of about 1.4 million people and have recently experienced a major wave of second hand electronics from abroad. Together with the imported fresh electronics, about time they all become waste known as e-waste or "electronic waste". E-waste is the waste that results from electronic equipment that are no longer useful, have reached end of life or became obsolete.

In **Zanziba**r, according to a survey conducted by Department of Environment in Zanzibar reported that Tanzania Revenue Authority (TRA) has imported approximately 1000 tons of used electronics between June 2013 and June 2014 alone (Department of Environment, Zanzibar, 2014). **Zanzibar** also import huge amounts of Fresh Electronic and Electrical Equipment (FEEE). For example, Stone Town Traders Ltd who is one of the major FEEE dealers which imports around 900 tons annually (ibid.). About time, this new imported equipment also reaches their end of life to become waste.

This is not a problem in **Zanzibar** alone, countries around the world have been taking necessary measures to combat e-waste that have either been imported or being generated within their countries. For instance; Malaysia in 2012 generated approximately 80,000 metric tons of e-waste from industrial sector only (Ibrahim, 2013) have taken necessary measures to ensure safe, effective, and economically beneficial management of e-waste (Suja, Abdul Rahman, Yusof, & Masdar, 2014). Until 2014, Malaysia has 18 full recovery facilities and 128 partial recovery facilities that practice available technologies have been entitled for the segregation, dismantling, and treatment of e-waste (Suja et al., 2014).

Just like **Zanzibar**; China is another victim of e-waste problem because china is the world largest importer of WEEE and exporter of EEE as it have imported around 17.5 million tons in 2000 and they were expected to generate about 400 million units of WEEE by 2015 (Lu et al., 2014). Until December 31st 2011, with the support from National Development and Reform Commission (NDRC) which is a ministry-level agency in charge of promoting circular economy in China, there were more

than 1000 e-waste recycling companies (Lu et al., 2014). In India, the national level generation of e-waste was approximately 150,000 tons in 2005 and was expected to increase by 400,000 tons per year by 2011 (A. Jain, 2010). Until 2014, there were total of 138 units of legally registered recycling companies in India ("List of Registered E-Waste Dismantler/Recycler in the country", 2014).

Both India and China have the world largest population and have large informal recycling sector, 99% of e-waste ends up in informal sector (Asiimwe & Åke, 2012). EU countries have different approach towards managing e-waste in their countries, Extended Producer Responsibility (ERP) program or "polluter pays principle" have been proven successful in countries like Switzerland. Switzerland have exceeded the goal set by EU directive, "Even though the 68,000 tonnes of e-waste collected in Switzerland in 2003 represented only 2.6% of the waste stream, it corresponds to a little over 9 kg/capita —substantially more than the 4 kg/capita target set by the EU in the WEEE Directive (EU, 2004)." (Sinha-Khetriwal, Kraeuchi, & Schwaninger, 2005).

This shows that, the world is taking necessary actions towards managing e-waste but the generation of e-waste keeps on increasing every year. "Despite the adopted measures and legislation, it is estimated that only 30-40 per cent of the total e-waste quantities is actually collected and treated through official channels" (Emmanouil, Stiakakis, Vlachopoulou, & Manthou, 2013). According to United Nations University report, the amount of global e-waste was estimated to be 41.8 million tons in 2014 ("Global E-Waste Volume Hits New Peak in 2014: UNU Report - United Nations University", 2016) and was estimated to be around 54 million tons in 2015 and is expected to increase to 72 million tons by 2017 ("World's E-Waste to Grow 33% by 2017, Says Global Report", 2016).

Zanzibar is lacking proper WEEE disposal infrastructure which led to accumulation of waste in landfills, residential places and even on streets. Up until now, there is no any official WEEE recycling facilities available in Zanzibar (Department of Environment, Zanzibar, 2014). Hence, the accumulation of waste keeps on rising and imposing various threats to human health and environment.

On a positive note, the generated e-waste also contains valuable material such as copper, zinc, gold, aluminum, platinum and others which can be recovered (Vadoudi, Kim, Laratte, Lee, & Troussier, 2015). Apart from various e-waste management strategies such as "buy new for an old one"

advanced recycling fees, tax credits, deposit-refund systems (Wath, Vaidya, Dutt, & Chakrabarti, 2010), there are business models that are being established to take advantage of the generated e-waste. EU and other developed countries have established e-waste business models that will help in managing the waste in their respective countries.

Main issue that guides the success of any e-waste business model and investment is the proper collection strategy of e-waste. Hence, **Zanzibar** need to have proper collection strategy in order to attract e-waste recyclers. Even in countries like China which is the largest exporter of EEE and importer of WEEE around the world faces the challenges of inadequate e-waste in their recycling plants (Yu, Williams, Ju, & Shao, 2010). Also EU countries like France stresses the importance of managing collection process correctly when developing an e-waste recycling process (Vadoudi et al., 2015).

This research is looking forward to propose an ICT based collection strategy in **Zanzibar**. Minimum research has been conducted so far on the significance of using ICT in e-waste management systems. ICT as described by Ministry of Internal Affairs and Communication of Japan, "Our country faces a mountain of social issues to be resolved, including safe and secure countermeasures and revitalizing the economy amid the declining population growth and aging of society. As the "magic bullet" to solve these issues, great expectations have been placed on Information and Communications Technology or ICT." (MIC-Japan, 2016).

Zanzibar have recently experienced using ICT in many services. For example, the emergence of mobile money, mobile banking, e-commerce, e-payments and many other services via their computers and mobile phones; though it is unclear on how the population have adopted to use those ICT services. It is high time now to embed ICT in helping and supporting the collection of e-waste.

There is lack of research or knowledge gap on e-waste business models in **Zanzibar** and using ICT in supporting e-waste management. This study addresses these research gaps by analysing effective business models that will create job opportunities and reduce the damage and effect of e-waste in **Zanzibar** society and will propose an ICT e-waste collection strategy.

1.1 Research Objectives

The main objective of this research is to formulate desired and operational e-waste business model that will fit best in Zanzibar context and the role of ICT in e-waste collection strategy. Specifically, the research will focus on the followings:

- To determine the mass flow and inventory of WEEE in Zanzibar.
- To examine consumer's perception and willingness to support the collection phase of e-waste, hence the consumer's intention.
- To determine consumer's perception of using ICT as a solution in e-waste collection, hence the adoption rate of the proposed innovation and diffusion of the proposed ICT innovation.

1.2 Research Question

What is the viable e-waste business model in Zanzibar and how can ICT support the selected business model?

- What is the status of WEEE in Zanzibar?
- What is the consumer's intention towards the behaviour that will support ICT collection strategy of e-waste?
- What is consumer's perception towards the ICT innovative solution in e-waste collection?

1.3 Research Theoretical Framework

Research is based on three main theories, Namely:

- Theory of Planned Behaviour (TPB)
- Roger's Diffusion Theory (RDT)
- Transaction Cost Theory (TCT)

Both TPB and RDT will be used to examine consumer's willingness to support and adopt to the proposed innovative solution. TPB examine consumer's perception and willingness to support the collection phase of e-waste by analysing the attitude of consumer towards end of life electronic and electrical equipment. RDT is used to determine the diffusion rate of the proposed innovation by analysing consumer's perception of using ICT as a solution in e-waste collection.

Another part of this research will focus on examining the status of e-waste in Zanzibar in terms of inventory and mass-flow involved by conducting field observation and analysing secondary data from potential e-waste stakeholders. Both consumer's WEEE willingness and status of WEEE in Zanzibar will provide Zanzibar WEEE baseline in terms of the available inventory and calculated feedback from consumer willingness to support the collection phase of e-waste and the diffusion of the proposed innovative solution.

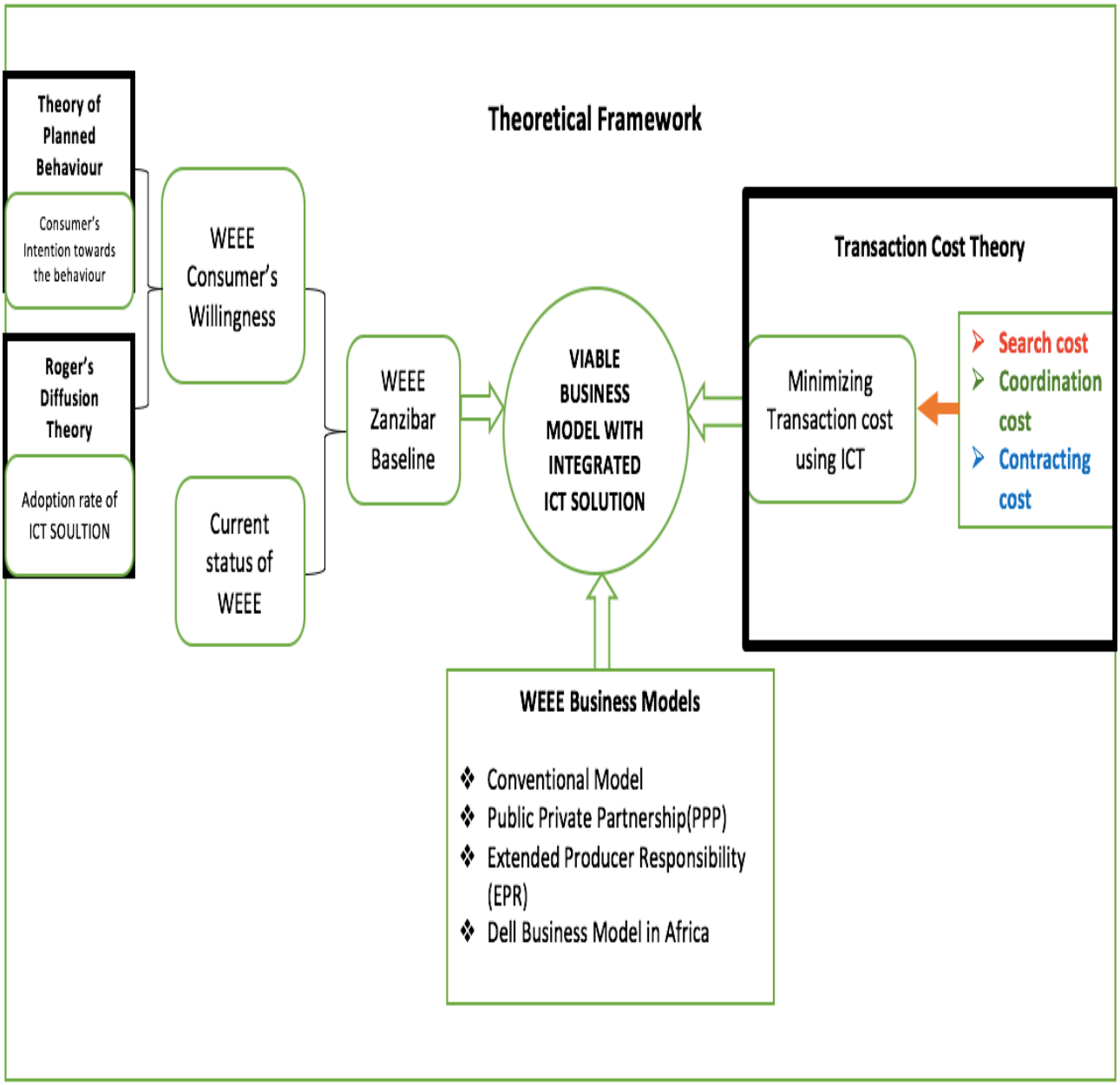

Figure 1: Research Theoretical Framework.

A thorough literature review will be used to evaluate and analyse the listed e-waste business models. The selected e-waste business model will be those who will fit-best in Zanzibar Context per e-waste baseline in Zanzibar information.

TCT will be used as a main emphasis on designing the mobile application (proposed e-waste collection innovative strategy). The mobile application will focus more on it will reduce contracting cost, e-waste search cost and coordination cost. The design and details of the proposed mobile applications is explained on chapter 7 of this report.

1.4 Limitation

Regarding this report, main limitation is about the financial analysis of the e-waste recycling facilities. More research is needed in getting an insight of all the investments that will be required to build and run the recycling facilities. Due to the scope and research objective, this analysis will not be included.

Also the fact that, there is no specific department or authority that keep track of importation of EEE in Zanzibar have led to the estimations of data based on mathematical calculation. For example, mathematical calculations were used to estimate the number of imported pieces of EEE in Zanzibar and the estimated weight in tonnes of EEE in Zanzibar. Author have estimated only 10% of the total imported EEE annually becomes waste. It can be more than 10% or less than 10%, calculating the proper percentage is out of scope of this project.

Several interviews were conducted to determine the potential stakeholder's feedback on the desired e-waste business model. The author had most of the interviews with head of departments, research and education personnel for some departments and in some cases a randomly selected staff in a department. Hence, the author is aware of the reliability issue of the feedback obtained from interviews.

Section 4.3 represents the ICT status and adoption of other ICT solutions of the United Republic of Tanzania. Zanzibar is part of United Republic of Tanzania. The research faced a limitation of getting

statistics covering Zanzibar only as there is only one body regulating Telecommunication and ICT in Tanzania.

1.5 Conclusion

Conclusively, this chapter introduced the problem statement with proper justification that e-waste is a major problem in Zanzibar and it is high time that necessary measures need to be taken. Section 1.1 and 1.2 introduced the research objectives and research questions respectively. Section 1.3 discussed the theoretical framework that was used in this research with three main theories; Theory of Planned Behaviour (TPB), Roger's Diffusion Theory (RDF) and Transaction Cost Theory (TCT).

Theory of Planned Behaviour is used to examine consumer's perception and willingness to support the collection phase of e-waste, hence the consumer's intention. Roger's Diffusion Theory is used to determine consumer's perception of using ICT as a solution in e-waste collection, hence the adoption rate of the proposed innovation and diffusion of the proposed ICT innovation. Transaction Cost Theory is used in designing the proposed ICT solution in a way it will reduce the transaction cost of e-waste recycling firms.

The following chapter will present the literature review conducted for the e-waste business models, e-waste conventions, hazardous components of e-waste, theories, ICT in waste management and reduction of transaction cost using ICT.

Chapter 2: Literature Review

In this chapter, a literature review is conducted and documented. According to the scope, research questions and objectives, literature review will be conducted for e-waste business models, e-waste conventions, theories, hazardous components of e-waste, ICT in waste management and reduction of transaction cost using ICT as seen in sections 2.1 to 2.6 below.

2.1 E-waste Business Model

E-waste generation keeps on raising every year and it is projected to increase even further for years to come. For example, it is forecasted to have 20 million tonnes of e-waste in china by 2040 from only 5.5 million tonnes in 2013 (Li, Yang, & Liu, 2015). As it will be elaborated in section 2.3 of this report, the harmful effects of e-waste to our environment and health, necessary measures and techniques need to be taken to oppose the growth of global e-waste.

One way to solve this problem is to add value to the waste and establish new business opportunities. Once consumers, recyclers and importers among other e-waste stakeholders realise the potential of earning profits from their waste, it will be a powerful driving factor in changing their perception towards managing their waste in proper and efficient manners. “Clearly, e-waste is not only an emerging problem, but also a business opportunity, given the volumes of e-waste being generated and their content of both toxic and valuable materials”(Li et al., 2015).

There are several ways to conduct businesses in e-waste industry, known as e-waste business models. Though there is a minimum literature concerning e-waste business models currently accessible, below is a list of business models being discovered across literatures:

- Conventional e-waste Recycling model (Spitzbart & Schluep*, 2014), (UNEP-DTIE, 2009), (A. Jain, 2010)
- Public Private Partnership (Spitzbart & Schluep*, 2014), (UNEP-DTIE, 2009), (A. Jain, 2010)

- Extended Producer Responsibility (a Jain & Deshpande, 2012), (A. Jain, 2010), (Garlapati, 2016) (Spitzbart & Schluep*, 2014), (UNEP-DTIE, 2009), (Suja et al., 2014), (Vadoudi et al., 2015)

A report from United Nation Environmental Program written for Cambodia (Cambodia & UNEP, 2009) have categorized e-waste business models as follows:

- Conventional Business Model
- Public Private Partnership (PPP)
- Extended Producer Responsibility

The above business models have also been recognized and evaluated in India (A. Jain, 2010). There is also other entrepreneurial opportunity from e-waste. Recycling of e-waste is a great venture for those interested in setting up their own entrepreneurship model as it almost assures financial gains (Meenakshi, D. T., & Harini, V., 2012). Entrepreneurs can create opportunities from collection, logistics, dismantling, recycling and even disposing. A study in US has suggested that the e-waste bill that would place a limit in exports would create about 42,000 new job opportunities ("Federal E-Waste Bill Could Create 42,000 New Recycling Jobs - Earth911.com", 2013).

2.1.1 Conventional E-Waste Business Model

This is one of the most preferred business model in areas where there is no proper collection, recycling and disposing facilities initiated by either government or other recycling plants. It is a model where by a recycler is buying the waste from either end users or collectors. After that the recycler starts the dismantling process and recover valuable products and earns revenues by selling its products. The characteristics of this business model are as follow(UNEP-DTIE, 2009):

- Recycler establishes e-waste recycling facility.
- Recycler purchases input raw material from the e-waste generators.
- Recycler recovers money by selling the e-waste fractions/ final product to smelters.
- Recycler has its own collection and transportation system for input raw material.
- Recycler finances the entire cost of collection, transportation and recycling through its own resources or through loans.

In this model, there is no direct intervention of government on the specified e-waste business (Spitzbart & Schluep*, 2014). Individual recycler can start this business via his own financial means, or bank loan. There is also a possibility of getting financial support from international development cooperation that are interested in environmental issues. It is very important for the recycler to poses or acquire knowledge that will help in negotiating international purchases (Spitzbart & Schluep*, 2014).

2.1.2 Public Private Partnership

This model as the name suggest, need the involvement of both public and private sector. “Project on Public Private Partnership (PPP) Project model is based on a contract or concession agreement, between a Government or statutory entity on the one side and a private sector company on the other side, for delivering an infrastructure service on payment of user charges” (UNEP-DTIE, 2009). It is the preferred model by both UNIDO and Microsoft Corp to reduce poverty in developing country like Uganda(Spitzbart & Schluep*, 2014). In this model, the involvement of public sector or government entity is to reduce the potential risk from the business.

PPP policy deferred from country to country, depending on the economic, social and cultural situation of that country. In Zanzibar, a special PPP unit has been established operating under the Ministry of Finance and Planning of Revolutionary Government of Zanzibar. Though the unit is not yet fully fledged, it has already produced a PPP policy of 2014 that is clearly indicating the all necessary information for a PPP projects.

As the Zanzibar PPP policy indicates, competitive tendering is used in the process of identifying the potential partner of the government from the proposed business. Meaning to say; first a proposal is submitted to the PPP office. The PPP office review the proposal and if it captures the interest of the government and it indicates as viable business, it announces a public tender. Whoever is going to submit the best deal to work with the government is going to be officially certified as a government partner is that business.

2.1.3 Extended Producer Responsibility

Extended producer responsibility is a model where by the producer is now required to extend their responsibilities to the EEE that they are selling by collecting their waste. It is the most preferred business model in Europe and Switzerland being the only country in Europe to have a decade of experience in using the EPR model. Switzerland is the most successful country in Europe in terms of e-waste handling and has exceed the EU directive goal. Switzerland has achieved to collect 68,000 tonnes in 2003 which corresponds to just over 9kg/capital exceeded the EU target of 4kg/capital (Sinha-Khetriwal et al., 2005).

Figure 2 represents the graphical model of EPR business model being utilised in Switzerland. Two major Producer Responsibility Organisations (PROs) are working on behalf of their member producers. The success of the model is based on what is known as “Advanced Recycling Fees” –ARF where by the larger percent of ARF is going to PROs. The fee is ranging depending on the type of EEE being purchased from 1 Swiss Franc for small items like hair driers to 20 Swiss Francs for TV and up to 40 Swiss Francs for bigger items like refrigerators (UNEP-DTIE, 2009).

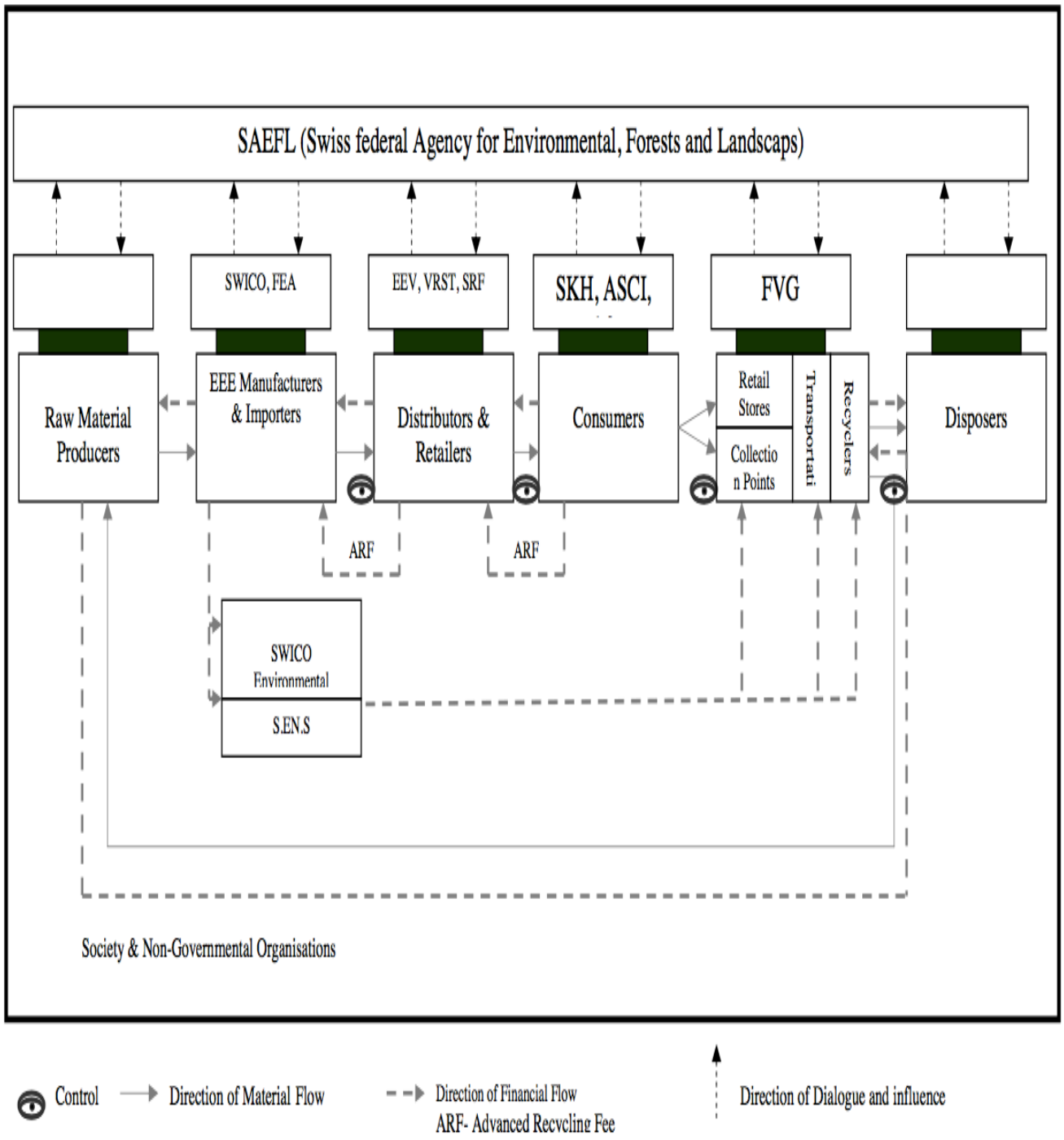

Figure 2: Switzerland EPR Model (Source: (Sinha-Khetriwal et al., 2005)*)*

2.1.4 Other E-waste Business Model

Apart from the above three explained business models, there are few other being mentioned in literature and there are many other who can be established from different countries. An example of other business models is recycling plant owned by municipality, association based facility and

WEEE dismantling by a social enterprise (Spitzbart & Schluep*, 2014). Apart from those, there are other business models being established by major electronic companies like Dell.

Other business models can be established based on interest from a certain government entity who are direct stakeholders of e-waste like port corporations and revenue authorities. It can also be established by EEE producers, importers and of course consumers who will identify proper entrepreneurial opportunities.

Due to unlimited possibilities of business models from e-waste and limiting research scope, this research will focus on analysing and exploring the following business models:

- Conventional e-waste Recycling model
- Public Private Partnership
- Extended Producer Responsibility

2.2 E-waste Conventions

As justified in chapter 1 of this report, e-waste is a global problem and it has proven to increase year by year. Hence, countries and regional associations have united to fight against this problem by regulating the e-waste trade between countries and usage of certain hazardous chemicals in producing EEE. In this chapter, main e-waste conventions will be analysed and explained:

2.2.1 Basel Convention

Basel Convention was established in 22 march 1989 by Conference of Plenipotentiaries in Basel, Switzerland. This convention was established because industrialised countries in the years 1970s were looking for options or rather cheaper options to disposed their waste and hence started exporting it to less developed countries (LDCs). As environmental and health awareness of individuals in the developed countries was increasing and everyone denying to be close to disposals(“Overview,” 2011).

Basel convention highlighted the need to stop exporting hazardous waste that are dangerous to both health and environment. Hence the main objective of this convention is to protect human health and the environment against the hostile effects of hazardous wastes. It also focused on other waste which are defined as household waste and incinerator ash("Overview," 2011).

The provisions of the Convention have the following principal aims("Overview," 2011):

- The reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes, wherever the place of disposal;
- The restriction of transboundary movements of hazardous wastes except where it is perceived to be in accordance with the principles of environmentally sound management; and
- A regulatory system applying to cases where transboundary movements are permissible.

Up until 2017, there are total of 156 parties where by United Republic of Tanzania has submitted their application on 07 April 1993 and became member from 06 July 1993 ("Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal," 2011).

2.2.2 Bamako Convention

Bamako convention was established in 1991 and came into force in 1998 in Bamako, Mali. The convention mainly focused on tightening intra-African waste trade and added radioactive waste to be banned too that was missing in Basel convention banned waste list("Bamako COP 1 Decides UNEP to Host Secretariat," 2013). Basel Convention proved to not taken seriously and there were still huge tonnes of waste are being disposed in Africa from developed countries. A famous story that has led to the establishment of Bamako convention is as described in Wikipedia page of Bamako Convention.

" important case, which occurred in 1987, concerned the importation into Nigeria of 18,000 barrels (2,900 m^3) of hazardous waste from the Italian companies Ecomar and Jelly Wax, which had agreed to pay local farmer Sunday Nana $100 per month for storage. The barrels, found in storage in the

port of Koko, contained toxic waste including polychlorinated biphenyls, and their eventual shipment back to Italy led to protests closing three Italian ports."- (Source: https://en.wikipedia.org/wiki/Bamako_Convention)

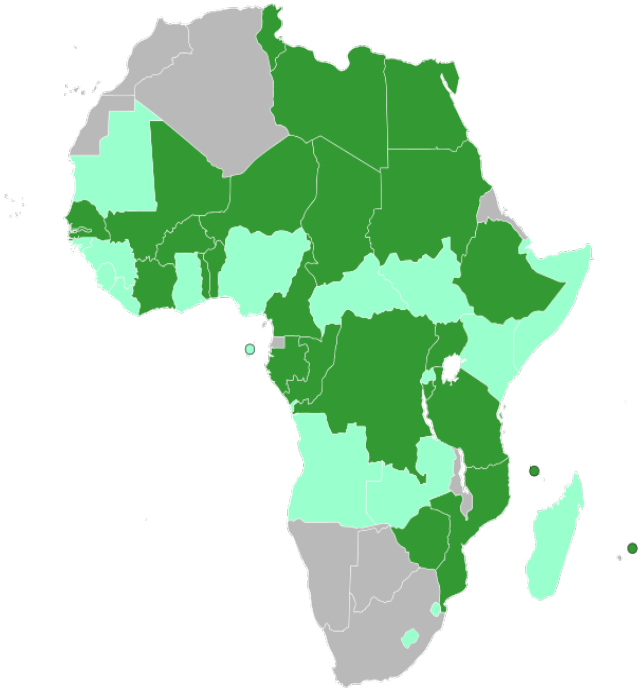

Figure 3: Bamako Convention member states (source: https://en.wikipedia.org/wiki/Bamako_Convention)

Bamako convention have a total of 25 parties and Tanzania being one of them as shown in figure 3 above where by dark green shows the ratified member states and light green shows signed member states.

2.2.3 Rotterdam Convention

The Rotterdam convention was established in 10 September 1998 and has come into force from 24 February 2004. This convention just like other convention which controls the trade of hazardous waste but also focus on pesticide and other industrial chemicals.

The objective of this convention is as follow("Overview," n.d.):

- To promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals to protect human health and the environment from potential harm.

- To contribute to the environmentally sound use of those hazardous chemicals, by facilitating information exchange about their characteristics, by providing for a national decision-making process on their import and export and by disseminating these decisions to Parties

Rotterdam Conventions have focused more on banning dangerous chemicals. As many EEE are composed of certain chemical compounds, it therefore also controlling the trading of e-waste. There are 157 member states ratified in this convention including United Republic of Tanzania("Status of ratifications," n.d.).

2.2.4 Stockholm Convention

Stockholm convention is focusing more on the usage of Persistent Organic Pollutants (POPs) that are resistant to environmental degradation. In 2001, the Stockholm convention presented and analysed the human and environmental effects of POPs which resulted to reduce or strictly prohibit the usage of POPs.

POPs have been divided into 3 categories(Convention, 2008):

- Elimination (Annex A): All chemicals listed are to be eliminated by member states in terms of both producing and using. Example of listed chemicals in Annex A are Aldrin, Endrin, Dieldrin, PCB and HBCD.
- Restriction (Annex B): Chemicals listed in Annex B are to be restricted from both being produced and used by member states. Example of chemicals in Annex B are DDT and perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride
- Unintentional Production (Annex C): This category has listed all chemical that its unintentional release shall be reduced.

United Republic of Tanzania have been ratified as a member state on 30th April 2004. Apart from Tanzania, there are other 180 member states.

2.3 Hazardous component of e-waste

E-waste should be managed in proper, safe and efficient methods as it has lots of effects on human health and environment. This is due to the fact that e-waste contains hazardous components such as halogenated compounds, radio-active substances, heavy metals and other metals as seen in table 1 (Garlapati, 2016). A city in southwestern china, Guiyu which is the largest e-waste recycling site has its residents exhibit substantial digestive, neurological, respiratory, bone problems and children are at risk of lead poisoning (McAllister, 2016).

Halogenated Compounds		Radio-Active Substances		Heavy Metals and other metals	
Substance	Occurrence in e-waste:	Substance	Occurrence in e-waste:	Substance	Occurrence in e-waste:
Polychlorinated biphenyls -PCB	Condensers, transformer	Americium	Medical equipment, fire detectors, active sensing element in smoke detectors	Arsenic	Light emitting diode
Polybrominated biphenyls -PBB	Fire retardants			Beryllium	Power supply boxes contains silicon controlled rectifiers and x-ray lenses
Polybrominated diphenyl ethers -PDBE	Plastics			Cadmium	Rechargeable Ni Cd- batteries, fluorescent layer (CRT screens), printer inks and toners, photocopying-machines (printer drums)
Chlorofluorocarbon -CFC	Cooling unit, insulation form			Chromium VI	Data tapes, floppy-disks
polyvinyl chloride -PVC	Cable insulation			Lead	CRT screens, batteries, printed wiring boards
				Lithium	Li-batteries
				Mercury	Fluorescent lamps that

			provide backlighting in LCDs, in some alkaline batteries and mercury wetted switches
		Nickel	Rechargeable NiCd- batteries or NiMH- batteries, electron gun in CRT
		Rare Earth elements (Yttrium, Europium)	Fluorescent layer (CRT-screen)
		Selenium	Older photocopying-machines (photo drums)
		Zinc sulphide	Interior of CRT screens, mixed with rare earth metals.
		Barium	Getters in CRT

*Table 1: Hazardous components of e-waste(*source: (Garlapati, 2016)*)*

2.4 Theories

In this section, all the theories that are part of the theoretical framework seen in figure 1 are going to be presented and discussed. Section 2.4.1 will discuss Theory of Planned Behaviour that is used to examine consumer's perception and willingness to support the collection phase of e-waste, hence the consumer's intention. Section 2.4.2 will present Roger's Diffusion Theory that is used to determine consumer's perception of using ICT as a solution in e-waste collection, hence the adoption rate of the proposed innovation and diffusion of the proposed ICT innovation. Finally, section 2.4.3 will present Transaction Cost Theory that is used in designing the proposed ICT solution in a way it will reduce the transaction cost of e-waste recycling firms.

Author is aware of other adoption theories like Theory of Reasoned Action (TRA) which focuses on person's intention to behave certain way but has decided to use Theory of Planned Behaviour with a similar goal but with an extra variable of perceived behavioural control- a very important variable is pushing an individual to adopt to the behaviour in question. Other theories such as Technology acceptance model with its modifications and extension are focus more on acceptance of individuals inside an organisation which is not the objective of this research and hence not part of this research.

2.4.1 Theory of Planned Behaviour

The theory of planned behaviour (TPB) is used to determine the behaviour of a person by first analysing his intentions. "TPB has become one of the most frequently cited and influential models for the prediction of human social behaviour"(Ajzen, 2011). The intentions are based on three other factors, namely(Francis et al., 2004),(Madden, Ellen, Ajzen, Sniehotta, & Ajzen, 1992):

- Attitude: Influenced by the likely consequence of the behaviour.
- Subjective norm: Influenced by the normative expectation of others.
- Perceived behavioural control: Influenced by external factors that might support or oppose the adoption of certain behaviour.

The higher the attitude towards the behaviour, higher subjective norm and higher perceived behavioural control will lead to higher intentions. For example, in this research the behaviour which was presented and analysed was "the usage of mobile application to sell e-waste". Considering that behaviour, the following factors need to be considered;

- One need to have positive attitude towards using the application to sell e-waste
- One should believe the society is expecting him to use the mobile application to sell e-waste
- One should have external factors that will support him to adopt the behaviour of using mobile application to sell e-waste

Combining the above three factors, one will have an intention of using mobile application to sell e-waste and potential adoption of the presented behaviour.

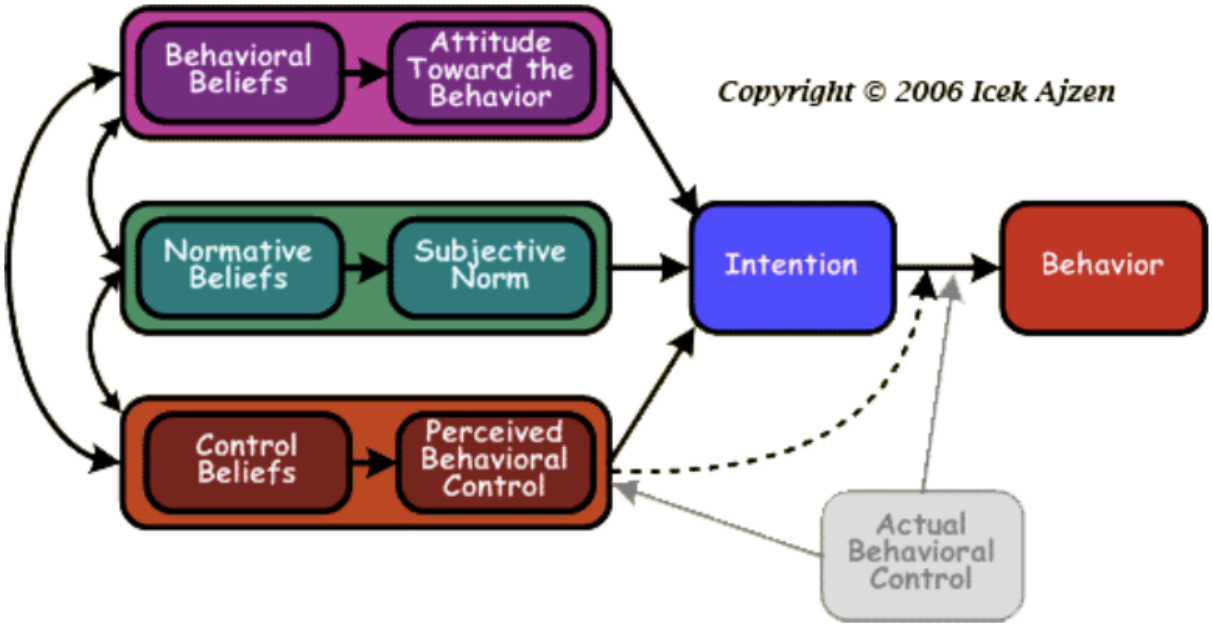

Figure 4: Theory of Planned Behaviour (Source: (Madden et al., 1992))

From figure 4 above, note that perceived behavioural control effects intention and after the intention is positive towards the behaviour, actual behavioural control will be a great factor towards adoption. This is because some behaviours are difficult to adopt and hence limit its voluntary feature and hence actual behaviour control is considered important in making the decision of adopting.

2.4.2 Roger's Diffusion Theory

Roger's diffusion theory basically focuses on how an innovation will diffuse or spread for adoption. "Diffusion is defined as the process by which an **innovation** is communicated through certain **communication channels** over **time** among the members of a **social system**" (Rogers, 1983). By analysing the definition above, it can be observed that diffusion of an innovation depends on:

- Innovation
- Communication Channel
- Time
- Social System

Innovation of new technologies have their own characteristics that led for that specific innovation to be adopted in a faster rate or slower rate than expected. For example; pocket calculators was adopted at a very fast rate when it was introduced but home videotape equipment had a very slow rate (Rogers, 1983). There are number of characteristics of the innovation itself that affect the potential adopter's behaviour on whether to accept or reject that technology. The following are the perceived attributes of innovation:

- Relative Advantage: the level to which an innovation is seen as better compared to the previous innovation (Rogers, 1983). By better it can be by archiving either economical advantage, social advantage or other factors.

- Compatibility: the level to which an innovation is compatible with existing values, experience and finally the need of the potential adopters (Rogers, 1983).

- Complexity: this can be defined as a degree of difficulty to use and understand the introduced innovation (Rogers, 1983).

- Trialability: the degree to which an innovation can be tested for experimental phase but on a limited basis (Rogers, 1983).

- Observability: it is the level in which the benefits and results of particular innovation can be seen and observed (Rogers, 1983).

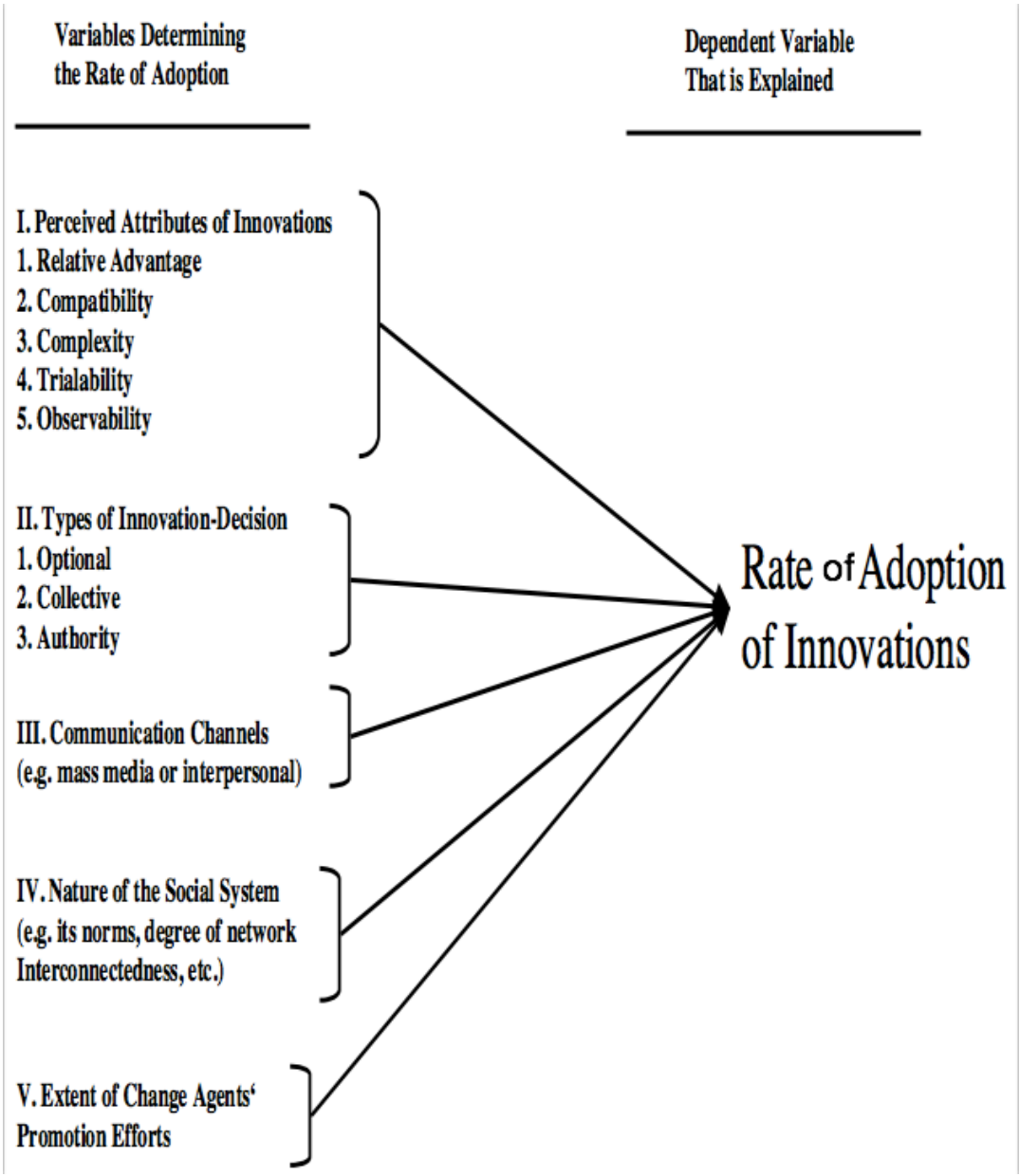

Figure 5: Variables determining Adoption rate in Roger's Diffusion Theory

As seen in figure 5 above, the rate of adoption is determined by not only attributes of innovation but also other factors. Other variables include communication channel with which it will be used to spread the information about the innovation. Each media being deployed will influence either positively or negatively the rate of adoption. "If interpersonal channels must be used to create awareness-knowledge, as frequently occurs among later adopters, the rate of adoption will be slowed"(Rogers, 1983).

Also, the innovation-decision type as it can be optional, collective decision or authority wise. If a decision of adopting to an innovation is being done on optional or individual level, the rate of adoption will be high compared to the scenario where by a decision to adopt to an innovation is to be made by larger group or authority.

Other two variables are nature of social system and extent of change agent's promotional efforts. In a society where the connectedness is much closer is likely to have higher rate of adoption.

2.4.3 Transaction Cost Theory

Transaction cost can simply be defined as a fee charged by financial intermediary like broker, bank or it can be defined as a cost related with exchange of goods or service between firms that do not have individually (Dictionary, n.d.). Any business firm might encounter transaction cost as most of the time firms do not own everything every time. Transaction cost is against neo classical economics where one of its assumption is that agent have full information of prices, markets, buyers, sellers, etc. It is impossible to have full information and firms have bounded rationality and therefore they act opportunistically. As Ronald Coase suggested in 1930, that firms are created due to the cost of transacting in the market because agents don't have full information("Transaction Cost Economics," 2015).

Firms need to consider transaction cost as extra cost from the usual production cost and distribution cost. From the lecture during the class of Entrepreneurship, Innovation and Business Model course, main types of transaction cost were listed as operational cost and contractual cost.

In operational cost, it includes search cost and communication cost. Firms are spending a lot of money in searching for its raw materials, searching for resource that a firm do not own but it needs it.

Another type of transaction is the contractual cost which include the cost of writing contracts and of course the cost of enforcing cost.

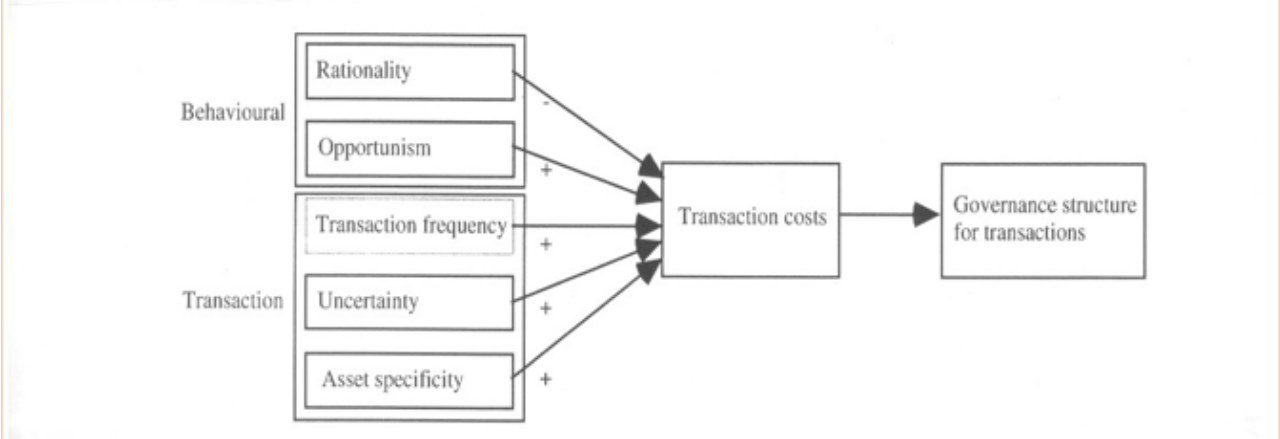

Figure 6: Williamson Concept on Transaction Cost

Figure 6 above shows the linkage between variables stated by Williamson that affects the transaction cost. If rationality is low and all other variable (opportunism, transaction frequency, uncertainty, and asset specificity) are high then transaction cost will be acquired and hence firms need governance structure for transactions. Note that Williamson consider business firms more as governance structure rather than production firms.

2.5 ICT in Waste Management

The introduction of ICT is managing waste is a potential tool in future world with better management of waste. There is a very minimal contribution of ICT in handling e-waste specifically but plenty of stakeholders are looking for various ways to use ICT in handling waste in general.

For example, "At ISWA's 2015 World Congress in the City of Antwerp, UNEP and ISWA presented "Global Waste Management Outlook (GWMO)". A comprehensive report that covers the global challenges of the waste management sector for the next decade. Surrounded by 1400 politicians and decision makers in the industry, I listened to David C. Wilson, Editor in Chief of the report, when he was going over the key results of the two-year study. And some of the facts of the global waste management situation shocked me. **But the good news is that ICT solutions and 'big data' are a key driver to take global waste management to the next level!**"(Abbas, 2015)

In 2016, Resource London with North London Borough held a conference to discuss the vital involvement of ICT in waste management. Among technologies that were discussed include(London,n.d.):

- Bin weighing technology
- Route optimisation and fleet optimisation
- Real-time tracking and reporting
- Bin fill rate sensors

More details of above mentioned technologies are found here: http://resourcelondon.org/resources/good-practice-and-case-studies/ict-in-waste-management/

2.6 Reduction of Transaction Cost Using ICT

ICT is now playing a huge role in reducing the transaction cost for companies. With the introduction of telephone and other communication technologies, companies have managed to reap the benefits of ICT in reducing the cost. This project will present an innovative ICT solution that will focus in reducing the transaction cost for e-waste recycling firms. "ICT is believed to contribute to economic development by reducing the transaction and information cost associated with any economic activities."(Radha Rao, 2009)

"The possibility to use ICTs for better information and a reduction of the transaction cost was studied by de Silva and Ratnadiwakara (2008) on small-holder farmers in Sri Lanka. They show that 11% of the total cost is informational search costs (NB: this case is within the scenario of a government promotion of fertilizers, which is believed to increase search activity). Broken down, information search costs account for 25% of the total growing costs, 20% of the selling costs, and 75% of the costs to decide on appropriate crops. The other factor ratios are less significant but still important related to the amount of money spent. This proves that ITCs can play an important role. In this particular case, by using a mobile phone instead of travelling to reach information, the information search cost decreased by 33%. Moreover the travel time can be used for doing something else." (Silva & Ratnadiwakara, 2008)

In this research, the author will introduce an ICT solution that will focus in reducing transaction costs for formal e-waste recycling companies.

2.7 Conclusion

In this chapter, an intensive literature review was conducted and presented with proper discussions. Main emphasis is on the e-waste business models, e-waste conventions, the theories that are used in theoretical framework, the hazardous effects of e-waste. Also, because the research is proposing ICT solution in the field of e-waste and the reduction of transaction cost from the proposed ICT solution, section 2.6 and section 2.7 presents the link between ICT with waste management and ICT with the reduction of transaction costs.

Next chapter will present that methodology that was used in the research.

Chapter 3: Methodology

In this chapter, the methodology of the research will be presented and discussed. Section 3.1 will present the methodological framework and will list all the methods that will be used.

3.1 Methodological Framework

The methodological part of the research is divided into three parts. The flow of methodology is as illustrated in figure 7 below. Note that it is necessary to get baseline of e-waste in Zanzibar together with thorough analysis of the e-waste business model to finally come up with the desired e-waste business model that will fit best in Zanzibar environment.

Primary data, total of 400 **questionnaires** will be distributed to 4 streets of Zanzibar Urban/West Region. The streets are selected based on income distribution and e-waste activity level. The selected streets are Kilimani, Chukwani, Mikunguni and Vikokotoni. More explanation on data collection approach is found later in chapter 6 of this report. **Interviews** with selected stakeholders will be conducted to get an insight in their contribution and their feedback on the desired business model. Selected stakeholders are found in data collection plan is section 6.1.

Secondary data that is needed includes importation and exportation data from Zanzibar Port corporation, users and subscribers of other ICT based solution (focus in mobile money) and other secondary data that might prove crucial to the research.

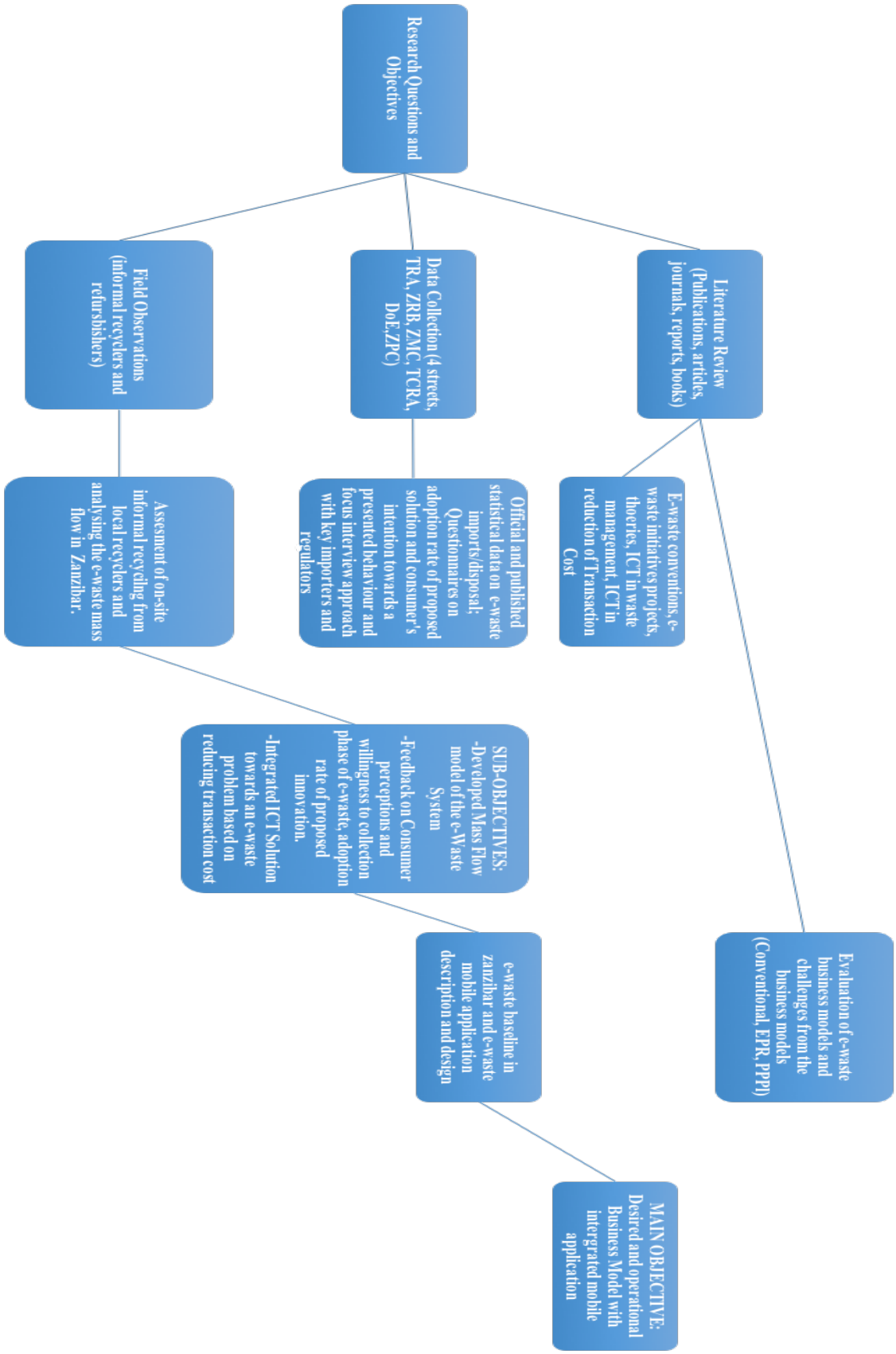

Figure 7: Methodological Framework (Source: Author)

Literature review: Evaluation of e-waste business models, challenges from the business models (Conventional, EPR, PPP). Evolution of e-waste initiatives projects, e-waste conventions and the three theories that will be used in our research as shown in figure 1 (theoretical framework) above. Also, the hazardous components of e-waste. Finally, a literature review on the link between ICT with waste management and ICT with the reduction of transaction cost.

Field Research: Conducting mass flow analysis that gives an insight of where the e-waste is being generated, which pathways it follows and how value is being added towards the followed path and finally to either being disposed or recycle. Also, to get an insight in informal recycling centres, their challenges and working environment.

3.2 Conclusion

In this chapter, a research methodology is presented. As the framework suggests, both primary and secondary data was used together with literature review and field observation. A roadmap of the methodological framework is seen in figure 7 above.

Next chapter will present Zanzibar e-waste and ICT state-of-the art based on literature review. This chapter will present and discuss several e-waste projects and initiatives in Zanzibar, policy and regulatory framework and ICT status.

Chapter 4: Zanzibar E-waste and ICT State-of-the-Art

In this chapter, the focus will be on analysing the current situation of e-waste in Zanzibar in terms of e-waste projects conducted so far, existing policies and regulation that indirectly regulates e-waste and status of ICT. Section 4.1 will discuss e-waste projects that have been conducted in Zanzibar. Section 4.2 will discuss policies and regulations and section 4.3 will focus on ICT state-of-the-art. This chapter is based on literature review but it is written as a separate chapter to emphasis the state of the art of both e-waste and ICT in Zanzibar.

4.1 E-waste Projects and Initiatives

There are very few projects concerning e-waste in Zanzibar, Department of Environment being the only stakeholder which is concerned on the potential threats and effect of WEEE in Zanzibar. In this chapter, the findings and analysis of the conducted WEEE projects will be presented.

4.1.1 Department of Environment Project (2010)

The first research concerning e-waste was conducted by Department of Environment in 2010. The research was conducted under the second phase of "sustainable management of land and environment project". The research focused more on the crisis of second hand goods importation. The research report pointed out the problem of over importing the so called "second hand or used" electronics in which the country clearly shows indication of failing the Basel convention agreements.

The research approached second hand dealers and have received feedback on how do they get their goods, from which countries do they order their goods, age group distribution of UEEE personnel, educational qualification of UEEE personnel, job status of UEEE personnel, how long their UEEE store have been operational, what kind of appliances are sold. The research received feedback on the quality of UEEE prior to sale, handling and storage of UEEE in stores, concerns over illegal dumping of WEEE, concerns over occupational health effect from handling EEE and many other aspects were also questioned. (DoE Zanzibar, 2010)

Relevant feedback to this research is as seen in figure 8 below which shows concerns over illegal or unauthorised dumping of WEEE. The received data shows 67% of respondents believes there is no effect from unauthorised dumping where by only 9% and 3% have admitted that they are aware of unauthorised dumping concerns respectively.

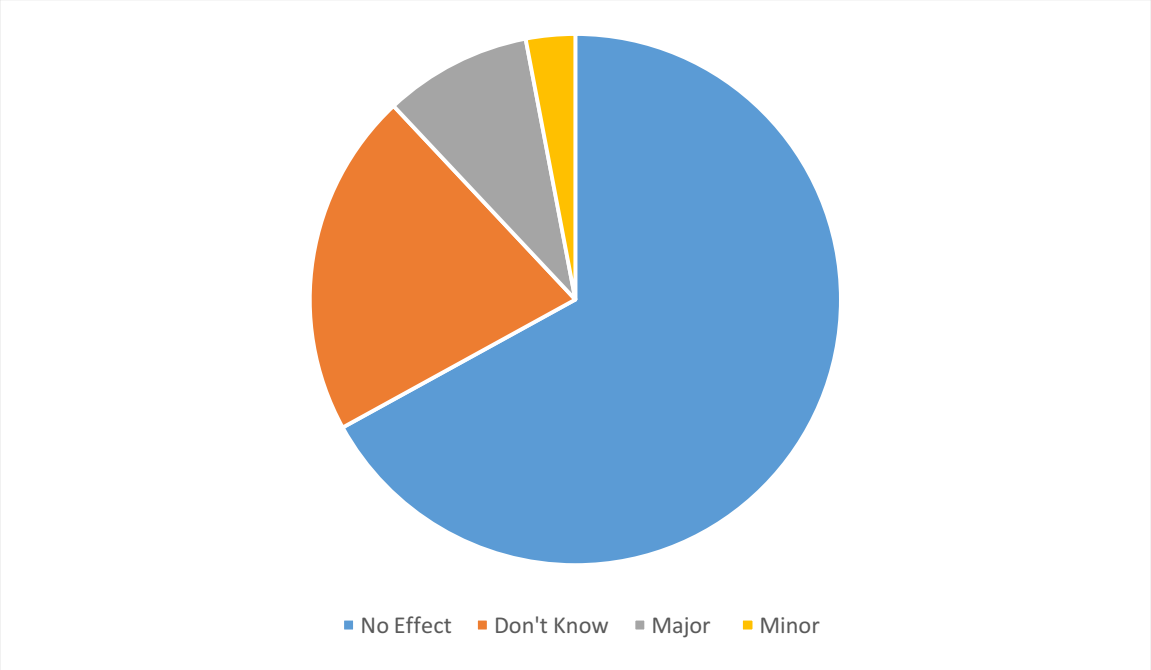

Figure 8: Concerns on where to dump rejected goods or unwanted components. (Source: (DoE Zanzibar, 2010))

The research also pointed out the frequently available EEE goods in Zanzibar. It is important to note that the research was conducted in 2010, about seven years ago. Hence, due to change of human and environmental needs, it might be the frequency of availability might have changed. The latest data on the frequency of certain EEE importation will be calculated on the next chapter of this report.

The research also pointed out the lack of having specific body to regulate the standard of goods in Zanzibar. Fortunately, just few years back Zanzibar Government have established Zanzibar bureau of Standards (ZBS). Specific contribution in the field of EEE since its establishment will be discussed later in this chapter. Also, the study pointed out the lack of unregulated importation at the Zanzibar Ports. The study also pointed out from which countries of origin the Zanzibar Port receives the UEEE. The figure 10 below shows that 53% of the respondents named Europe as the continent of origin.

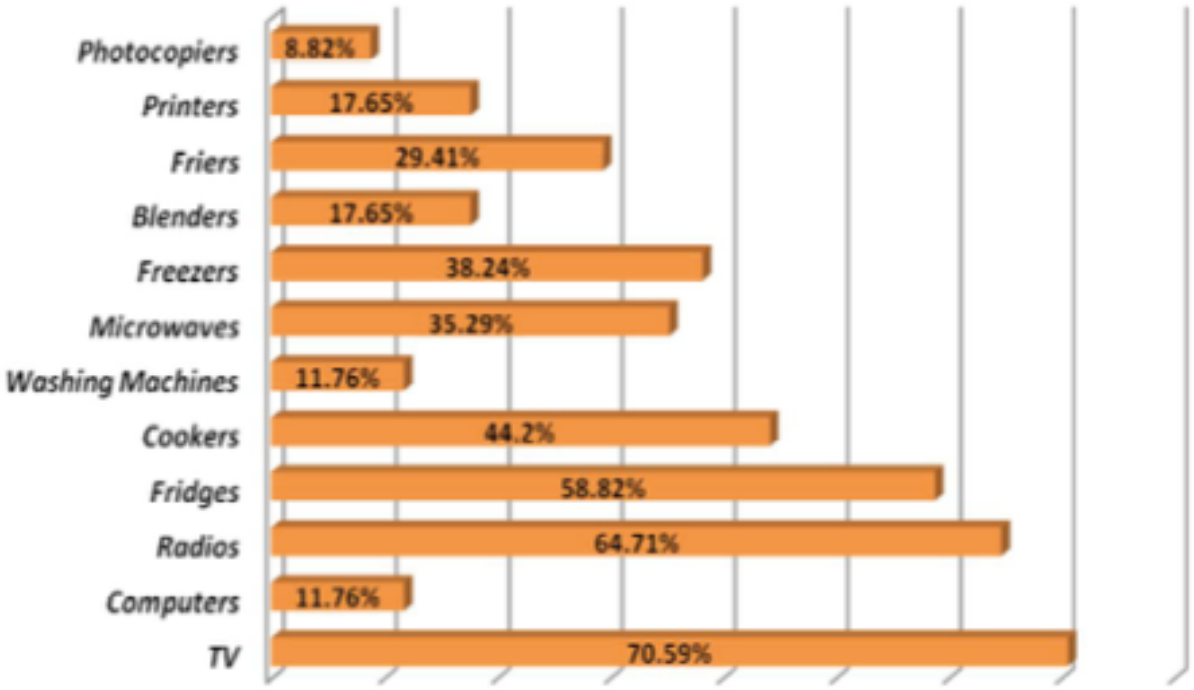

Figure 9: Frequency of Availability of UEEE in Zanzibar. (Source (DoE Zanzibar, 2010))

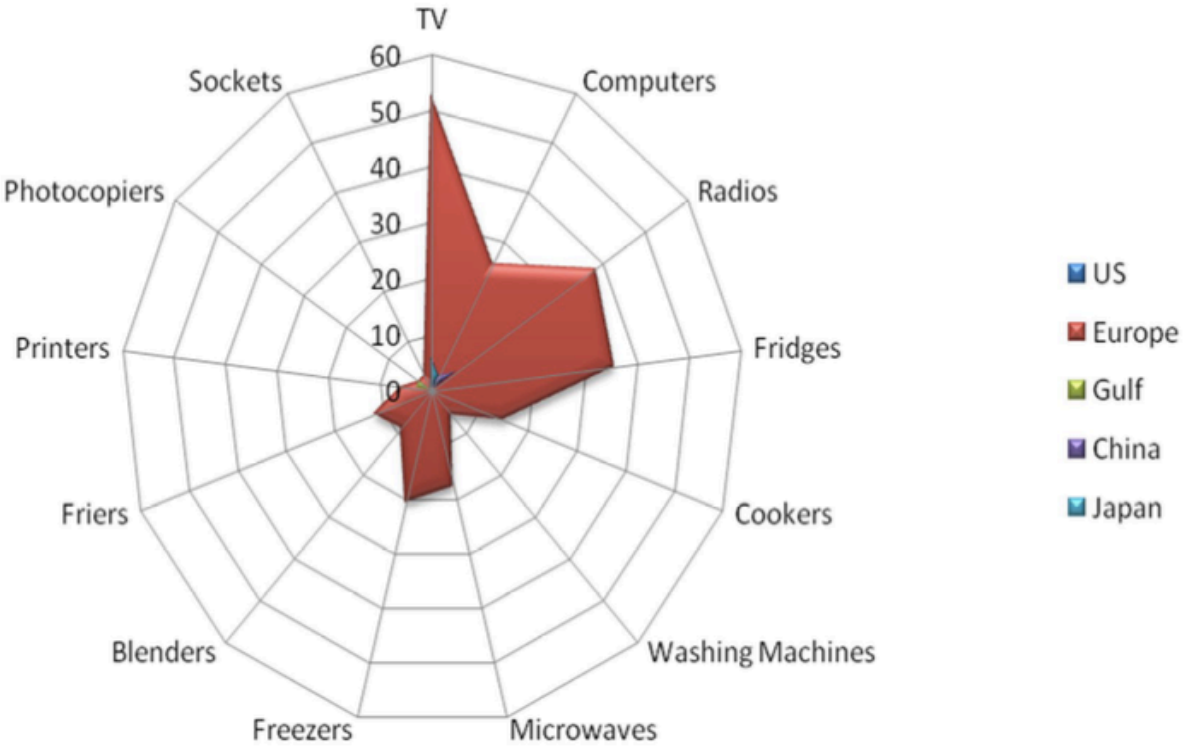

Figure 10: Country of origin of UEEE. (Source ((DoE Zanzibar, 2010))

4.1.2 Department of Environment Project (2014)

In 2014, Department of Environment conducted another research under the title "IMPORT, HANDLING, DISPOSAL AND RECYCLING OF E-WASTE: A SITUATIONAL ANALYSIS FOR ZANZIBAR". For the import analysis part, the report stated clearly that there is no official statistical data of imported WEEE in Zanzibar but the research using data from TRA has estimated 940 tonnes of WEEE was imported between June 2013 and June 2014 alone. Some dealers have shown their concern that Zanzibar might be importing more than what TRA data are suggesting. In chapter 5 of this report, an estimated amount of EEE being imported is going to be calculated and presented.

In terms of handling, disposing and recycling, the report has admitted the lack of infrastructure to dispose and recycling EEE in Zanzibar. The report suggests, even if Zanzibar will ban right away the importation of WEEE in the country there are still going to be serious consequences of the already imported WEEE. Other important findings of the report are as follow(DoE Zanzibar, 2014):

1. Unregulated Importation of WEEE
2. Lack of research on WEEE
3. Lack of awareness of international agreements concerning e-waste (Basel Convention, Bamako Convention, etc.) among e-waste stakeholders in Zanzibar.
4. Coordination between key government entities concerning e-waste is lacking.
5. In 2001, the department of environment submitted a draft to ban completely the importation of WEEE in the country but was later rejected. Due to the economic situation of Zanzibar, many individual can't afford to buy new EEE rather they buy used EEE which are definitely way cheaper compared to the new ones.
6. Zanzibar Bureau of Standards (ZBS) was required to develop regulatory framework and guideline on the importation, handling, disposing and recycling of e-waste in Zanzibar.
7. TRA have raised its import duties for WEEE by almost 100% from 1,7 Million TSH in 2013 to 3,4 Million TSH in 2014 for 40ft container.
8. Ministry of Health of Zanzibar developed its guidelines for controlling the donation of medical equipment in the country.
9. Number of complaints from locals on frequent burning of WEEE in streets and informal landfills.

10. Calling for the establishment of WEEE accounting system which will keep records on the importation, handling and recycling of WEEE in Zanzibar.

4.1.3 Zanzibar Bureau of Standards (ZBS)

ZBS has been given the task to develop regulatory framework and guidelines for the importation, handling and disposal of WEEE in Zanzibar. The guideline has focused more on the standard of the imported EEE, especially second hand EEE. The guideline doesn't focus handling, disposing and of course recycling of the WEEE.

The guideline also stated the list of allowed and banned list of used EEE to be imported in Zanzibar as seen in table 3 below.

Allowed list of used EEE in Zanzibar	Banned list of used EEE in Zanzibar
• Air Conditioning Units. • Appliances for hair cutting, hair drying. • Clocks, watches and equipment. • Cellular Telephones and Fax machines. • Deep Fryers. • Desktop Computers (with Central Processing Units (CPUs), Mouses, and Cathode Ray Tube (CRT) Monitors. • Electric cookers and electric stoves. • Electric Kettles. • Electric mixers and grinders. • Electric Toys, Treadmills, and all equipment used for video/electronic games. • Electronic tools such as drills, chain saws, milling machines, lawn mowers, etc. • Hi-fi Speaker & Amplifier Sets. • Irons. • Laptops and its accessories. • Lighting systems. • Microwave ovens. • Photocopying and Scanning machines. • Photographic equipment including cameras and film processing and production systems. • Pocket and desk calculators. • Printers and their ink cartridges. • Radio receivers including Car Stereo systems.	• Touches. • Plugs. • Switches. • Sockets. • Electrical and electronic cables. • Cardiology equipment. • Dialysis equipment. • Radiotherapy Equipment. • Specific equipment needed for Educational, Research, Development and Monitoring purposes for Schools, Colleges, Universities, Laboratories, Research units and institutions.

• Refrigerators and Freezers. • Sewing machines. • Toasters. • TV sets. • Vacuum cleaners and accessories. • Video recorders, CD and DVD players. • Washing Machines. • Decoder. • Projector. • Stabilizer and voltage regulator	

Table 2: list of allowed and banned used EEE in Zanzibar (Source: ZBS e-waste guideline)

During interview, head of ZBS department have raised his concern on how to deal with below standard EEE that have been denied entry to Zanzibar. A proposed solution from this research could be an ideal way to get rid of the below standard EEE.

4.2 E-waste policy and regulatory framework

United Republic of Tanzania doesn't have specific regulations developed for electronic waste but there are number of other regulations mostly dealing with environment, standards and safety in which might somehow be linked with e-waste in general (Gumbo & Dr. Kalegele, 2015). Table 4 below list down the regulations and their respective responsible authority to implement the act.

S.N	Legal Instrument	Responsible Organ
1	National Environmental Management Act No.20 of 2004.	Vice President's office National Environmental Management Council Local Government Authorities.
2	The Environmental (Solid Waste Management) Regulations of 2009.	Vice President's Office National Environmental Management Council Local Government Authorities.
3	The Environmental (Hazardous Waste Control) Regulations of 2009.	Vice President's office National Environmental Management Council Local Government Authorities.
4	Tanzania Foods, Drugs and Cosmetics Act of	Tanzania Foods and Drugs Authority Ministry of

	2003.	Health and Social Welfare.
5	Occupational Safety and Health Act of 2003	Ministry of Labor, Youth and Culture Occupational Safety and Health Authority
6	Tanzania Bureau of Standards Acts No.3 Of 1975	Ministry of Industry and Trade Tanzania Bureau of Standards.
7	Fair Competition Act of 2003 Merchandise Marks Act of 1963	Fair Competition Commission
8	Atomic Energy Act of 2003	Tanzania Atomic Energy Commission
9	Water Resources Management Act No11 of 2009	Ministry of Water Urban Water Authorities River Basins Authorities
10	Local Government (District Authorities) No.7 of 1982 Local Government (Urban Authorities) No.8 of 1982	Local Authorities

Table 3: Regulations related to e-waste in Tanzania (Source: (Gumbo & Dr. Kalegele, 2015))

There are also number of policies targeting environment, national health, energy, ICT and science technology but again there is lack of specific e-waste policies in the country. Figure 11 below shows the policies that are related to e-waste.

Figure 11: Policies related to e-waste in Tanzania. (Source: (Gumbo & Dr. Kalegele, 2015)

4.3 ICT Status and Adoption of other ICT solutions

United Republic of Tanzania, together have a total population of 53.47 million people. Communication is one among the union matters and there is one major governing body known as Tanzania Communication Regulatory Authority (TCRA). This body have been working to ensure all types of communications (voice, internet, postal) and other ICT services are penetrating further across Tanzania at the same time regulating operators to ensure fair and competitive environment.

TCRA releases quarterly reports to the public indicating the status of communication sector in Tanzania. Data shows that there is an increase of number of subscribers to mobile networks in each year between 2013 to 2016. From 24,7 million in 2013 raising to 40 million in 2016 as seen in figure 12 below.

Contrary, number of subscribers for a fixed network tends to decrease recently from 40 million, the highest peak in 2012 to less than 30 million in 2016. This shows that people in Tanzania just like many other parts of the world are migrating towards mobile world.

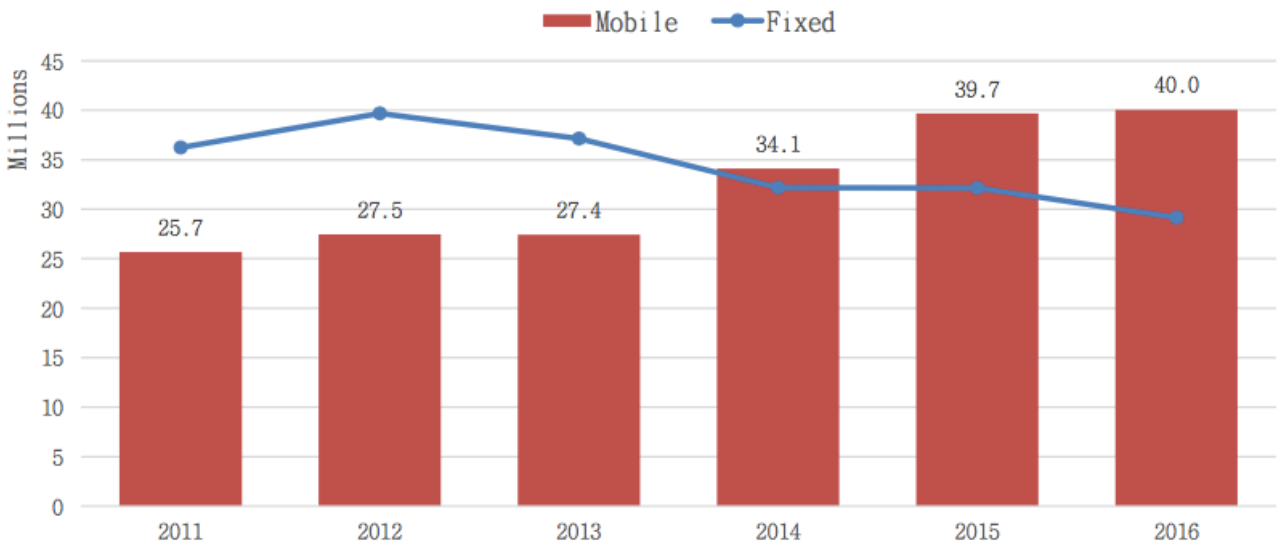

Figure 12: Subscription to Mobile and fixed Networks (Source: TCRA)

In terms of internet, both number of users and penetration rates have been increasing each year. Table 4 below shows the number of users by technology type between the year 2011 to 2016. As it can be observed, there were only just over 5 million internet users in 2011 but the number kept on increasing each year to almost 20 million users in 2016.

In terms of technology, again mobile wireless is taking bigger portion of users almost 91% of users in 2016.

Type of Service	2011	2012	2013	2014	2015	2016
Fixed Wireless	968.088	777.461	1.056.940	1.913.082	662.882	1.218.693
Mobile Wireless	3.665.680	6.031.323	7.493.823	11.320.031	16.280.943	18.014.358
Fixed Wired	677.450	712.095	761.508	984.198	319.698	629.474
Total	5.311.218	7.520.878	9.312.272	14.217.311	17.263.523	19.862.525
Penetration	12%	17%	21%	29%	34%	40%

Table 4: Estimated number of Internet users by technology type (Source: TCRA)

The penetration rate for the internet have been increasing each year in which it was only 12% in the year 2011 raising to 21% in 2013 and to 40% three years later in 2016 as seen in figure 13 below.

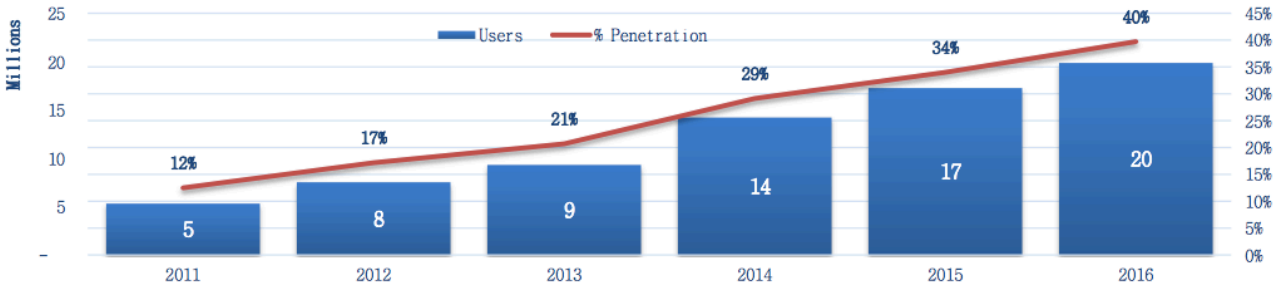

Figure 13: Trends of Internet Penetration (Source: TCRA)

In terms of ICT innovation that have been recently introduced to the public in Tanzania such as mobile money, a lot of Tanzanians have adopted to these new solutions. Up until July 2014, there were already over 14 million subscribers of mobile money, an ICT innovation that have been introduced very recently.

Figure 14 below illustrates the number of subscribers of mobile year for the whole year of 2016. Note that there is a huge increase of subscribers comparing to that of July 2014, reaching to over 18 million subscribers as of December 2016.

The improvement of communication sector in Tanzania is vital for future introduction of new ICT based solutions. TCRA together with other stakeholders of the government are working hard to ensure even more improvement in the coming years. Also, the adoption rate and readiness of Tanzanians in accepting innovative ICT solution is speeding up the diffusion of such innovations.

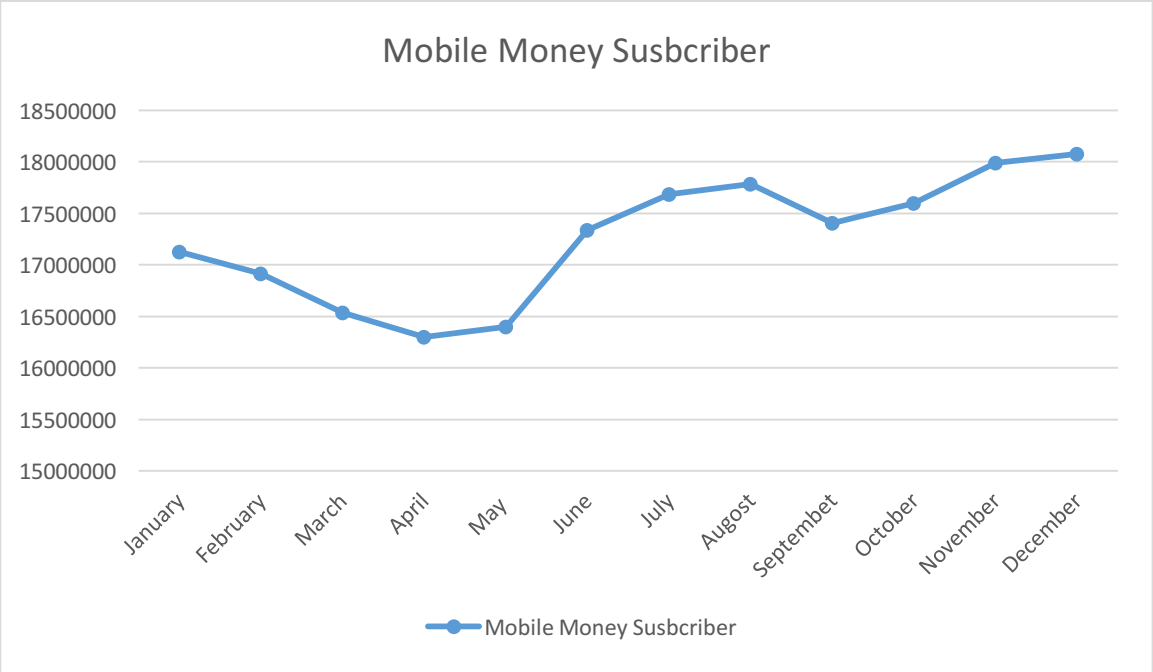

Figure 14: Mobile Money Subscribers (Source: TCRA, author)

As the proposed solution is ICT based and it requires mobile internet for its successful operation, such promising data from TCRA are proving to be vital for the application. Even the adoption rate and diffusion rate of other ICT innovations such a mobile money somehow shows how Tanzanians are open and supportive for innovative solutions and ideas.

4.4 Conclusion

In this chapter, state-of-the-art of both e-waste and ICT was presented. The chapter focused on literature review on e-waste projects and initiatives, policy and regulations and ICT status together with the adoption of other ICT solutions such as mobile money.

Next chapter will present the Zanzibar e-waste inventory analysis and mass-flow model. Both items are missing right now in Zanzibar as there is no statistical records of neither EEE nor WEEE in Zanzibar. Hence, author has prepared a separate chapter to present his efforts in estimating both EEE and WEEE together with mass-flow model.

Chapter 5: Inventory Analysis and Mass-flow model

This section will present the results obtained from analysing secondary data to estimate the amount of e-waste generated in Zanzibar annually. Author of this report noticed a lack of statistics that indicates amount of e-waste that is being generated in Zanzibar from all potential government e-waste authorities. As there is no special unit or department that regulates e-waste in Zanzibar, all other units such as Zanzibar Port Authority which imports both fresh and used EEE do not have records as they understandably don't feel the need to do so. Section 5.1 will present the e-waste baseline in Zanzibar which will focus on stakeholders and inventory analysis. Section 5.2 will present the mass-flow model that the author designed based on field observations and interviews.

5.1 E-waste Baseline (Stakeholders and Inventory)

In Zanzibar, the main stakeholders involved in dealing with EEE equipment from importation phase to disposal phase are categorised into 4 main groups. Stakeholders in each category are as shown in table 5 below.

Group	Stakeholder
Importation and Revenue Authorities	• Zanzibar Port Corporation (ZPC) • Zanzibar Revenue Board (ZRB) • Tanzania Revenue Authority (TRA)
Environmental bodies and Municipal Councils	• Environmental Department from Ministry of Environment (DoE) • Zanzibar Municipal Council (ZMC)
Distributors, retailers, dealers and consumers	• Importers of fresh and used EEE • Distributors of fresh and used EEE • Outlet owners of EEE shops • Consumers include government institutions and offices, companies,

	private households, universities, hospitals, others.
Refurbish and informal recyclers	• EEE technicians • Producers of other household material like cooking stoves

Table 5: E-waste Stakeholders in Zanzibar (Source: Author)

Currently, none of these stakeholders have taken any necessary measures to directly deal with electronic waste except for the informal recycling group. Informal recyclers collect the end of life EEE and extract the copper wires and metal substances only. The metal part is used to make other day to day household metal things such as cooking stoves and barbeque stoves as seen in figure 15 below.

Figure 15: Recycled E-waste from Informal Sector (Source: Field Picture)

From all the visited informal recycling centres, they have admitted that they are not aware of health and environmental effects of EEE. Recyclers are dealing with WEEE without any precautions and finally dispose the unneeded part of the waste in streets and landfills as seen in figure 16 below. Hence, the informal sector only scratches the recycling activities and creating even bigger problems for themselves (health-wise) and surrounding environment.

Figure 16: Disposed Unwanted EEE waste. (Source: Field Picture)

Other stakeholders seem to be involved with only matters that interest them. For example, ZPC only deal with the number of containers imported and exported without keeping track of how many of those containers were having EEE or other goods. This research considers ZPC as a WEEE stakeholder because it is the entry point of almost all the FEEE and UEEE.

Never the less, by analysing the data of imported and exported containers between year 2002 and 2014 from ZPC (see Appendix 2), it shows an increase of containers in most years. It is difficult to conclude that this increase of containers shows an increase of importation of EEE in Zanzibar

because the data doesn't specify what's inside of those containers but this data correlates with TRA data which shows an increase of value of EEE being imported in Zanzibar.

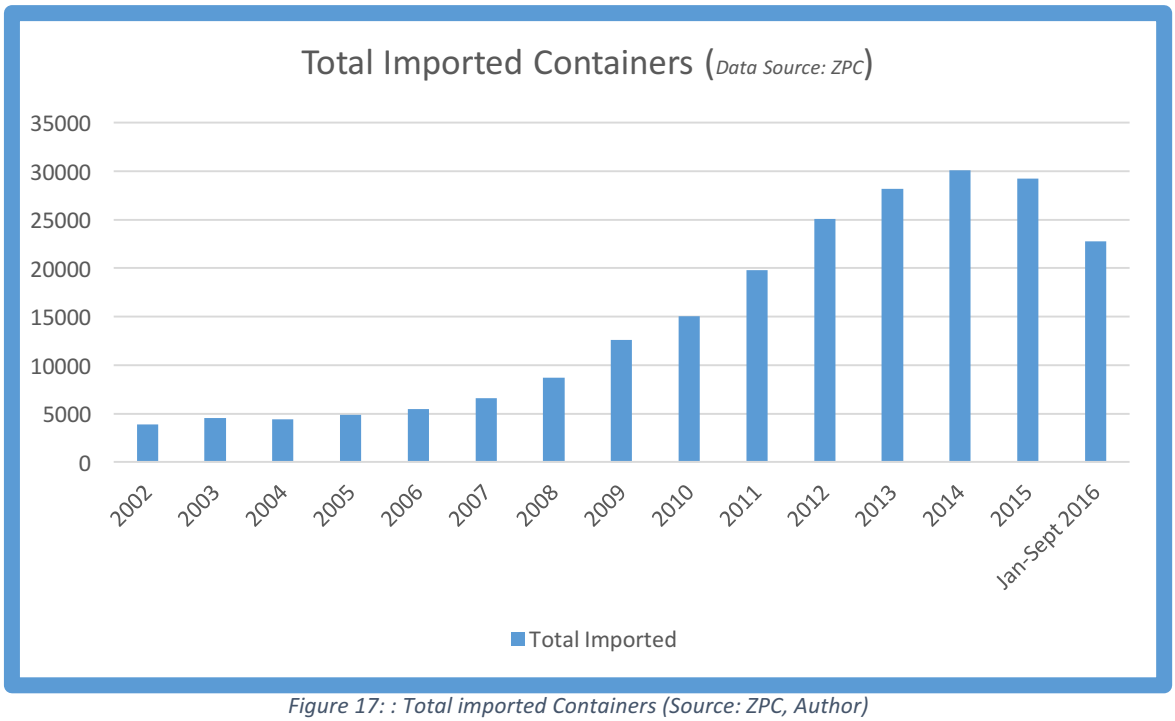

Figure 17: : Total imported Containers (Source: ZPC, Author)

TRA data that was provided between the year 2009 to 2014 shows the amount of money of each of the imported goods. Since the data files provided were too big to be attached in as appendix (more than 200 pages), author has prepared a summary of the data as seen in appendix 3 of this report. For the sake of this research, only EEE were filtered by the author from the given set of data. To limit the scope of data, only eight electrical and electronic equipment were selected by the author to get an insight of how much money have been invested by Zanzibar EEE importers. The selected EEE are computers, televisions, radios, printers and scanners, cookers, fridges, and mobile phones. Note that, TRA as a revenue body and an important WEEE stakeholder, focuses more the value of the stocks and amount of import duties to be charged.

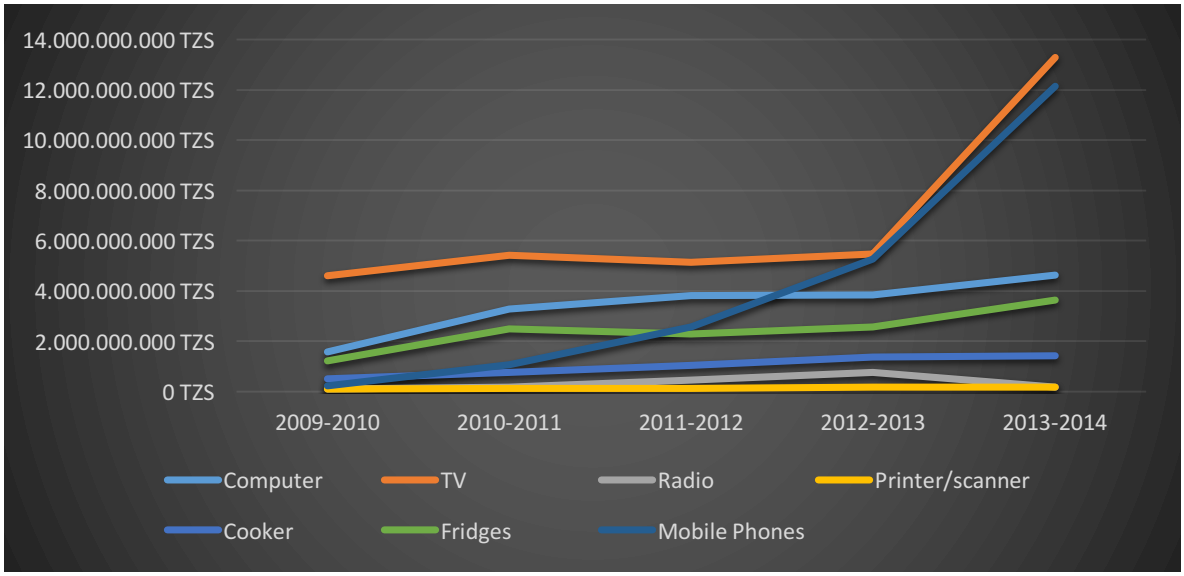

Figure 18: Money value of Imported EEE (Source: TRA, author)

Figure 18 above clearly shows an increase in money being invested in EEE between 2009 to 2014. For example computers, the author has observed just over 1.5 billion TZS was invested in 2009 and have increased each year reaching over 4.5 billion TZS by 2014. Mobile phones have increased from just quarter of a billion in 2009 to over 12 billion TZS by 2014. Imported value of televisions have raised dramatically to 13 billion in 2014 from just over 4 billion in 2009. By combining this set of data and the number of imported containers, one can argue that the importation of both fresh and used EEE have increased over the years.

The main finding of this research is that none of the above-mentioned stakeholders are keeping track of how many tonnes or pieces of EEE are entering the country. Revenue bodies are only dealing with tax and revenues, and port is much more concerned on number of all containers imported and exported. Therefore the author has used this secondary data from TRA as seen in appendix 3 to calculate and estimate annual importation of EEE in terms of pieces and weight in tonnes.

From the TRA data, the author found a way to estimate numbers of pieces of imported EEE annually. The approach to estimate number of pieces is based on annual value of money as seen in figure 18 above for the selected EEE and based on base price allocated by TRA as seen in table 6 below. The reason to calculate average price is because it is impossible to know how much of that money invested in importing the specific EEE per year was invested in buying new or used EEE.

Items	Used-Prices($)	New-Prices($)	Average Prices ($)
Television	15	100	57.5
Handset cell phone	10	30	20
Printer and scanner	10	20	15
Computer	50	180	115
Fridge	15	100	57.5
Cooker	20	50	35
Radio	10	30	20

Table 6: Base Prices of EEE (Source: TRA, author)

The following formula is used to estimate the number of pieces (Source: Author);

$$Estimated\ Annual\ Number\ of\ Pieces\ of\ Imported\ EEE\ = \frac{\text{Annual Value of Money of Imported EEE}}{\text{Average Base Price for New and Used}}$$

Based on the above formula, estimated number of television pieces being imported annually in Zanzibar is as follows (Source: Author):

$$Estimated\ Annual\ Number\ of\ Pieces\ of\ Imported\ \mathbf{TV}\ = \frac{\text{Annual Value of Money of Imported } \mathbf{TV}}{\text{Average Base Price for New and Used}}$$

Year	Money Value (TZS)	Money Value (USD)
2009-2010	4.601.949.486,90 TZS	$2.060.236,15
2010-2011	5.414.465.123,40 TZS	$2.423.989,40
2011-2012	5.143.461.306,00 TZS	$2.302.664,33
2012-2013	5.475.200.601,60 TZS	$2.451.179,93
2013-2014	13.282.253.583,60 TZS	$5.946.301,47

Table 7: Imported Money Value of Television (USD-TSH rate =2233,70 based on 25th March 2017 rate from Google), (Source: Author)

$$Estimated\ Annual\ Number\ of\ Pieces\ of\ Imported\ \mathbf{TV}\ for\ the\ year\ \mathbf{2009-2010}$$

$$= \frac{2.060.236,15}{57,5} = 35.830,19$$

Therefore, an estimated number of pieces for the 2009-2010 was around 35.830 pieces. Using the above procedure, estimated number of TV pieces between the 2009 to 2004 is as shown in table 8 below.

Year	Estimated Number of TV Pieces Imported
2009-2010	35830
2010-2011	42156
2011-2012	40046
2012-2013	42629
2013-2014	103414

Table 8: Estimated Number of Imported TV pieces (Source: Author)

Again, using the above procedure to calculate estimated number of imported computer, radio, cooker, printer and scanners, fridge and mobile phone and is summarized in the table 9 below.

Year	Computer	Fridge	Radio	Cooker	Printer & Scanners	Mobile Phones
2009-2010	6129	9360,08	22867	6316	2710	5130
2010-2011	12734	19352,29	3997	9665	3681	23477
2011-2012	14796	17732,23	9847	13384	3514	57246
2012-2013	14958	19957,70	16728	17475	5102	117549
2013-2014	18010	28229,39	3639	18201	5093	271918

Table 9: Estimated Number of EEE. (Source: Author)

From the figure 19 below it shows that all the selected EEE equipment are increasing in terms of pieces except for radios. Note that it is just an estimated number of pieces, the prices of the selected EEE are probably increasing every year but this research have used the latest prices (2017) provided by TRA.

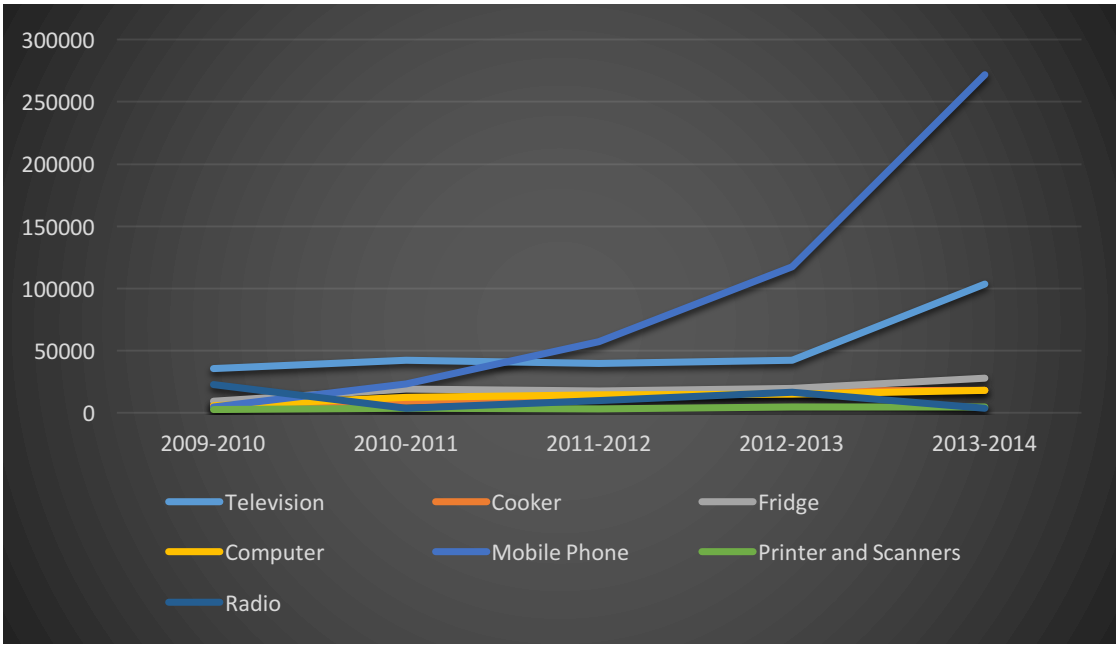

Figure 19: Estimated Number of Imported EEE (Source: Author)

Using the number of pieces imported annually, it can be used to estimate number of tonnes of those selected EEE by using average weight of EEE. The average weight of the selected EEE are as seen in table 10 below. Note that using the TRA data, it doesn't specify desktop or laptop instead it considers both as computers. Therefore; to estimate weight of computer, average weight of laptop and desktop computers is calculated by the author.

Items	Average Weight - Kg
Television	31,6
Handset cell phone	0,1
Printer and scanner	6,5
Computer	9,9 Desktop, 3,5 Laptop (Average 6,7)
Fridge	35
Cooker	46
Radio	2

Table 10: Average Weight of EEE (Source: http://ewasteguide.info/weight)

Table 11 below shows the estimated weight in tonnes of the selected EEE annually. It can be visually observed in figure 20 that all EEE are increasing every year except for radio. A good argument for the reduction of radio importation in recent year is because of changing culture of current generation. Current generation are less interested in radio and have shifted their focus to mobile and personal computers.

	Television	Computer	Cooker	Printers and Scanners	Radio	Fridge	Mobile Phone
2009-2010	1132,23	41,06	290,52	17,61	4,57	327,60	0,51
2010-2011	1332,14	85,32	444,58	23,93	7,99	677,33	2,35
2011-2012	1265,46	99,14	615,65	22,84	19,69	620,63	5,72
2012-2013	1347,08	100,22	803,83	33,17	33,46	698,52	11,75
2013-2014	3267,88	120,67	837,25	33,10	7,28	988,03	27,19

Table 11: Estimated amount of imported EEE in tonnes (Source: Author)

All other EEE are increasing almost every year and some are increasing by more than 100% every year. For example, Television in 2012-2013 only 1347 tonnes were imported compared to 3267 tonnes in 2013-2014.

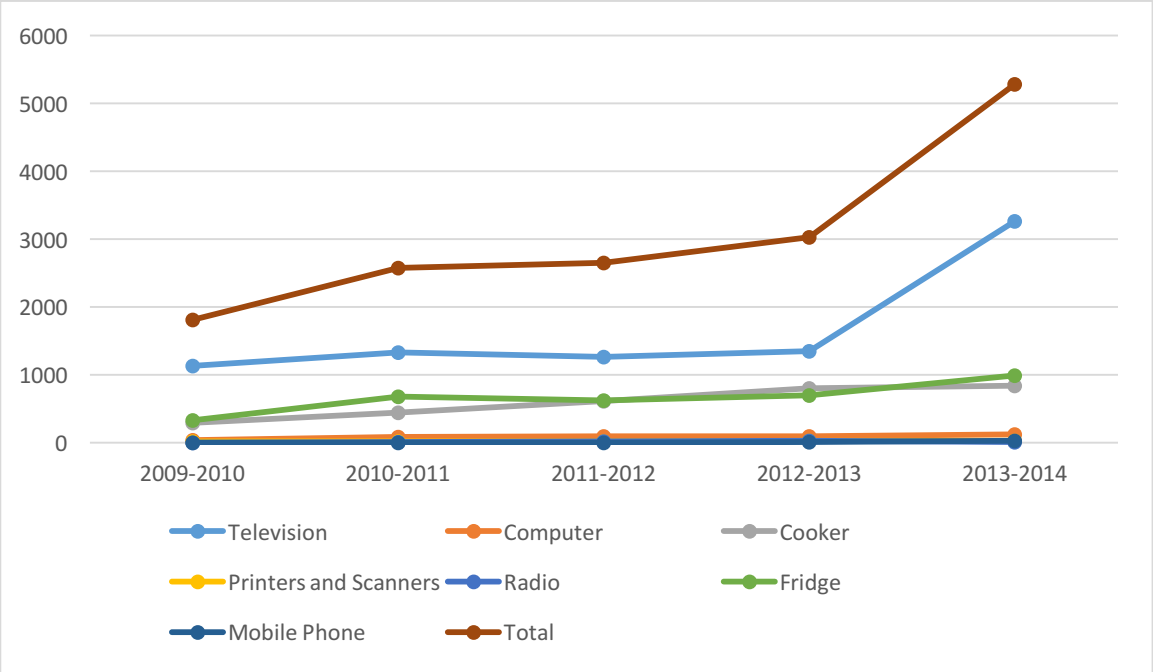

Figure 20: Weight of Imported EEE in tonnes (Source: Author)

Note that the sudden rise of mobile phones has raised exponentially from 11,75 tonnes in 2012-2013 to 27,19 tonnes in 2013-2014. This is due to the growing demand of mobile phones and the improvement of mobile networks as discussed in previous chapter of this report.

A total of over 5200 tonnes of EEE have been imported in 2013-2014 compared to just over 3000 tonnes in previous year (2012-2013). It is uncertain how many percent of the imported EEE became waste at the end of the year. But let's assume only 10% of the imported EEE becomes waste, it means Zanzibar have added 520 tonnes of e-waste in the year 2013 only. These 520 tonnes and all the other electronic waste from previous year are dangerously disposed at home, streets and informal landfills.

5.2 Zanzibar E-waste mass flow

Zanzibar e-waste mass flow model is composed of five phases; importation, distribution, consume, refurbishment and recycling, and disposal and auctioning. Major finding of this mass flow model is that most of the imported EEE have no means to be properly disposed. Another finding is that the first three phases and the last phase are very active compared to the fourth phase.

Meaning to say, more EEE both fresh and used are entering the country and demand is increasing every day with a very slow refurbishing and recycling phase letting most of the EEE to be disposed in informal landfills, streets and some are just kept at home. Very small amount of WEEE is being auctioned to the informal recyclers. It's a very small amount because recyclers have very poor facilities to handle the waste, hence they work on very small scale.

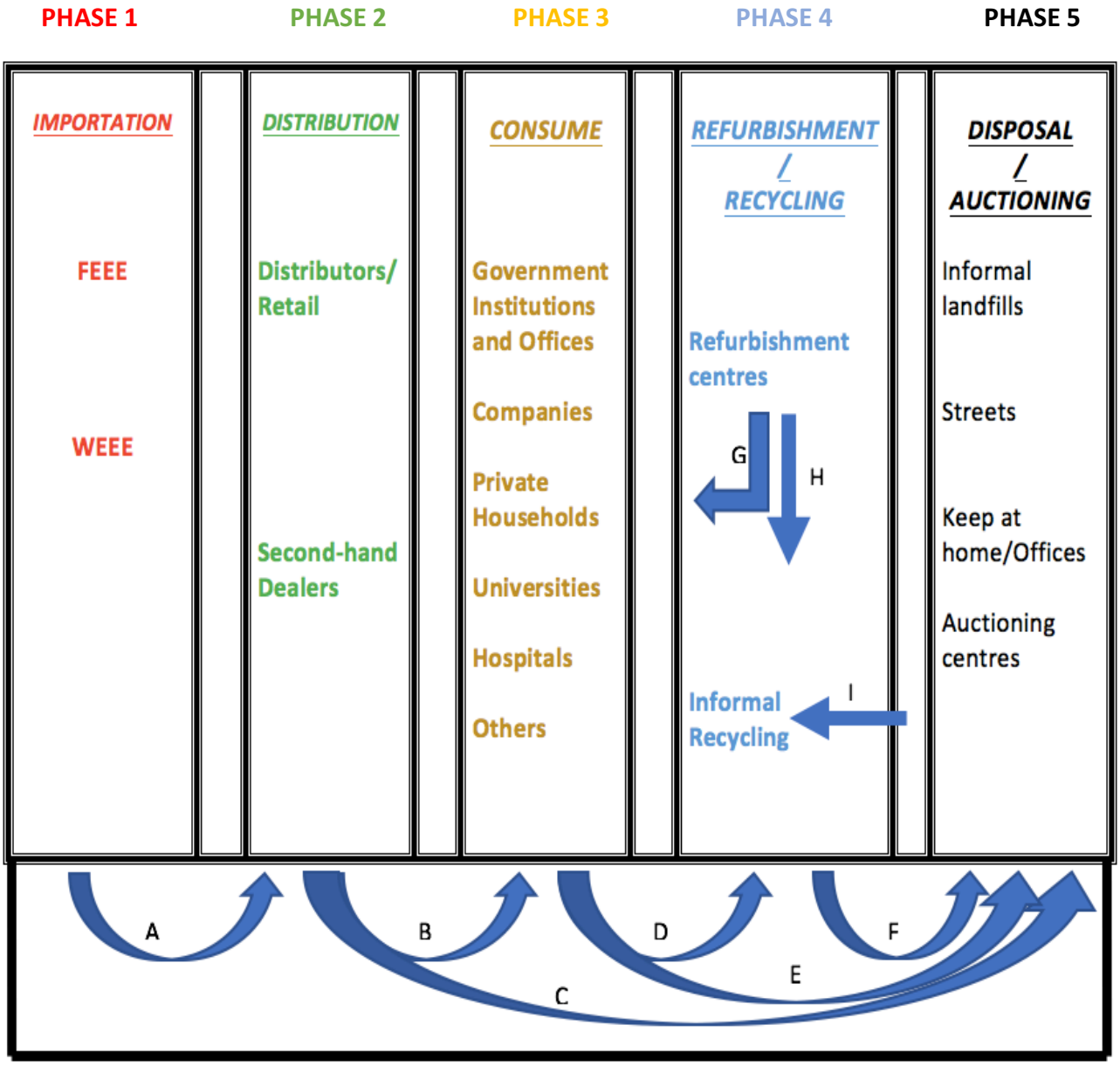

Figure 21: Zanzibar e-waste Mass flow model. (Source: Author)

Figure 21 above clearly illustrates the e-waste mass flow model of Zanzibar. The phases included are as follows:

- Phase 1: This is the importation phase. In Zanzibar, both fresh and used EEE are of great demand as both mobile networks and other services are penetrating further to rural areas. Therefore, more importers of EEE have emerged. Due to financial situation of the individuals here in Zanzibar, second hand products have been the favourite as they can get them for cheaper prices compared to the new ones. Arrow A shows the movement of all the imported EEE to the distribution phase.

- Phase 2: In distribution phase, two more categories are defined. Distributors who are dealing with new or fresh EEE and those who are dealing with used or second hand EEE. Data from Zanzibar Statisticians Office shows there are total of 157 shops most of them in Zanzibar Urban Region dealing with second hand products. The demand of new EEE is still there especially for the Chinese brands where one can get new products for way cheaper price. Arrow B shows the movement of EEE from distributors to the consumers who are buying or getting those EEE. For the second-hand goods, sometimes the imported EEE are way old and almost have reached or have already reached end of their life and therefore instead of being sent to consumers it is directly sent to auctioning centres for the informal recyclers to bid on it as shown is arrow C.

- Phase 3: Consume phase list down all users of those EEEs. All the listed consumers in figure 21 above are consuming the EEE and once the devices fail by some faults there are two ways. Arrow D shows the consumers sends the EEE to refurbishment centres to be repaired and reused. Arrow E shows consumer chooses one the listed options to dispose the EEE.

- Phase 4:in phase 4, it depends on the condition of EEE. If it is repairable, then it might be repaired and brought back to consumer as indicated by arrow G. If not repairable, then it will either be sent to informal recyclers as indicated by arrow H or it will be disposed indicated by arrow F.

- Phase 5: Disposal is the last phase of EEE in this mass-flow model. Here the waste is mostly disposed in streets, landfills, kept at home and offices or being auctioned back to informal recyclers.

5.3 Conclusion

Conclusively, author used section 5.1 to estimate annual importation of EEE in terms of pieces and weight in tonnes in Zanzibar. Results shows that the importation of EEE increasing every year in Zanzibar with some of the equipment increasing by number of folds such as mobile phones and TVs. Author estimated only 10% of total annual imported EEE becomes waste by the end of the year making it over 500 tonnes of WEEE was generated in 2014 only. Combining with WEEE that was generated in previous years and that will be generated for as long as no any handling and disposal of e-waste is taking place, this is quite a threatening data and therefore most of this waste is accumulated in landfills and streets. Section 5.2 presented the mass-flow model of the e-waste in Zanzibar archiving one of the objective of this research.

Next chapter will discuss the data collection, presentation and analysis.

Chapter 6: Data Collection, Presentation and Analysis

After getting a deep understanding of the e-waste situation in Zanzibar and all the supporting literature from chapter 1 to chapter 5, in this chapter all data that were collected as mentioned in chapter 3 in methodology section are going to be presented and analysed. Section 6.1 will present the data collection plan. Section 6.2 will focus on how the questionnaire that was used for data collection was designed and the sample space of the research. Section 6.1 will also present the feedback obtained from the questionnaires focusing on both two theories; Roger's Diffusion Theory to analyse the adoption from the innovation perspective and Theory of Planned Behaviour to analyse the adoption from the individual perspective focusing on consumer's intention. Section 6.2 will present the feedback from interview conducted between the author and potential e-waste stakeholder in Zanzibar. The interview was mainly focusing on the stakeholder's involvement in the e-waste sector and share their view on which e-waste business model will fit best for Zanzibar context. Last section of this chapter; Section 6.3 will present the insight from field trips to informal recycling centres in Zanzibar town and some of the affected e-waste areas around the city.

6.1 Data Collection Plan

Based on research objectives, this research is divided into four (4) main parts as seen from the theoretical framework. Each part will be evaluated using specific methodology as seen from the methodology framework. Four parts are:

PART 1: Consumer's willingness on adopting an ICT solution and diffusion of ICT solution
PART 2: Status of e-waste
PART 3: Minimizing transaction cost using ICT solution
PART 4: E-waste business model

PART 1:

To measure consumer's willingness, consider the following illustration that consist of three entities in the proposed collection strategy using mobile application (ICT).

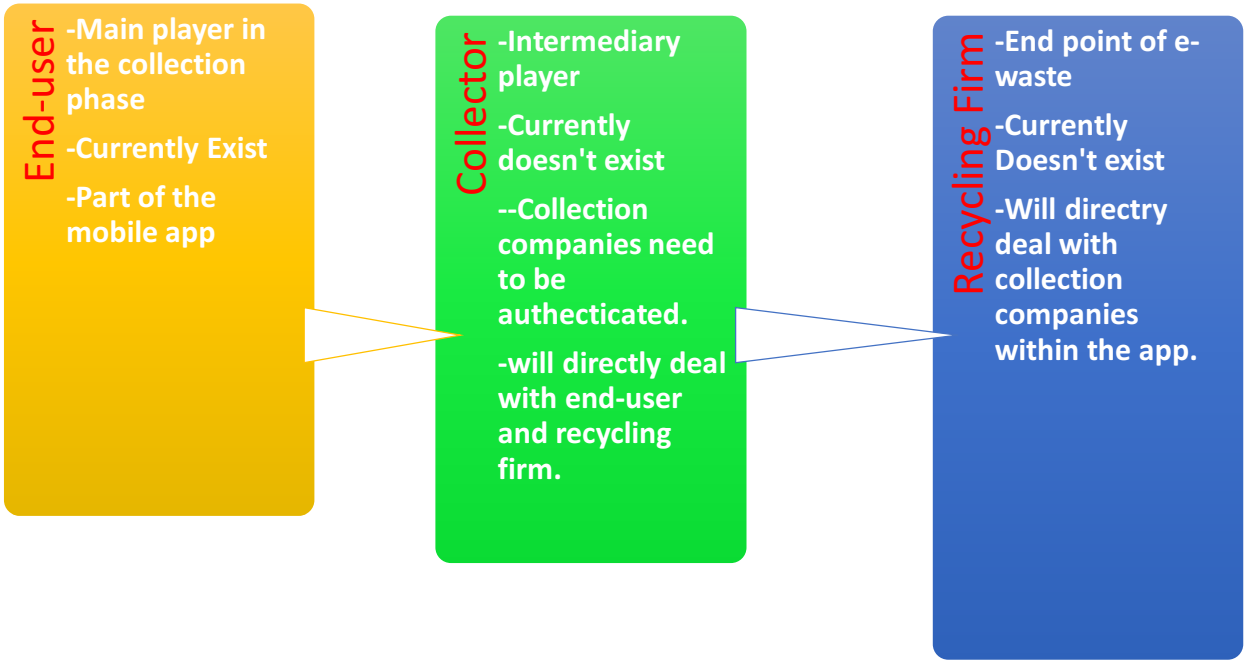

Figure 22: E-waste Actors (Source: Author)

In assessing consumer's willingness, the focus is on:

1. In supporting the collection phase of e-waste, hence consumer's intention towards the behaviour of using mobile application to sell e-waste (Theory of Planned Behaviour-TPB)
2. The adoption rate and the diffusion of the proposed innovation [solution] to end-user. (Roger's Diffusion Theory-RDT)

To archive focus area 1 and 2, a set of questionnaire was developed based on both respective theories, TPB and RDT). The questionnaire was distributed to end-users from urban region of Zanzibar.

PART 2:

Status of e-waste was analysed via field observation and secondary data from the various government institutions and informal e-waste recycling sector.

PART 3:

In minimizing transaction cost using ICT, which is mobile application. In designing the mobile application, focus on the functionality of the application was to reduce various transaction cost such as search cost, contracting cost, logistic costs, etc.

PART 4:

Finally, a literature review method and interviews was used to evaluate all three business models, their characteristics, advantages and dis-advantages. The following business models were reviewed:

- Public-Private Partnership
- Conventional Business Model
- Extended Producer Responsibility (EPR)

The following stakeholders were interviewed to give a feedback on the desired business model in Zanzibar:

- TRA – Tanzania Revenue Authority
- ZRB- Zanzibar Revenue Board
- ZMC – Zanzibar Municipal Council
- TCRA – Tanzania Communication Regulatory Authority
- DoE – Department of Environment
- ZPC – Zanzibar Port Corporation
- ZBS – Zanzibar Bureau of Standards
- COSTECH – Commission of Science and Technology
- PPP- Public Private Partnership

6.2 Questionnaire

One part of this research is to analyse the adoption rate of the proposed ICT solution (mobile application platform for selling e-waste all the way to recyclers) from the innovation perspective and from individual perspective (consumer's intention towards the behaviour). Hence, two theories were selected; Roger's Diffusion Theory and Theory of Planned behaviour respectively. The

questionnaire was developed based on variable that defines each of the pre-mentioned theories as seen in table 12 below.

The questionnaire will have three parts:

Part 1	Demographic Details • Age • Gender • Ethnicity • Education level • Status in a family (father, mother, child, etc.)
Part 2	Theory of Planned Behaviour **(Note: only using direct measures)** • Attitude • Perceived norm • Behavioural control • Intention

Part 3	Roger's Diffusion Theory
	• Attributes of Innovation
	  ○ Relative advantage
	  ○ Compatibility
	  ○ Complexity
	  ○ Trialability
	  ○ Observability
	• Innovation-decision
	• Communication channels
	• Nature of the social system
	• Extent of change agent

Table 12: Questionnaire Section

NOTE:

- Only direct measure of the TPB are included in the questionnaire due to time and resource limitations and to avoid developing very long questionnaire as RDT is also part of the questionnaire and it have number of variables too.

6.2.1 Sample Space

The research has focused in distributing 400 questionnaires to get a feedback on consumer's intention and adoption rate from innovation perspective. Unguja being the main island is composed of three regions. Urban/west region, north region and south region. Due to lack of resources both time-wise and financial-wise, only 4 streets from the urban/west region were carefully selected as part of the research sample space.

Figure 23: Zanzibar (Source: http://www.worldatlas.com)

The main reason of selecting Urban/West region is because of its nature of having a mixture of people from different part of the Zanzibar as it is the capital of the islands. The selected streets are

Kilimani, Chukwani, Vikokotoni and Mikunguni. Each of these streets were selected due to its unique characteristics as follows:

- Chukwani: medium-high income individuals
- Vikokotoni: active second hand shopping street
- Mikunguni: active informal recycling and low-income individuals
- Kilimani: medium income individuals

Income distribution is important as they reflect the habits of purchasing either new or used electronic and it was important for the research to get a feedback of adopting the proposed innovation from low, medium and high income individuals. It was interesting to observe a feedback from high income individuals that they are willing to sell their WEEE for very small income. A total of 400 questionnaires were distributed in those 4 streets, 100 questionnaires from each street.

Demographic Details

From the 400 questionnaires distributed around 4 streets equally (100 questionnaire for each street), the first part of the questionnaire focused on demographical details. From the feedback, 50.3% of the respondents were male while 49.7% were females. It was just a coincidence to have an equal ratio between genders. Regarding age categories, 3 categories were used as seen in figure 24 below.

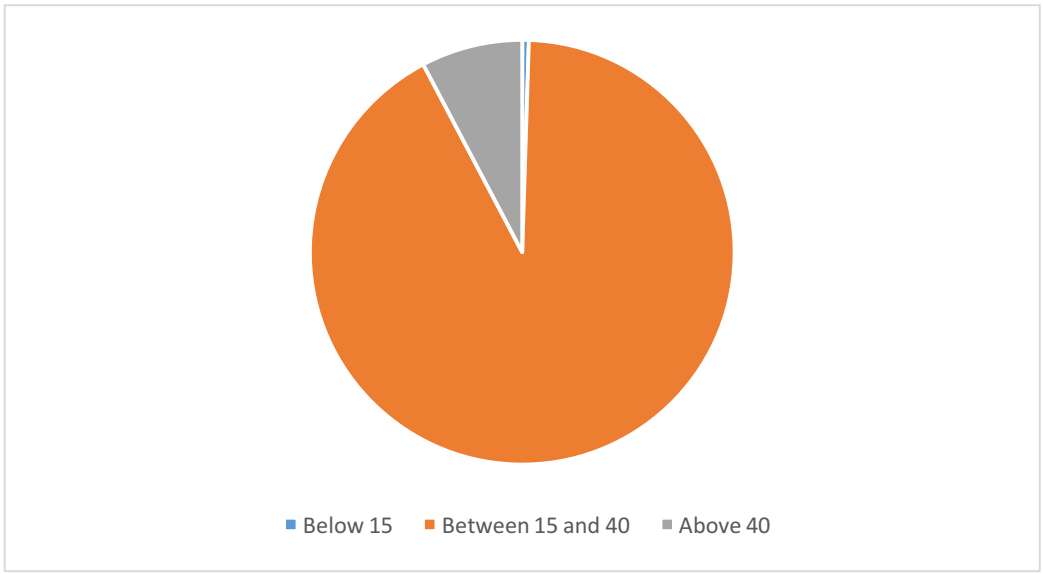

Figure 24: Age Feedback of the Respondent

Important note from the demographical feedback, is the ownership of smartphones as it will support the proposed idea of mobile application platform. If, less people own smartphone then the application will lack the device support and hence might hinder its operations. On other side, if more people own the smartphone devices then it shows more people have the capability to install and use the proposed mobile application. Feedback shows that 89% owned smartphone while only 11% did not own a smartphone.

With a mix of educational background from the respondents as seen in figure 25 below, higher percent (49.4%) of the respondents said they own between 5 and 10 EEE in their households which is quite a lot considering the number of households in Zanzibar. This data reflects the increasing demand for EEE in Zanzibar as shown in chapter 5 of this report.

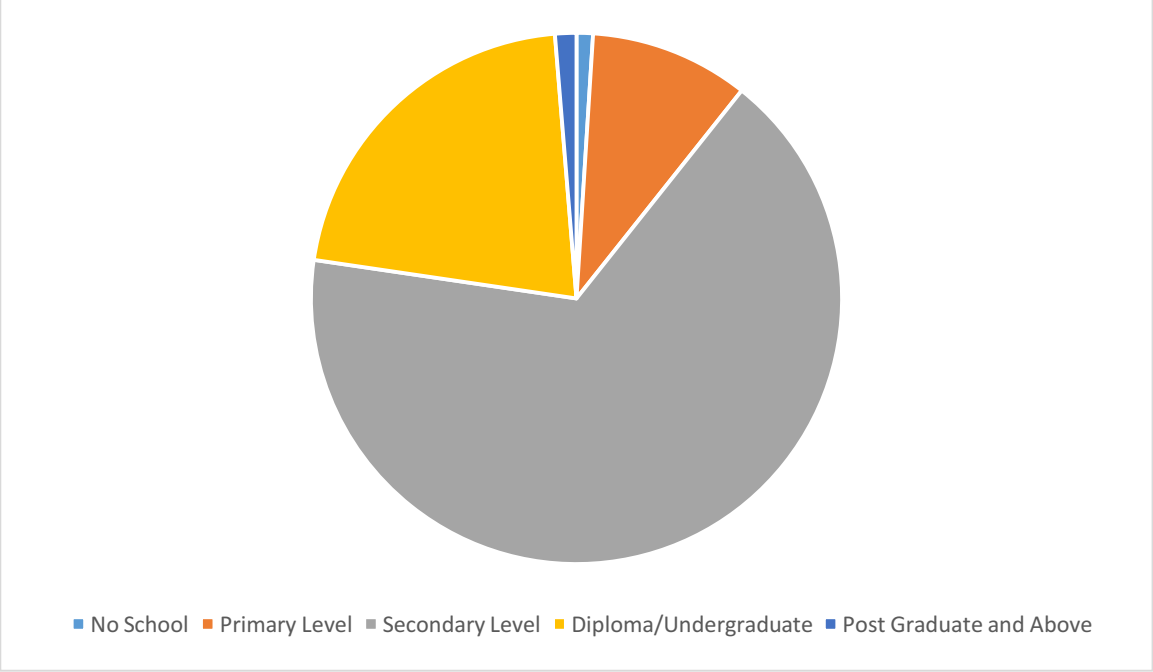

Figure 25: Education Feedback of the Respondents

6.2.2 Consumer's Intention towards the behaviour

In this section, an analysis of the feedback obtained from the 400 questionnaires distributed across 4 streets will be analysed. The analysis of this section will cover section 2 of the questionnaire which focused on examining consumer's perception and willingness to support the collection phase of e-

waste, hence measuring consumer's intention towards the behaviour of using mobile application to sell e-waste using Theory of Planned Behaviour (TPB).

As the TPB model suggests, the behaviour is influenced by the intention which in turn is influenced by attitude, subjective norm and perceived behavioural control. Hence, the author will first examine the three attributes (attitude, subjective norm and perceived behavioural control). Which of these three variables is having higher mean hence higher contribution towards positive intention of adopting the behaviour. Table 13 below represents averages for all three variables.

	ATTITUDE	SUBJECTIVE NORM	BEHAVIORAL CONTROL
Mean	6.9729	6.8434	6.3669
N	397	386	393
Std. Deviation	.14561	.49420	.77960

Table 13: Average of Dependent Variables of TPB

In a scale of 1 to 7, an average of 6.9729 was obtained for attitudes marking a very positive attitude from the respondents. All questions that were asked in the attitude category were accessing the attitude of the respondents towards the proposed behaviour. Likewise, an excellent feedback was obtained from subjective norm category of 6.8434. Finally, an average of 6.3669 for behavioural control, lowest among the other variables but still an excellent feedback.

With all three variables are having a mean of higher than 6, indicates that the respondents are having a very positive attitude towards the behaviour, the respondents also believe the society are expecting them to adopt to the behaviour and finally the respondents are very confident in both controllability of the behaviour and self-efficacy towards the behaviour.

In measuring the consumer's intention, an average from the intention is calculated. "This is a proxy measure for behaviour. It represents a person's motivation in the sense of her or his conscious plan or decision to perform certain behaviour (Conner & Armitage, 1998). Generally, the strong the intention is, the more likely the behaviour will be performed."(Minnesota State University, n.d.) In

terms of intention as the model suggests in figure 4, the average intention observed from the feedback of the respondents was 6.895 as seen in table 14 below.

INTENTION		
Mean	N	Std. Deviation
6.8950	397	.45494

Table 14: Average Intention

This is quite an excellent feedback noting that respondents are ready with a very positive intention to adopt towards the proposed behaviour of using a mobile application to sell their e-waste.

6.2.3 Adoption rate of the Proposed Innovation and Diffusion of Innovation

In this section, the author will present descriptive analysis obtained from part 3 of the questionnaire which was focusing on diffusion rate of the proposed innovation using Roger's diffusion theory.

The descriptive analysis of the theory is based on mean calculation for the 5 attributes of innovation. As Roger himself explained in his innovation book, " Nevertheless, an ideal research design would actually measure the attributes of innovations at t1 in order to predict the rate of adoption for these innovations at *t2* (Tornatzky and Klein, 1981)." (Rogers, 1983). Hence, in this research, the author will analyse the 5 attributes as depicted in figure 26 below to predict the rate of adoption of the proposed mobile platform as innovative solution.

For each respondent, an average is calculated for each attribute. Then an average of the averages from the attribute is calculated, which in this case will present a rate of adoption for each respondent. Finally, an average rate of adoption is calculated which will present the final rate of adoption for the proposed innovation.

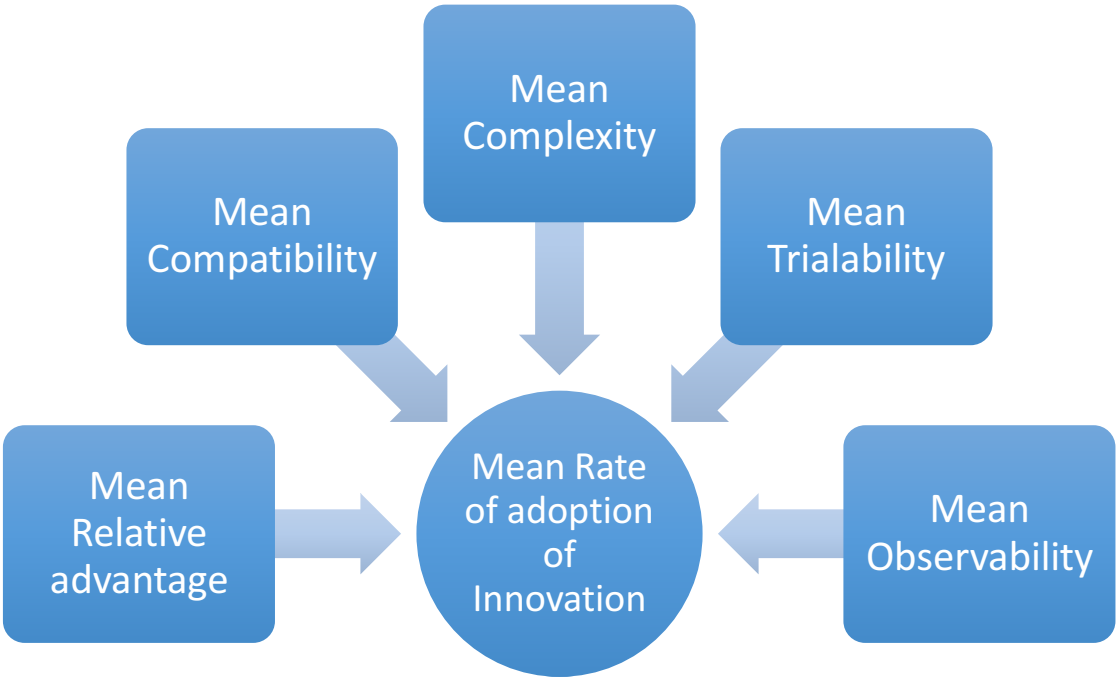

Figure 26: Attributes of Innovation

As a Likert-scale from 1 to 7 was used, any number higher than 4 indicates a positives rate of adoption and less than 4 indicates negative rate of adoption.

After analysis, the following results were obtained:

Statistics

AVERAGE RATE OF ADOPTION OF INNOVATION

N	Valid	390
	Missing	10
Mean		6.9228
Median		7.0000
Std. Deviation		.23562
Range		1.67
Minimum		5.33
Maximum		7.00

Table 15: Adoption rate of Innovation

From table 15 above, with an average of 6.9228 it predicts an excellent rate adoption of the proposed mobile application to sell e-waste.

Other aspects of the theory as seen figure 5 above is used to get an insight of the nature of the preferred communication channels, nature of the social system, and the preferred opinion leaders and the innovation-decision process that will help faster diffusion rate of the proposed innovation.

From the feedback obtained, regarding the communication channel deciding between interpersonal or mass media, respondents chose interpersonal with an average of 6.81 highest compared to any other communication channel as seen in table 16 below. This directly reflects to the nature of the island, a very small island where people have a culture of sitting together in families and in streets (famously known as barza - translates to sitting spots) as a symbol of unity and culture.

	TELEVISION	RADIO	IM APPS	SOCIAL MEDIA	SMS	NEWSPAPER
Mean	6.66	6.17	5.83	6.17	6.19	4.61
N	398	397	396	398	397	397
Std. Deviation	.868	1.520	2.017	1.852	1.471	2.453

Table 16: Average of Mass-Media

The communication channel feedback also correlates with opinion leader feedback as seen in table 17 below. Respondents were asked to rate how often they talk and discuss about new innovation with the listed leaders. Again, due to the nature of the culture, head of family has a highest mean in frequencies of obtaining information of new innovations.

	HEAD OF FAMILY	LOCAL LEADER	LOCAL COUNSELOR	RELIGIOUS LEADER	CHARISMATIC LEADER
Mean	6.78	4.04	3.59	3.77	3.94
N	398	397	398	395	398
Std. Deviation	.891	2.513	2.584	2.604	2.544

Table 17: Average of Opinion Leaders

Finally, three innovation-decision option were presented to the respondent, in which they preferred optional decision and collective decision with an average of 6.96 and 6.77 respectively. This feedback also correlates with other feedback with a sense of “unity” and “togetherness” within the communities.

6.3 Interviews

In this section, the feedback from the interview conducted by the author to potential e-waste stakeholders is presented. All interviews were physically conducted in their respective offices. The interview focused on getting feedback on potential stakeholder's involvement in e-waste problem in Zanzibar and receiving feedback on which e-waste business model will fit best in Zanzibar context. The following are the feedback obtained from each stakeholder listed below:

6.3.1 Tanzania Communication Regulatory Authority (TCRA):

Tanzania Communication Regulatory Authority, TCRA have been one of the front liner's in rising awareness of e-waste problem in Tanzania. On its effort to reduce the importation of below standard mobile phones, last year it has decided to switch off or deactivate all fake mobile phone in Tanzania. The thousands of switched off phones are eventually still in streets meaning that it has increased the e-waste though there are on-going plans from TCRA to collect and probably destroy them.

Regarding the business model, TCRA have pointed out that environmental projects that follow PPP model normally receive support from the government due to its nature in making the environment of its citizens safer and cleaner. If PPP model is going to be the selected model, then both the public and private parties should act responsibly to ensure sustainable and viable business and having cleaner environment.

Regarding the conventional model, TCRA's feedback was highlighting the fact that only smart investors, who can detect the opportunity from e-waste will grab the opportunity, hence there is a risk of receiving poor support from investors.

Commenting on Extended Producer Responsibility (EPR), TCRA have pointed out the problem of continuous importation of used electronics and therefore loosing track of ownership of specific device due to exchange of ownership that arises from the dealing with second hand goods. Usually it implementing EPR, the producer or Producer Responsibility Organisations (PROs) need to collect

the waste of an EEE that was sold within the country by the producer or via agents. In second hand business, those EEE are coming from abroad and by the time the consumer is buying the used item here in Zanzibar, the producer is totally unaware of it. Another issue of EPR is that there is a possibility of importing unauthentic EEE and its waste won't be accepted by the producer or PROs and therefore part of the e-waste problem in Zanzibar will remain unsolved.

6.3.2 Zanzibar Revenue Board (ZRB):

Zanzibar Revenue Board have straight away ruled out Conventional Business Model as they believe it will be dangerously operated. They pointed out that e-waste business is not like any other business as it might cause threatening effects if it will not be properly operated. Their concern is that, if a private investor will be the sole operator of this business, investor's focus might be to maximize profits and might not take the working environment and the health conditions of his employees seriously.

Having said so, they believe Public Private Partnership (PPP) will therefore be a perfect fit in safeguarding occupational safety and viable business. The involvement of Government in this business it means it will make sure that the working environment are safe and all safety precautions for the employees are been taken seriously. On the other side, the private sector will focus on managing the business and ensuring sustainable income. This is not a division of responsibilities but the orientation of perspectives for both public and private parties that will work together in e-waste business.

Finally, EPR somehow received a good feedback from ZRB as they believe by having PROs in Zanzibar will lift the responsibility and risk from both government and investors. PROs will collect the waste on behalf of their member producers and therefore it will be conducted more efficiently and more seriously and of course as a revenue body they didn't forget that the PROs should pay taxes.

6.3.3 Zanzibar Port Cooperation (ZPC):

Zanzibar Port Corporation (ZPC), have first made it clear that as a port authority they only work on number of containers being imported and exported in Zanzibar regardless of what is in those

containers. Therefore, they are not aware of how many tonnes or containers of EEE are imported in Zanzibar. They know in total; the number of containers being imported as shown in appendix 2. Even though their focus is not in EEE importation statistics but they are aware that African countries are victims of e-waste globally. Zanzibar is not an exception; they are aware that there might be huge stocks of EEE and used EEE coming in Zanzibar.

Regarding the business model, ZPC have preferred PPP but on one condition; that both public and private sector should act accordingly and responsibly to avoid any failure of this prosperous project. If there is no guarantee of that, then conventional business model might be productive.

EPR was not recommended at all due to the same reason as mentioned by other stakeholders above; the issue of second hand good importation and fake products. ZPC even pointed out that most of the EEE products being sold in Zanzibar are without any warranty contracts from the dealers which means most of the dealers do not have direct transactions with the producers.

6.3.4 Commission of Science and Technology (COSTECH):

Commission of Science and Technology, COSTECH have been working very hard and closely with supporting youth in terms of identifying ICT business opportunities in Tanzania. They are very much impressed on how the researcher who is Tanzanian have managed to innovate ICT solution that will boost and support e-waste business opportunities in Zanzibar that will eventually produce number of job opportunities. As Science and Technology have led to increase the demand of EEE such as mobile phones, laptops, and even more advanced washing machines, TVs and so on, COSTECH are very handy stakeholder of e-waste in Zanzibar.

From their feedback, conventional business model has been favourite as it encourages self-employment as long as funding are available. Apart from funding which is of course a big problem, lack of need technological knowledge to run the recycling facility might be another obstacle towards conventional e-waste business model.

Due to these shortcomings, they suggested EPR to be better option compared to conventional because the PROs or the producers might not face challenges in terms of funds and the needed technical knowledge. But COSTECH have thought that a policy will be needed to make EPR possible. The policy should be established and implemented and it will be important to note that each company that is importing its EEE in Zanzibar should clean. Due to the nature of EEE market in Zanzibar, most of the dealers are not directly buying from producers, this policy might be hard to both initiate and implement. For example, you can find products from producers like SONY and HITACHI in Zanzibar without necessarily having local agents.

PPP might not be having all the above-mentioned shortcomings from both conventional and EPR as it won't be short of funds if they will believe it is for the sake of public benefits and it won't be having difficulty in searching for the needed technical knowledge but it should make sure that each party is doing what it is supposed to do for a mutual benefit.

6.3.5 Zanzibar Municipal Council (ZMC):

Zanzibar Municipal Council, ZMC have admitted that currently there is no any initiative from ZMC in terms of disposing, collecting and recycling e-waste in Zanzibar. ZMC are currently working on domestic waste only. Because there is no any strategy of separating waste from household level, all waste ends up in the same landfill and is considered as waste in general. ZMC admitted of finding a lot of EEE in the landfills and is hoping that a proper authority to be identified and given the responsibility of e-waste in Zanzibar.

Regarding the business models, ZMC have recommended conventional business model as they believe it will be more effective as investor will look forward to sustain his business and therefore reducing e-waste in Zanzibar. EPR business model didn't receive good feedback from ZMC due to the increasing importation of used electronics in Zanzibar.

PPP business model will be a successful business model but the facilities should hire qualified and competent personnel and both parties should have full sense of ownership.

6.3.6 Department of Environment (DoE):

Department of Environment which is under Ministry of Environment of Revolutionary Government of Zanzibar have been working and looking for a solution to the e-waste problem in Zanzibar. It has conducted two researches in Zanzibar in 2010 and 2014 as explained in chapter 4 of this report. DoE are very excited and impressed with the proposed solution from this project.

DoE have suggested PPP is better option because it is self-sustainable. From the investment perspective, it is safer to partner with public sector to reduce the business risks. As for the EPR business model, it is more of a regulation level otherwise the model will not function. Imposing regulation to producers, which are not that many who have local agents here in Zanzibar might not be as effective as intended.

5.3.7 Tanzania Revenue Authority (TRA):

Tanzania Revenue Authority (TRA) have recommended EPR model. They recommended EPR in a way that each producer should have its agent collecting waste on the producer's behalf. This way, each producer will be responsible for its waste which per TRA will ensure efficiency and sustainability.

From the conventional e-waste business model, their main concern was that the model will depends on the investor's interest on which type of waste to collect and which not to collect, hence there is a chance that the problem will not be fully solved.

5.3.8 Zanzibar Bureau of Standards (ZBS):

Zanzibar Bureau of Standards, ZBS have been given the task by the government to make develop a guideline that will be used to control the standard of the imported EEE in Zanzibar. The guideline is complete and now ZBS are in final stages to install the devices that will be used to perform the inspection of the imported EEE at Zanzibar port. With the given guideline, there is a chance that the imported EEE will be below standard and therefore will not be allowed to enter. ZBS currently do not know what will they do with such EEE that are below standards. That's why they were very open to welcome the proposed solution from this project. Instead of either burning the below standard

EEE or return it back to its country of origin, ZBS can forward the stock to the recycling facility and they will act as collector in the proposed platform.

Regarding the business models, ZBS preferred PPP business model as they believe with the involvement of government with its power to make regulations and impose them it will be crucial in attaining better results and sustainable project. Also with PPP; other government institutions like ZBS will also play role in helping the project more valuable and operational. Contrary, conventional business model will not be taken seriously without regulations as there is chance that the problem will not be solved.

For EPR business model, the problem of fake products and importation of second hand EEE might be a big obstacle towards the success of this project, hence not a favourite business model.

5.3.9 Public Private Partnership (PPP):

Finally, an interview was held with a special department that mediates all projects that fall under PPP scheme. During the interview, PPP department explained how they look for projects that will have public interest. The procedure of collaborating with a government is being explained in chapter 2 of this report. In short, first a project has been submitted to the PPP department from a private investor. Then PPP department will announce a tender for that specific project. All other interested private investors will compete and whoever win the tender is going to be a government partner under PPP scheme.

Regarding PPP e-waste business model, the department has emphasized on the benefits of conducting business with Public sector. The benefits include risk sharing, refund guarantee with projects that are of high priority with the government. Contrary, conventional business model will save itself from bureaucratic procedures that arise from PPP business model. Also lack of other resources that might be contributed by the government like land, security and government support make PPP a better option compared to conventional business model.

6.4 Field Observation

As part of the methodology explained in chapter 3 of this report, number of field trips have been conducted by the researcher to get an insight of e-waste informal recycling centres and to understand the mass-flow of e-waste in Zanzibar.

The field trips were conducted at Alinato street in which a very famous informal recycler is located with a nick name “vunja vunja” translating to “break break” due to his continuous breaking of EEE to extract copper wires and very few other things. Another field trip was conducted at Mikunguni street where a few local refurbishers and recyclers were visited. Another field trip was conducted at Gulioni street which is famously known as “kwa wagonga vyuma” translating to iron or steel hitters.

All the visited locations had many things in common. For example, they all relied on getting the EEE such as fridges, computer and cooker from second hand EEE dealers and via bidding process that is taking place at a famous bidding street of Darajani.

Precisely, the location where the bidding is taking place in Darajani street is known as Mnadani which translates to bidding area in which different products ranging from clothes, electrical and electronics, to even sometimes vehicles are available.

Figure 27: Recycling Centre at Gulioni (Source: Field trip)

Figure 28: Recycling Centre at Gulioni (Source: Field trip)

The informal recyclers have admitted that it is very rare to receive EEE from consumers which shows that most of the already bought EEE by consumers are kept at home or disposed in streets or informal landfill once they reach end of life. This point is proving that it is high time now for Zanzibar to include a consumer in e-waste solution in order to collect all the waste rather than just allowing it to disposed at home or streets. It also shows that there are huge stocks of waste that can be collected from the consumers because statistics shows increase of purchasing of all EEE except radios from the year 2009 to 2014 as seen in chapter 4 of this report. Right now, the consumers don't feel the responsibility in handling e-waste. They expect the government to take care of the problem.

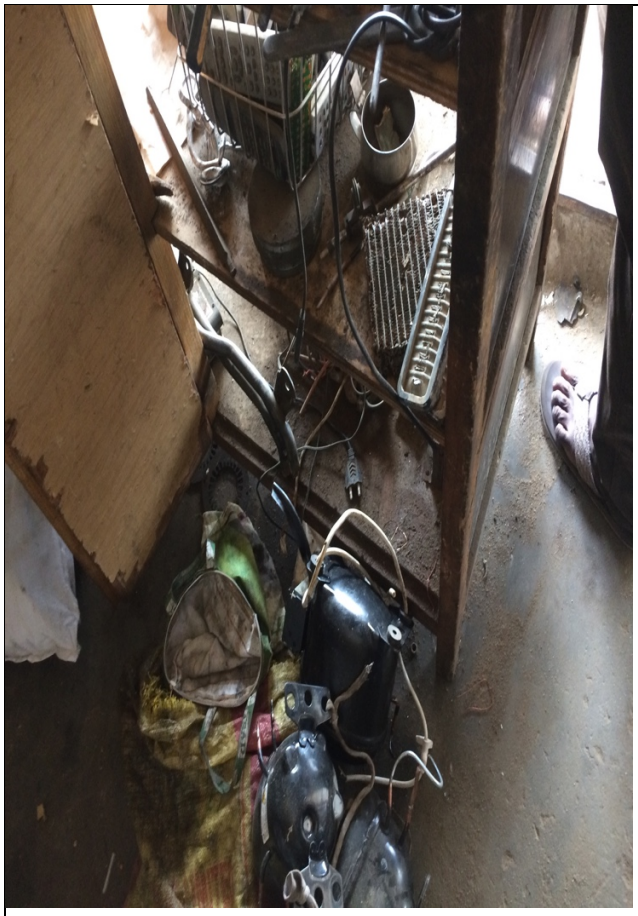

Figure 29: Recycling Centre at Alinato Street(Source: Field trip)

Figure 30: Recycling Centre at Alinato Street(Source: Field trip)

It was also observed that; all informal recyclers are working in an unsafe environment and are unaware of health and environmental effects of EEE they are working on. As seen figure 27 and figure 28 above, the workshops are very local with no any safety hazards and precautions being considered. All the EEE are being dismantled without any gloves or eye protectors or even major healthy precaution tools. In figure 29,30 and 33 it shows that EEE are kept inside the room without air conditioning and it is mostly hot throughout the year here in Zanzibar, meaning that some of the chemicals from EEE can burst, erupt or even radiate harmful substances.

Figure 31: Refurbishment Centre at Mikunguni (Source: Field trip)

All the visited recyclers have shown interest in a very small portion of the EEE. Most of them are looking for copper wires and small parts found in EEE such as bolts. In figure 10, from the TV only a deflector is extracted which consist of large copper coil leaving the rest of the TV as it is. By doing so, it shows that the informal recycling sector only recycle a very small portion of the available waste and even the collected waste only a small portion is recycled. Most of the remaining parts are again being disposed in informal landfills and streets. There are many parts that can still be recovered from the disposed remaining of the already dismantled EEE but due to lack of knowledge, capitals, tools and technology they end up in streets and landfills.

Figure 32: Recycling Centre at Alinato Street (Source: Field trip)

Figure 33: Refurbishment Centre at Mikunguni Street (Source: Field trip)

The informal recyclers are making cheap goods from the metal or iron being recovered. They make local barbecue stoves, cooking stoves, and other kitchen utensils as seen in figure 15 and figure 27 above. According to them (informal recyclers); they buy the waste based on weight and it costs them around one us dollar per estimated kilogram of iron or steel in that item. For example, figure 28 shows a picture of fridge in which it consists of more than just a steel, therefore the price for that fridge is totally based on the estimated weight of steel or iron in that fridge.

Figure 34: Refurbishment Centre at Mikunguni Street (Source: Field trip)

Figure 35: Refurbishment Centre at Mikunguni Street (Source: Field trip)

Finally, the researcher has observed the mass-flow of e-waste in Zanzibar as described in chapter 5 of this report. From the mass-flow model, the research has observed the continuous importation, consumption and threatening disposal level of e-waste around streets and informal landfills. From the field observation, e-waste can be defined as a big problem that need to be solved by taking necessary actions in terms of collecting, properly disposing it and finally recycle it to reap the economic benefits of the waste. Also, consumers need to be educated in terms of responsibility awareness so that they participate fully by making sure that they only buy electronic devices when needed and to be responsible in terms of where to dispose the end of life electronic devices. The field observation has motivated, guaranteed and inspired the researcher that now it is the time to introduce the proposed e-waste solution in Zanzibar with proper e-waste business model to ensure economic sustainability and viability.

6.5 Conclusion

Conclusively, this chapter presented all data that were collected and intensive analysis was conducted in each part. Section 6.1 highlighted the data collected plan that was used based on methodological framework presented in chapter 3 of this report. Section 6.2 presented the feedback obtained from questionnaire and analysed the results. The results show that consumer are willing to support the collection phase of e-waste with quite excellent feedback on their intentions. Consumers also shows that they are ready to adopt to the proposed innovation as discussed above and the diffusion of innovation. Section 6.3 presented feedback obtained from listed e-waste stakeholders regarding the desired e-waste business model in Zanzibar. Most of them preferred PPP business model. Finally, the chapter presented feedback obtained from field trips.

Next chapter will present the ICT solution that the author has innovated and the consumers are eagerly waiting to adopt it.

Chapter 7: Proposed Solution

From chapter 6 in section 6.2, consumer's feedback shows that they have a very high intention in adopting the behaviour of using mobile application to sell e-waste and the adoption rate of the proposed mobile application to sell e-waste is excellent. In this chapter, the author will present the proposed mobile application in section 7.1 and how it will fit to the proposed business model in section 7.2.

7.1 ICT based Collection Strategy (Mobile Application)

As explained and justified in the chapter 1, the main issue in investing in e-waste recycling plant in having sufficient waste to recycle. Hence. To make the desired business model to be sustainable and viable and be economically stable, this thesis proposes an ICT based collection strategy. Mobile application that will provide a platform for main e-waste stakeholders to trade the waste from the consumer all the way to recycler.

It is important to note that, the proposed mobile application will focus in reducing transaction costs. As the transaction cost theory is explained in chapter 2, the main transaction costs are operational cost such as search cost and coordination costs and contracting cost such as cost of developing the contacts and enforcing them.

Sections 7.1.1 will present and explain the conceptual platform of the proposed mobile application, section 7.1.2 will explain the possible scenarios and use cases will be presented in section 7.1.3. Last section of this part will explain how the proposed mobile application will reduce transaction costs.

7.1.1 Conceptual Platform

The mobile application will have three main users, namely electronic and electrical devices consumers, collectors and recyclers. The application will run under bidding process, where by collectors will bid for the posted EEE. In other words, consumer must set starting bidding price for

their EEE and maximum bidding days. Whoever won the bidding after the bidding time is over is considered a winner. The conceptual platform of the proposed platform is divided into three main categories. The signing up phase marked by blue arrows, the process phase marked by green arrows and finally the logistic phase marked by red arrows as seen in figure 36 below.

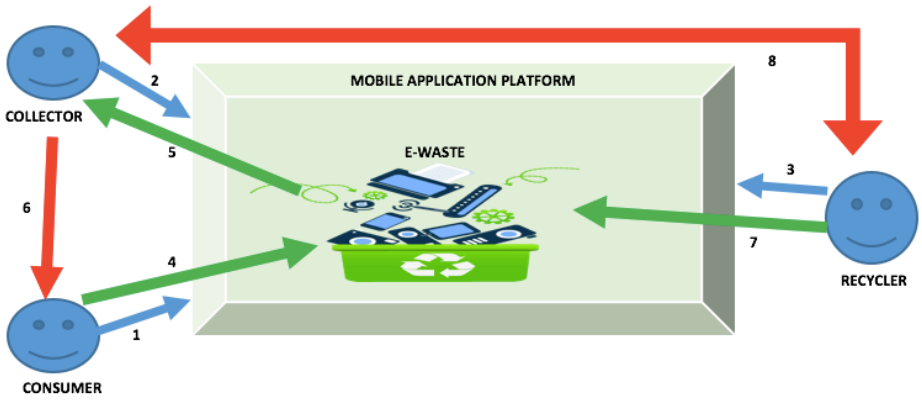

Figure 36: Conceptual Platform of the Proposed Mobile Application.

Process	Explanation
1	EEE consumer sign up with application
2	EEE collector sign up with application
3	EEE recycler sign up with application
4	Consumer publish his e-waste post stating clearly the description of the EEE and starting bidding price.
5	Collectors view the new post with all necessary details like starting bidding price, description of the item and maximum collection time.
6	Collector who won the bid approaches the consumer for picking up the waste and for completing the payment procedures.
7	Recycler searches for the item of his interest from the mobile application, only collector who possess the searched EEE will be presented to the recycler. Recycler will submit his offer to the preferred collector chosen from the list of collectors presented earlier.
8	Either collector or recycler will deliver or collect the waste respectively

Table 18: Conceptual Platform Processes

7.1.2 Scenarios

Based on the functionality of the proposed application, the scenarios will be explained from the actor's perspective. From the application, there are three (3) actors; consumer, collector and recycler.

Consumer:

Consumer must sign up to the mobile application as his first step. During the sign-up process, necessary details include full name, address, username, password and contact details must be included. After the successful signing up process, a consumer can sign in with his credentials anytime he wishes to do so. Once signed in, consumer can publish his post. For example; a consumer wants to sell his end of life television, he must create a post for it in the mobile application. Creating a post is what is known as publishing.

The publish phase will require the consumer to fill in some necessary details. The details include the following:

- Description: consumer need to fill in the model, colour, size, estimated weight, and condition of the electrical or electronic equipment he wishes to sell.
- Bidding details: consumer should fill in starting bidding price and maximum bidding days.
- Picture upload: A picture of the EEE to be sold should be uploaded into the system. This functionality might not be a compulsory one.
- Maximum collection time: this is the time that a collector is given to pick up his item before this time has run out. This is important because a consumer cannot wait forever for a collector to pick up his item. For example, a consumer can set 3 days as the maximum collection time. It means any collector who won the bid for this item should collect this item within 3 days otherwise the consumer will be given an option of republishing the same item.

Once published, all collectors will be able to view the published item from their news feeds in the application. The collectors will start the bidding process and once the bidding time is over, only one

collector will emerge victorious. Meanwhile, the consumer will receive the notification of the collector who won the bid with all the necessary details like full name, address and contact number of the collector who won.

The consumer should be expecting the collector to pick up his item within the collection time set by the consumer during the publishing process. If collector didn't like the item's condition during the collection process leading to change his purchasing decision or if the collector didn't show up to pick up his item until a collection time has run out, the consumer will be given to option by the system; to either republish his item or delete the post. If he chooses to republish, the post is going under similar stages as before, waiting for another collector to win the bid. If he chooses to delete the post, the item will be stored in consumer's history in the system.

Apart from the above-mentioned functionalities of the system, consumer will also be given an option to edit his profile details anytime he wishes to do so.

Collector:

Just like consumer, collector will also be required to sign up in the system but his process is a little bit different from consumer. Due to environmental and security concerns, collectors will need to be certified by the department of environment to make sure that they have safe place to store the purchased items from consumers and they have right intentions of collecting the waste and not for illegally exporting it.

During the sign up process, the collector should go through the following stages:

- From the system, the collector will fill up the registration form. The form shall include all necessary details including full name, address, contact details, username and password.
- The system will store the submitted application form and it will give the collector an option to print out the form and it will assign the collector a **special 8-digit key**. **Please note that the system admins can decide on any number of digit key not just 8-digit key as been mentioned here. Finding the suitable number of digits for a safer key is beyond the scope of this project and the author recommends more research is needed to find out.**

- Upon arrival at department of environment, the assigned personnel will process his application and will decide to approve or reject the collector's request. If the request is rejected, the collector will work on the needed requirements for his application to be approved. If the application is approved, the collector will be given 8-digit verification code. As an example, consider table 19 below. During the sign up process, the collector is assigned 8-digit key from the left column **FGDE-4325**. Once his application is approved, the department of environment will give the collector another 8-digit that will act as verification code. But the department should give him **KLSW-5302** as his verification code because only this key can activate his profile based on his previous key given during the sign up. All of this keys will be created and stored in the system.

8-digit Given to collector by the system during the sign up	8-digit given to collector by the Department of Environment as verification code
XDES-2345	FDSE-6424
FGDE-4325	KLSW-5302
JHDR-8344	LKSE-8473

Table 19: An example of Verification Codes for Collectors

- Once given the verification code, the collector will log in again using his user credentials to the mobile application, the system will request the collector to enter his verification code. If the verification code is correct, the collector will now have a full access to view and bid for all the published EEE in the platform. Note that, the collector will now have to enter his verification code only as he has already created his profile during the sign-up process.

Once signed in, the collector can view the published post by consumers and start the bidding process. It is necessary for the collector to view the maximum collection time set by the consumer to decide which post to bid and not to bid. After the bidding time is over, all collectors who have bided for the item will receive a notification of which collector have won the bid. The collector should pick up his item within the collection time. Once picked, the collector should notify the

system that he has collected the item by pressing the “collected” button. The system will automatically add this item to collector profile. The collector will have a page on his profile indicating which items he is possessing and the quantity of each item as shown in table 20 below.

ITEM	QUANTITY
Laptops	24
fridges	47
Cookers	32
Television	28
Mobile phone	129
Printers	31

Table 20: An example of Collector's stock page

Note, the collector act as a middle man between the consumer and the recycler. Therefore, he will have other functionalities that will allow him to interact with the recycler that will be explained here in brief and in detail in the next section (Recycler Scenario). In short, the collector will be able to receive an offer from the recycler. After receiving the offer, the collector will either accept, reject or reply with counter offer.

Recycler:

It will be compulsory for all recyclers to have a profile in the mobile application platform. As recyclers have completed all registration and licensing procedures for their recycling plants, they will be given a verification code from the department of environment for them to be part of the platform.

Once signed in, the recycler is presented with a search box only. Recycler should type-in the EEE he is looking for. The system will list down all collectors who are possessing the searched EEE. The recycler will review the collector and approach any collector that he selected from list. The approach process includes sending an offer letter to collector indicating quantity and price of the item the recycler wants from the collector.

Upon receiving the offer letter, the collector can either accept, reject or reply with counter offer to recycler. If the offer is accepted, the recycler contact the collector for delivery and payment agreements. If the offer is rejected, the recycler can submit another offer to collector or decide to send an offer letter to another collector. Finally, if the collector decides to send a counter offer, the recycler can now either accept, reject or again send a counter offer.

To conclude on scenarios, all actors will be provided with an option to edit their profile details including full name, company name, address, contact details and of course passwords.

7.1.3 Use Cases

In this section, use-cases of the proposed mobile application will be presented and discussed. Figure 37 below presents all the actors and their respective use cases. Each of the use-case is described as follows:

Sign up: This use-case is necessary for consumer, collector and recycler.

Verify: Consumer will sign up to the system without being verified while both collector and recycle must be verified by the DoE as explained in section 7.2.1 above.

Sign in: All actors are given the functionality to sign in only after successful sign up into the system.

Publish: This use case is for consumer where by the consumer can publish a post for his/her e-waste that need to be sold. The consumer will add necessary information such as clear description of the item, photo of the item, maximum collection time, stating bidding price and bidding duration.

Republish: This use case is used by a consumer when a bid is over and the collector who won the bid didn't show up for collection during the collection period. The consumer can either decide to republish the post or delete the post. By republishing, the consumer is basically allowing the collectors o start the bidding process again.

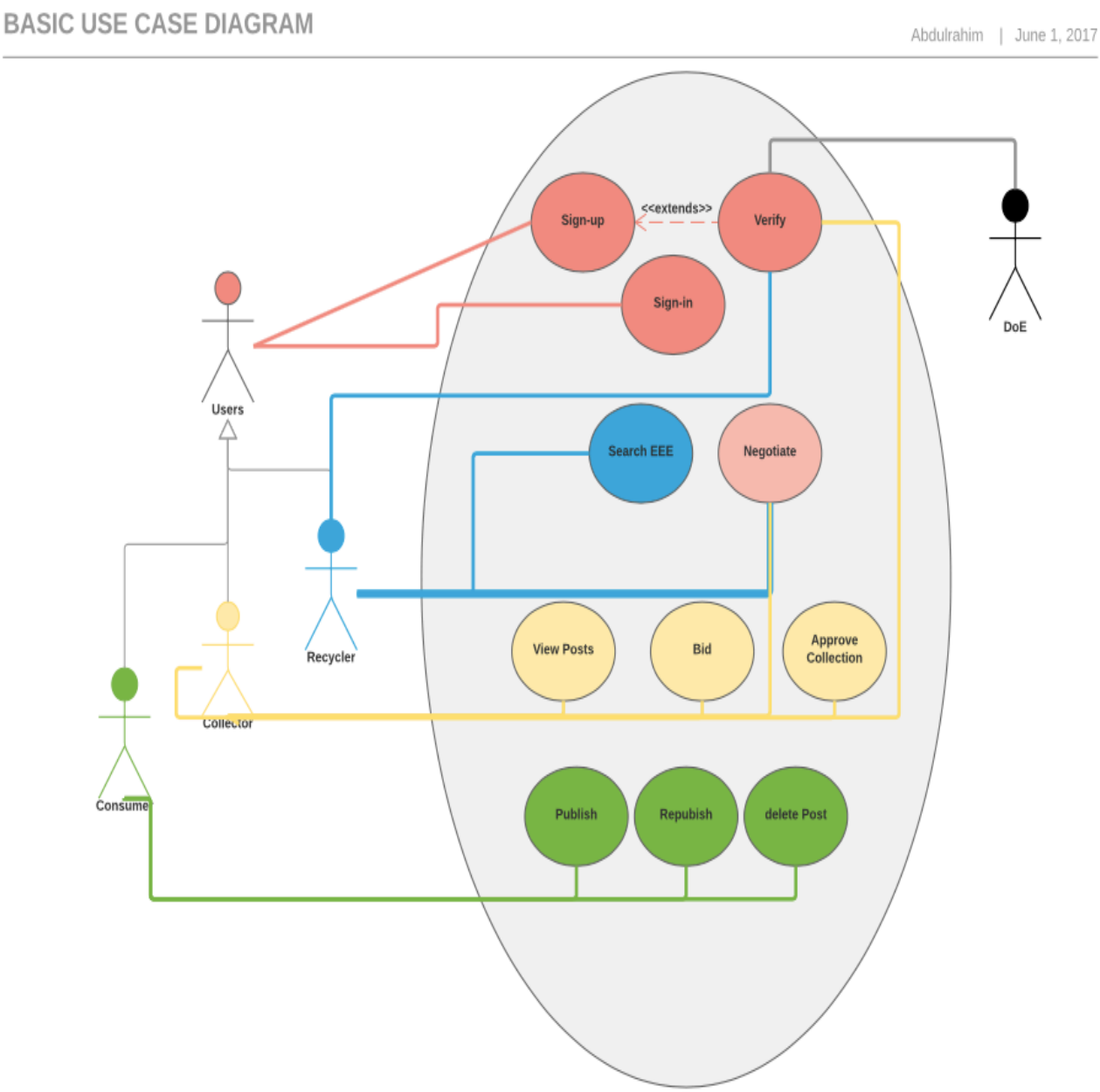

Figure 37: Basic Use Case for the Proposed Mobile Application

Delete post: consumer can only use this option after the bidding process is over. If the collector has successfully collected his item, the consumer can delete the post from his history. If the collector hasn't picked up his item within the collection period and the consumer doesn't want to republish the post, he can delete it.

View post: Collector will have the functionality to view post that are being published by the consumer. The post will appear on collector's home page once logged in. The collector can view many posts by scrolling down the screen.

Bid: During the viewing of post by scrolling down the screen, the collector can bid on any post. The bidding price of the collector must be higher than the starting bidding price set by the consumer and higher than current bidding price that is set by latest bidding collector. It will be very important for the collector to note the maximum collection time to assure himself that if he wins the bidding process then he will be able to collect the item within the collection period.

Approve collection: The collector upon successful completion of bidding process and has collected the item within the collection period, he should approve the collection in the system so that the item posted by the consumer is being added into the collector's stock automatically. For example, the if the collector have just purchased 2 cookers from a consumer and have collected it, once he approves the collection the system will add those two cookers to the collector's profile. If the collector will cheat that he has collected the item and the system add the item to his profile, it will damage his profile and hence a problem for him and it won't affect anyone because the recycler will only pay for item on physical transaction and not via online transactions.

Negotiate: This use case is used by both the collector and recycler. The recycler will search for his item(s) that he wishes to recycle and the system will list down all collector's profiles that possess the searched item. The recycler will then choose one or more collector to submit their offer depending on the collector's stock. The collector will receive the offer submitted by the recycler and he will either accept, reject or send a counter offer. If the collector accepts, they communicate to complete the logistics. If the collector reject, the negotiation ends and the recycler will decide on sending a new offer or looking for other collectors. If the collector send a counter offer, the recycler will be given an option to either accept, reject or send a counter offer.

Search EEE: The recycler home page will be an empty search box that will allow him to enter the item he is looking for as seen in figure 39 below. Here, the recycler will enter the item for example

cooker, fridge, television, mobile phone etc. and the system will look for all collectors the have the searched item in their stocks and list the collector to the recyclers home page. The recycler then start the negotiation process with the collector as explained in negotiate use case above.

7.1.4 Requirement Specification

In this section, the author will list down all functional and non-functional requirement. Note that MoSCoW model (Must, Should, Could, Would) is applied but because all the listed functional and non-functional requirement are necessary to make the application work as intended hence fall under "must", the author has omitted the priority column from both table 21 and table 22 below as all listed items are having similar priority "M" which means must.

Note that all the below functional and non-functional requirements are derived from the use-case diagram (refer figure 37). The use cases are derived from scenarios explained above in this section for consumer, collector and recycler.

Functional Requirement

Table 21 below list down all functional requirement of the proposed mobile application. The functional requirements are derived from the use cases from the figure 37 above. The use cases are derived from scenarios explained above for consumer, collector and recycler.

Use Case	No	Name	Description
Sign up	F1	Register user name	The consumer should provide any name, collector and recycler should use either their real names or company names.
	F2	Register address	Physical address of all actors
	F3	Register contact	Contact details of all actors, including telephone, mobile, fax, email, etc.
	F4	Register password	Secret key for access

Verify	F5	Assign primary Key	The system will provide this number to the collector and recycler to attach it with the application form when submitting to DoE.
	F6	Register secondary Key	DoE will provide secondary key to authorised collector and recycler and need to fill in the verification key to the system for approval.
Sign in	F7	Provide username	Enter username
	F8	Provide password	Enter password
Publish	F9	Provide item photo	A clear photo of the item being published.
	F10	Provide maximum collection time	The consumer need to set the maximum time that is given to collector who won the bid to collect his item.
	F11	Provide bidding period	The consumer need to set for how long the bid should take place.
	F12	Provide starting bidding price	The consumer need to set the initial price of the item.
	F13	Provide item description	The consumer need to provide a short description of the item. Details such as model, production year, etc.
Republish	F14	Edit item photo	The consumer can add clear photo of the item being published.
	F15	Edit maximum collection time	The consumer can re-set the maximum time that is given to collector who won the bid to collect his item.
	F16	Edit bidding period	The consumer can re-set for how long the bid should take place.

	F17	Edit starting bidding price	The consumer can re-set the initial price of the item.
	F18	Edit item description	The consumer can edit a short description of the item. Details such as model, production year, etc.
Delete	F19	Confirmation	The consumer need to confirm if he wants to delete the post.
View Post	F20	Display published posts	The applications will display the published post in order of consumer's choice. Either latest posts or hot posts.
Bid	F21	Register the bidding price	The collector need to fill in the bidding price. The price should be higher than the current price of the item.
Approve collection	F22	Update the collector's stock	Once the collector have physically collected his item from the consumer, the collector will have to approve the collection from the system and the system will add the published item to the collector's stock.
Search	F23	Provide the search word	The recycler will enter the search word of the electronic and electrical equipment.
	F24	Display the result	The system should display the results to the recycler. The results will be in order of stock quantity of the collectors.
Negotiate	F25	Provide the offer price	The recycler provides the amount of money the company wishes to buy the stock.

	F26	Provide the quantity needed	The recycler provides the amount of items the company wishes to buy.
	F27	Display the offer	The system will display the offer to the collector or recycler (depending on the phase of negotiation).
	F28	Accept the offer	The system notifies the collector or the recycler (depending on the phase of negotiation).
	F29	Reject the offer	The system notifies the collector or the recycler (depending on the phase of negotiation).
	F30	Send the counter offer	The system will display the offer to collector or recycler (depending on the phase of negotiation).

Table 21: Functional Requirement

Non-Functional Requirement

Table 22 below list down all non-functional requirement of the proposed mobile application. Again, the priority for the listed items is similar as “Must”.

NF1	Platform	The application should be available in android platform first then the iOS.
NF2	Verification Code	The system should generate a random pair of primary and secondary key.
NF3	Username	Username for the collector and recycler could be name of the company owner or the name of the company only. Consumer can choose any name.

NF4	Password	Password should contain letters, numbers and at least one symbol.

Table 22: Non-Functional Requirement

7.2 Desired Business Model

In this section, the report will present and explain the business model that will fit best to Zanzibar context. **The chosen business model has been decided by the author based on feedback that been received and documented in this report from various potential e-waste stakeholders in Zanzibar, field trips, intensive literature review, observing informal recyclers and the developed mass flow of e-waste in Zanzibar**.

PPP is proposed by the author as the business model that will fit best in Zanzibar. This is due to the following reasons and arguments:

- Government involvement in this project is crucial to push and change mind set of all stakeholder by establishing regulations and enforcing them.

- The proposed project is new in Zanzibar and therefore there are number of risk that might be associated in establishing such a business. PPP is the best option in terms of risk sharing.

- In order to attract more attention from investors, the government might assist by contributing resources that will be needed to run the facilities like land, security and tax exemptions and hence reduce the capital investments.

- The involvement of government into such a project might fit well into the initial efforts made by the government to the control of e-waste in Zanzibar. For example, ZBS being a government department will help to control the importation of below standard EEE in Zanzibar by inspecting all imported EEE. The department of environment might support the project in authenticating collectors and making sure the recyclers are doing their responsibilities.

- If the project will fail by any reason, under PPP scheme there is a chance of get a refund from the government.

- As it is business that needs extra care to avoid any effects and health complications, involving government into this project will ensure all safety hazards and precautions are taken into considerations at the recycling facilities.

- As the importation of second hand goods in Zanzibar tend to increase every year, PPP model is the model that will guarantee the collection of all EEE regardless if they are new or used, authentic or unauthentic hence the model will cover whole scope. Compared to EPR model, where by it won't be able to deal with second hand or unauthentic EEE which will remain in streets and home or other producers might not be interested being part of the business model making the problem un solved. Comparing it with conventional model, there is a chance that the owner will tend to choose to collect and which type not to collect depending on waste profit margins.

- In PPP model, the government might have the chance to decide what type of waste each investor might be working on. This will help to distribute the waste to the investors and therefore making sure that there is a balance on all types of waste being collected and recycled.

- Using PPP model, the government will have an extra source of income from taxes imposed to both collectors and recyclers and profit share from the business (subject to the agreement between the government and private investor).

- The investor will have a government support in many of the needed decisions to make the business sustainable and collecting more waste from consumers.

- Consumers, collectors and recyclers will take the project seriously as long as government is part of it.

- The project might receive blessing from international organisations and Zanzibar might gain international recognition as one of the country that is taking the e-waste problem seriously.

- Depending on agreements made, the waste coming from all government institutions might be a great input to the recycling facilities every year.

The proposed e-waste business model as seen in figure 38 below have included all the necessary entities that need to collaborate to archive the required results. The model start from the importation phase of EEE at Zanzibar port. During the importation, ZBS will start by making sure all the imported EEE in Zanzibar are inspected and only those EEE that passes the quality check can enter Zanzibar blocking all other EEE that are below standard.

After the inspection, the consumers can now buy and use the EEE and will be advised by DoE to download and install the proposed mobile application. Consumers should use the application to get rid of the unwanted or end of life EEE they purchased by getting back some income as an incentive. The author is aware that not everyone owns a smartphone in Zanzibar. This is due to the data collected in 400 households in Zanzibar that showed only 11% did not own smartphone but 89% owned smartphone. DoE should educate consumers that do not own smartphone to request other people who own smartphone to use their app within their streets or neighbourhood.

The collectors must be certified by the DoE as being explained in this chapter above to avoid unwanted and unsafe use of the waste. Finally, the recyclers who are part of the mobile platform will operate their business on PPP scheme. The model ensures the recycler to have a continuous inflow of e-waste using the proposed mobile application platform and reap all the benefits of PPP business model that are listed above in this section.

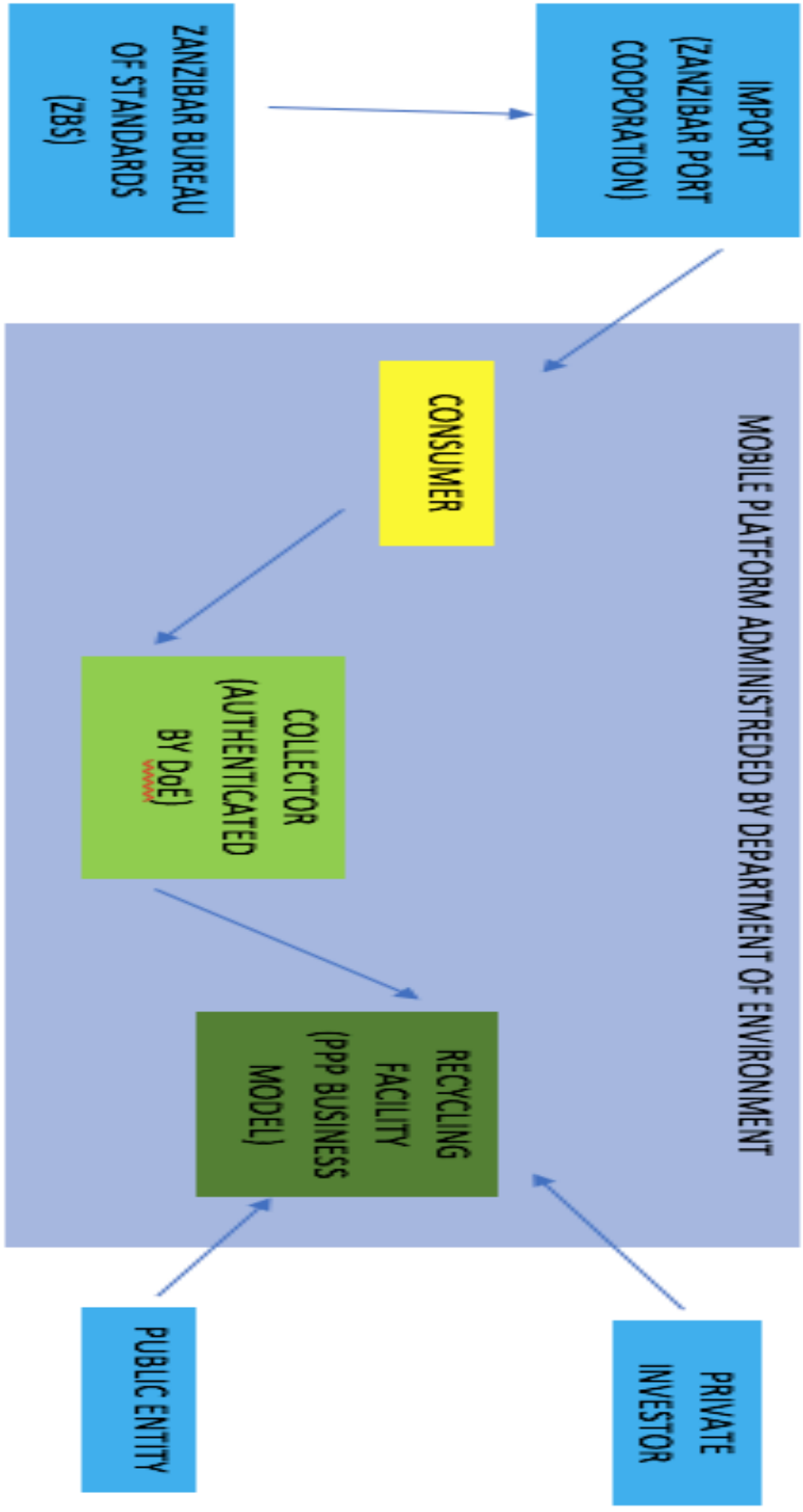

Figure 38: The Proposed Public Private Partnership (PPP) Business Model for E-Waste (Source: Author)

7.2.1 Reduction of Transaction Cost

The proposed ICT solution; mobile application is aiming in reducing the transaction cost that occur from the recycling firm. As explained in chapter 2 of this report; there are two main types of transaction cost, operational cost and contractual cost. In this section, the author will explain how the proposed mobile platform will reduce the transaction cost for the e-waste recycling firms in Zanzibar.

Reduction of Operational Cost:

Two main costs under operational cost are search cost and communicating cost. The mobile application is connecting consumers of EEE, collectors and recycler to ensure that the consumer's waste is transiting at collectors towards the recyclers instead of keeping the end of life devices at home or disposing on streets or informal landfills. Hence the recyclers are required to search for their needed waste via the mobile application as explained in previous part of this chapter for free without any charges being imposed. Also, via the mobile application the recyclers will be able to negotiate will collectors by submitting offers to each other until a deal is being agreed for free as a means of communication, therefore the recyclers will not have communicating costs in terms of searching for waste.

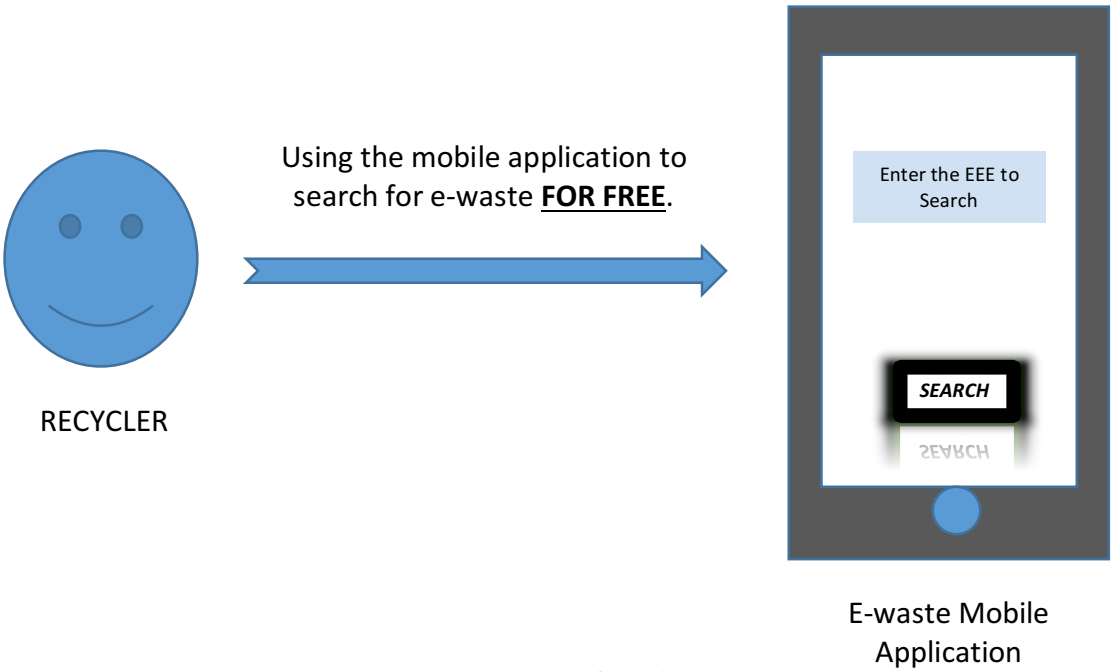

Figure 39: Reduction of Search Cost

Figure 40 above illustrates a prototype of how a recycler can use the application to search for e-waste without any search cost. The same applies to communicating cost as the recycler can negotiate with the collector via the application only to reach an agreement on the price and quantity of waste. As explained in section X of this report, the recycler will send an offer to collector using a pre-defined form in which the collector will have three options; accept, reject or send a counter offer to recycler.

Reduction of Contractual Cost:

In any firm, making contracts and cost of enforcing contracts are considered as transaction cost. Using the propose mobile application, recycling firms in Zanzibar will cut contractual costs in terms of purchasing the e-waste. The recycler won't be needed to have any long-term official contracts with collectors and therefore there will be no cost in making the contracts and no any ongoing cost of enforcing contracts.

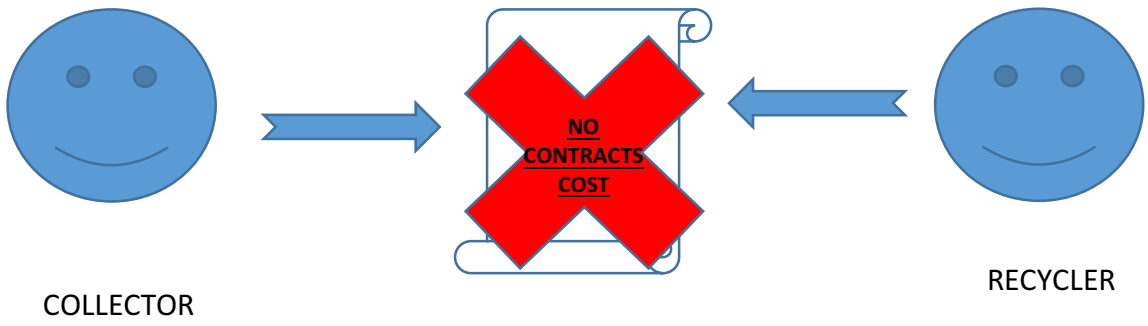

Figure 40:Reduction of Contractual Cost

Apart from the contracting cost, other cost such as brokerage cost are also being avoided by using the proposed mobile because there is no middle man or brokerage between the recycler and collector.

7.2.2 SWOT Analysis

In this section, SWOT analysis of the proposed business model will be presented.

Strength • Ensures availability of e-waste to the recyclers • Risk sharing • Contribution of resources from the government such as land and security • Government support • Incentive to consumers • Recycle all types of waste; new or used, authentic and unauthentic.	Weakness • Bureaucratic process • Culture gap between the public and private sector
Opportunity • Gaining regional and international reputation • Increasing demand of EEE • No competition within the same field	Threats • Exposing revenues and investment information to the public • Replacement of staffs involved from the public sector

Table 23: SWOT analysis of the proposed business model (Source: Author)

7.3 Conclusion

In this chapter, the proposed ICT collection strategy was presented and discussed with the conceptual platform, use-cases, scenarios and requirement specifications. Also, the proposed business model of PPP was discussed in section 7.2 above and how the solution will reduce the transaction costs.

Chapter 8: Conclusion

Conclusively, to solve the problem of continuous rise of accumulation of e-waste in Zanzibar streets and landfills as indicated in the developed mass flow model, this project focused on introducing e-waste business model that will convert the e-waste trash to e-waste treasure and therefore it will reduce the dumping of e-waste around the country. Research analysed three business models, where by Public Private Partnership (PPP) business was selected as the preferred and viable business model compared to Conventional and Extended Producer Responsibility (EPR) business models. This is because in PPP business model, the involvement of a public sector is crucial in supporting the model in terms of risk sharing, resources such as land, security and labour support, policy issues, investment guarantees in projects that fails are refunded by the government but only if the government agrees to do so during the contract agreements.

With a threatening statistic of an estimated 520 tonnes of e-waste generated in 2013-2014 only, lack of acts of policies specifically for e-waste and lack of disposing and recycling facilities, it shows that Zanzibar is having a huge stock of e-waste and introducing e-waste business models only won't be enough. There is need to introduce collection strategy. This research innovated an ICT collection strategy that will allow e-waste to easily and efficiently collected and being recycled at the recycling facilities. With the mobile application, it's a win-win situation by both the public and private sector as the public will now have cleaner and safer environment by having a guaranteed and efficient way to dispose their waste and for the private sector it will reduce the transaction cost involved.

The research also analysed if the consumers are willing to adopt to the proposed innovation to get an insight on how the consumer will respond to such an ICT collection strategy and the diffusion of innovation to the society. Using Theory of Planned Behaviour, results show that consumers are having a very promising and high intention towards the behaviour of using mobile application to sell e-waste. In terms of adoption rate of innovation, using Roger's Diffusion Theory it shows an excellent adoption rate with a sense of closer connectedness society which will influence the higher adoption rates. With the proposed business model integrated with an ICT collection strategy and the readiness of the consumers, e-waste problem will be solved by great extent and will open e-waste business opportunities.

Chapter 9: Recommendation and Future Research

In this chapter, author will present his recommendations and areas that need further research based on his experience, challenges and efforts towards contributing in this area of research. The following are the recommendation:

- Zanzibar should establish a special database on the amount of imported EEE being imported in Zanzibar for all EEE devices. The database will be crucial for rising awareness of e-waste and helping the authorities to make better decisions and establishing policies.

- Due to the threatening results of e-waste in Zanzibar, there is a necessity to establish an authority or department that will regulate e-waste in Zanzibar or assign this task to the already existing authorities.

- Zanzibar should monitor the effects of EEEs to our societies (environment and health) and establish policies accordingly.

The following are the areas of future research:

- More research should be conducted to analyse proper financial investments that will be needed to establish and run e-waste recycling facilities.

- A research is needed to understand how much of the imported EEE becomes waste after the end of the year.

- More research is needed in analysing the percentage of e-waste that exist in households, streets, and informal landfills.

- More research is needed to determine the proper verification system of the collectors and recyclers. This research proposed 8-digit verification key without taking into consideration any of the possible security concerns, hence more research is needed.

Appendix

Appendix 1: QUESTIONNAIRE

Research Title: The role of ICT in enhancing e-waste business opportunities.

Researcher's Name: Abdulrahim Haroun Ali

University: Aalborg University, Denmark.

Questionnaire Description:

This questionnaire is focusing in analyzing the behavior of end-user of electronic devices and willingness to adopt to new innovation. The behavior is as mentioned in part 2 "The usage of mobile application to sell e-waste" and is analyzed using Theory of Planned Behavior. From the innovation perspective, Part 3 of this questionnaire is accessing how will the innovation (Mobile Application for selling e-waste in Zanzibar) diffuse and hence the adoption rate by using Roger's Diffusion Theory.

Key Abbreviations:

e-waste: electronic waste

EEE: electronic and electrical equipment

Part 1: Demographic Details

A. Age: □ below 15 □ between 15 and 40 □ above 40

B. Gender : Male □ Female: □

C. Education level:

□ No school □ Primary level □ Secondary level □ Diploma/Undergraduate

□ Postgraduate and above

D. Status in a family:

□ Grandfather/Grandmother □ Father/Mother □ Child □ Other

E. Region: □ Urban West Unguja □ North Unguja □ South Unguja

F. How many EEE you own: □ Less than 5 □ Between 5 and 10 □ More than 10

Part 2: Question for Theory of Planned Behavior (TPB)

Behavior: The usage of mobile application to sell e-waste

Attitude

Using mobile application to sell my e-waste would be:

1.	*Bad*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	*Good*
2.	*Senseless idea*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	*Wise idea*
3.	*Unpleasant experience*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	*Pleasant experience*
4.	*Harmful*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	*Beneficial*

Subjective Norm

5. Most people who are important to me think that

I should not 1 2 3 4 5 6 7 I should

use mobile application to sell my e-waste.

6. It is expected of me to use mobile application to sell my e-waste.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

7. I feel under social pressure to use mobile application to sell my e-waste.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

8. People who are important to me want me to use mobile application to sell my e-waste.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

9. Most people who are important to me think that it would be fine to use a mobile device for selling my e-waste.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

10. I think other people who are important to me would be willing to adapt to use mobile application for selling e-waste.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

11. Most people who are important to me would be in favor of using a mobile application for selling e-waste.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Behavioral Control

Self-efficacy

12. I have a sufficient extent of self-confidence to make a decision to use mobile application to sell my e-waste.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

13. For me to use mobile application to sell my e-waste is

difficult 1 2 3 4 5 6 7 easy

14. I have a sufficient extent of knowledge to use smart phone.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Controllability

15. The decision to use mobile application to sell my e-waste is beyond my control.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

16. Whether I use mobile application to sell my e-waste or not is entirely up to me.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Intention

17. I expect to use a mobile application to sell my e-waste.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

18. I want to use a mobile application to sell my e-waste.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

19. I intend to adopt a mobile application for selling the e-waste

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Part 3: Question for Roger's Diffusion of Innovation Theory

Innovation: Mobile Application for selling e-waste in Zanzibar.

1.0 Attributes of Innovation

1.1 Relative advantage

20. Using mobile application to sell my e-waste is safer than throwing it away.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

21. Using mobile application to sell my e-waste is better than just keeping it at home.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

22. Using mobile application to sell my e-waste is easier way to get rid of it.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

1.2 Compatibility

23. Using a mobile application to sell e-waste is what is needed to keep our environment clean.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

24. Mobile application for selling e-waste fit right into the way I want to get rid of e-waste

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

1.3 Complexity

25. I believe using mobile application to sell e-waste will be easy.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

26. To use mobile application to sell e-waste is less time-consuming

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

1.4 Trialability

27. Free version of the mobile application will be important in my decision to use the application.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

28. It is more likely that I will use the application if it will be for free.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

29. Free version of mobile application will allow me to get to know the features and functionality of the app better.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

1.5 Observability

30. The benefit of using the mobile application to sell e-waste will be visible in my neighborhood.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

31. To use mobile application to sell e-waste will reduce the accumulation of waste in streets and landfills**.**

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

2.0 Communication Channel

32. I often hear about new innovation from family and friends.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

33. Scale the media that you usually obtain information about new innovation

	Strongly disagree----------Strongly agree						
Television	1	2	3	4	5	6	7

Radio	1	2	3	4	5	6	7
Social Media	1	2	3	4	5	6	7
Instant Messaging Apps	1	2	3	4	5	6	7
SMS	1	2	3	4	5	6	7
Newspapers	1	2	3	4	5	6	7

3.0 Measuring opinion leaders

34. Rate how often you talk and discuss about new innovation with the following leaders:

	Less frequent----------More frequent						
Head of family	1	2	3	4	5	6	7
Local leader (sheha)	1	2	3	4	5	6	7
Local counselor (Diwani)	1	2	3	4	5	6	7
Religious leaders	1	2	3	4	5	6	7
Charismatic leaders from the government	1	2	3	4	5	6	7

4.0 Innovation-Decision

35. I am more likely to adopt to new innovation if it is:

	Strongly disagree----------Strongly agree						
Optional	1	2	3	4	5	6	7
Collective decision	1	2	3	4	5	6	7
Authority	1	2	3	4	5	6	7

Appendix 2: ZPC DATA

ZANZIBAR PORTS CORPORATION

CONTAINER TRAFFIC FROM 2002 - SEPT, 2016

YEAR	DISHARGED (IMPORT)							LOADED (EXPORT)							TOTAL DISCHARGED AND LOADED		
	CONTAINERS				TOTAL CONT.	TEUS	TONS	CONTAINERS				TOTAL CONTRS.	TEUS	TONS	TOTAL CONTR'S	TOTAL TEUS	TOTAL TONS
	20'		40'					20'		40'							
	F	E	F	E				F	E	F	E						
2002	3,208	44	603	1	3,856	4,460	77,555.93	573	2,551	211	399	3,734	4,344	24,496.69	7,590	8,804	102,052.62
2003	3,746	79	745	-	4,570	5,315	87,986.72	923	3,019	269	427	4,638	5,333	32,891.17	9,208	10,648	120,877.88
2004	3,281	267	946	1	4,418	5.398	75,270.81	955	2409	416	545	4,325	5,286	44,881.30	8,743	10,684	120,152.11
2005	3,218	165	1,476	6	4,865	6,347	94,976.44	880	2,593	312	1,101	4,886	6,299	35,642.82	9,751	12,646	130,619.26
2006	3,735	101	1,640	5	5,481	7,126	99,250.29	780	2,723	306	1.373	5,182	6,861	35,219.61	10,663	13,987	134,469.90
2007	4,276	54	2,278	7	6,615	8,900	111,712.48	694	3,648	305	1,884	6,531	8,720	40,394.07	13,146	17,620	152,106.55
2008	5,722	5	2,966	-	8,693	11,659	173,794.21	709	5,050	357	2,627	8,743	11,727	49,148.99	17,436	23,386	222,943.20
2009	9,332	4	3,240	-	12,576	15,816	283,157.87	647	8,481	368	2,795	12,291	15,454	53,908.14	24,867	31,270	337,066.01
2010	10,541	53	4,477	1	15,072	19,550	345,496.93	737	9,881	294	4,025	14,937	19,256	62,493.92	30,009	38,806	407,990.85
2011	13,750	25	5,998	-	19,773	25,771	482,844.92	961	12,510	316	5,735	19,522	25,573	81,074.52	39,295	51,344	563,919.44
2012	17,410	1	7,689	1	25,101	32,791	578,184.52	1,185	15,993	615	6,927	24,720	32,262	105,890.53	49,821	65,053	684,075.05
2013	20,066	3	8,056	32	28,157	36,245	570,314.14	968	18,287	617	6,902	26,774	34,293	106,517.03	54,931	70,538	676,831.17
2014	20,565	95	9,392	26	30,078	39,496	609,852.52	1,543	18,893	880	8,782	30,098	39,760	138,575.60	60,176	79,256	748,428.11
2015	21,231	1	7,951	31	29,214	37,196	744,982.49	1,211	20,728	1,037	6,976	29,952	37,965	127,480.69	59,166	75,161	872,463.18
JAN-SEPT, 2016	16,547	3	6,237	-	22,787	29,024	592,044.36	565	16,325	590	5,607	23,087	29,284	88,605.76	45,874	58,308	680,650.12
TOTAL	156,628	900	63,694	111	221,256	285,094	4,927,424.62	13,331	143,091	6,893	56,105	219,420	282,417	1,027,220.82	440,676	567,511	5,954,645.44

Appendix 3: SUMMARY OF TRA DATA

	Year	Amount In TZS	Amount in $	Estimated Number of Pieces	Estimated Weight in Tonnes
COMPUTER	2009-2010	1.574.292.761,40 TZS	704.791,49	6128,62	41,06
	2010-2011	3.271.026.392,40 TZS	1.464.398,26	12733,90	85,32
	2011-2012	3.800.806.643,30 TZS	1.701.574,36	14796,30	99,14
	2012-2013	3.842.300.529,30 TZS	1.720.150,66	14957,83	100,22
	2013-2014	4.626.261.418,20 TZS	2.071.120,30	18009,74	120,67
TV	2009-2010	4.601.949.486,90 TZS	2.060.236,15	35830,19	1132,23
	2010-2011	5.414.465.123,40 TZS	2.423.989,40	42156,34	1332,14
	2011-2012	5.143.461.306,00 TZS	2.302.664,33	40046,34	1265,46
	2012-2013	5.475.200.601,60 TZS	2.451.179,93	42629,22	1347,08
	2013-2014	13.282.253.583,60 TZS	5.946.301,47	103413,94	3267,88
RADIO	2009-2010	102.164.489,80 TZS	45.737,78	2286,89	4,57
	2010-2011	178.551.783,30 TZS	79.935,44	3996,77	7,99
	2011-2012	439.924.621,20 TZS	196.948,84	9847,44	19,69
	2012-2013	747.327.693,30 TZS	334.569,41	16728,47	33,46
	2013-2014	162.579.756,90 TZS	72.784,96	3639,25	7,28
PRINTER / SCANNER	2009-2010	90.794.058,80 TZS	40.647,38	2709,83	17,61
	2010-2011	123.341.217,30 TZS	55.218,35	3681,22	23,93
	2011-2012	117.739.691,10 TZS	52.710,61	3514,04	22,84

	2012-2013	170.959.297,50 TZS	76.536,37	5102,42	33,17
	2013-2014	170.627.622,80 TZS	76.387,89	5092,53	33,10
COOKER	2009-2010	493.755.962,40 TZS	221.048,47	6315,67	290,52
	2010-2011	755.581.804,80 TZS	338.264,68	9664,71	444,58
	2011-2012	1.046.331.104,50 TZS	468.429,56	13383,70	615,65
	2012-2013	1.366.154.435,70 TZS	611.610,53	17474,59	803,83
	2013-2014	1.422.949.033,50 TZS	637.036,77	$18201,05	837,25
FRIDGES	2009-2010	1.202.187.849,70 TZS	538.204,71	9360,08	327,60
	2010-2011	2.485.565.103,60 TZS	1.112.756,91	19352,29	677,33
	2011-2012	2.277.487.506,40 TZS	1.019.603,13	17732,23	620,63
	2012-2013	2.563.321.603,20 TZS	1.147.567,54	19957,70	698,52
	2013-2014	3.625.718.727,70 TZS	1.623.189,65	28229,39	988,03
MOBILE PHONES	2009-2010	229.196.400,60 TZS	102.608,41	5130,42	0,51
	2010-2011	1.048.801.727,10 TZS	469.535,63	23476,78	2,35
	2011-2012	2.557.399.147,50 TZS	1.144.916,12	57245,81	5,72
	2012-2013	5.251.389.077,40 TZS	2.350.982,26	117549,11	11,75
	2013-2014	12.147.658.088,80 TZS	5.438.357,03	271917,85	27,19

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