Master Thesis

Developing Green Waste Management System in Lebanon, Feasibility Study of Kitakyushu Eco Town, Japan (A Proposed Model)

By

Ghannam Osama

Student ID: 52117614

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Supervisor by: Profssor Behrooz Asgari PhD.

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DECLARATION

I, GHANNAM Osama (Student ID 52117614) hereby declare that the contents of this master's Thesis are original and true and have not been submitted at any other university or educational institution for the sake of degree or diploma. All the information derived from other published or unpublished sources has been cited and acknowledged appropriately.

GHANNAM Osama 2019/07/14

5 Rs	reject, reduce, reuse, recovery, and recycle.
WM	waste management
WMS	Waste management system
SME	small medium enterprises
BOP	Bottom of the Pyramid Marketing
NFC	Near Field Communication
RFID	Radio Frequency Identification
KWh	Kilo Watt Hour
MW	Mega Watt
GW	Giga Watt

Abstract

Waste management has been a serious problem in Lebanon, mainly because there is no developed waste management system. Landfill was the only way used which was causing health and environmental problems. Problems increased dramatically to become a crisis since closing the main landfill in 2015 leading to overflooding of the streets, sea and public utilities with garbage without finding alternative solutions. Many individual and NGO's initiatives were launched yet most were not successful. 50 small and medium sized sorting and composting facilities were established with a capacity of 5 to 250 tons/day yet still less than needed as shown in the Fig.1:

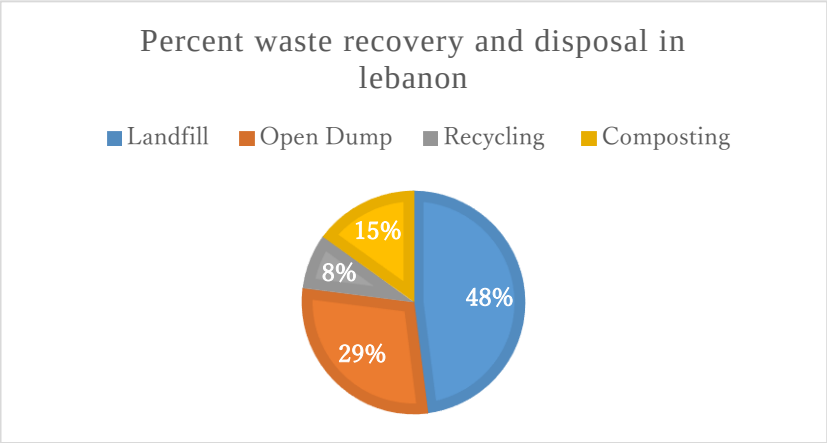

Fig. (1) Percent waste recovery and disposal in Lebanon.

Source: (Abbas, 2017)

By looking at different studies done all over the world and Eco-town Kitakyushu in particular, this study is to prove that partial solutions don't solve the problem; rather a green waste management system is needed. There are many things that make waste management system successful; the most important one to be taken into consideration is

establishing a developed Eco-town, increasing public awareness and involving people taking into consideration 5 Rs: reject, reduce, reuse, recover, and recycle. Therefore, it is required to educate people to cooperate for the success of the system. Based on this, a model was developed with best practices that suits the Lebanese people. A feasibility study for the model was conducted collecting data by a questionnaire. 121 questionnaires were collected, out of which 4 were rejected due to lack of data. Out of the 117 respondents, 91.5% are affected or highly affected by the negative practices of waste management. As a result, 61.5% are willing to actively participate in saving the environment and 90.6% would like to be engaged in forming a sustainable system that solves the problem of garbage disposal. Lastly, 89.7% are willing to do segregation even without financial incentive and only 10.3% will do separation only if they got financial incentive. However, nobody rejected the idea of separation. In addition, they showed acceptance of using recycled materials and working in a recycling factory. All in all, this emphasized the importance of decentralization where all stakeholders have to cooperate for the success of this suggested model.

CHAPTER ONE: INTRODUCTION

1- Introduction to Lebanon and Eco-Town Kitakyushu.
2- Research objectives.
3- Research questions.
4- Limitations.
5- Hypothesis.

CHAPTER ONE: INTRODUCTION

Since July 2015 Lebanon suffered from garbage filling streets, gardens and the sea. This situation pushed the Lebanese government to accept that the claims of locals living in the neighborhood were legitimate hence a quick action has been needed to be taken to stem the tide of worsening health condition in the main landfill “Naemi”. Naemi landfill was established in 1997. In 18 years, 12 million tons of waste were dumped there, which was higher than the capacity that the Naemi landfill could accommodate. (Aboujaoudé & Chalfoun, 2017). It led to 80% of deaths resulting from worsening health conditions like cancer in the surrounding area. (Hamzah, 2019) This led to the revocation of contract of the company named “Sukleen” which was assigned with the collection of garbage in Beirut and surrounding areas. From that time onwards nobody dumps their garbage outside. The current available solution the government has is a local landfill. However, no region accepts having a landfill in their residence area, as this is the major cause of infectious diseases, nasty smell and disgusting scenery. Urgent short-term solutions were like distributing white bags to reduce the negative effects. Some people burn garbage in the street, some bury it in gardens, and others throw it into the sea. A personal initiative came from an engineer who started a recycling factory, but its capacity was very small in comparison to the need. Some supermarkets bought small machines to recycle PET bottles like a vending machine. Many associations launched initiatives such as encouraging people to do separation to reduce the negative effects. However, there is

no point of separating without having a recycling factory. On the governmental level, the project that was mostly agreed on was having incinerators and they thought it was the best solution. Meanwhile all projects have been short term and there has been no sustainable project to save the environment and change the situation. The aim of this study is to develop a model for a thorough sustainable waste management system in Lebanon based on the Kitakyushu Eco Town and test whether it would be feasible. (Details of the Kitakyushu Eco Town Appendix- B)

1-1- Research objectives:

1- To identify prerequisites to develop a total waste management system.

2- To improve waste segregation by the community through education.

3- To test the effectiveness and feasibility of developing Eco Town concept in Lebanon.

4- To keep the suggested system sustainable and up to date.

5- To substitute, even if partially, the current landfill system with Eco Town.

1-2- Research Question:

1- What model best illustrates the Kitakyushu success factors for waste management system?

2- Can the suggested model be feasible in Lebanon?

1-3- Limitations:

Due to the long distance between Japan and Lebanon, great efforts were needed to contact people concerned, as well as distributing a questionnaire. Because of the new model variables, it is difficult to assess the understanding of the various questions in the survey by those who answered. Unfortunately, after trying for many months to get a response from various government offices in Lebanon non was forth coming. Some data was only available in Arabic which needed to be translated into English.

1-4- Hypothesis:

1- There is statically a positive relationship between social cooperation and sustainability of the suggested model.

2- There is statically a positive relationship between waste treatment system and sustainability of the suggested model.

Sub hypothesis:

1- Eco Town in Kitakyushu has valuable implications for developing a total waste management system in Lebanon. The model suggested by this research is feasible

CHAPTER TWO: LITERATURE REVIEW

Chapter two is a summary of literature review, and it is divided into three main areas:

1- Education
2- Segregation
3- Technology

CHAPTER TWO: LITERATURE REVIEW

The purpose of this chapter is to summarize the most effective studies done in different parts of the world and try to learn from them to develop a thorough management system that is suitable to Lebanese nature.

2-1- Education:

2-1-1- Design and Development of an Integrated Solid Waste Management System for Huai Nam Khun, Thailand. (Duong, 2010)

The study explains about different types of people living in one area. The purpose of the study to bring up the quality of life of those people. The study explains about the project, the cost and limitation which is "human fabricated systems are never perfect; however, it is not based on the perfect design to avoid project failure"

The model simulation shows that the system is feasible and theoretically 71% expected reduce the waste volume. As shown in Fig. (2-1), the study suggests different methods such as incinerators, recycling and sometimes education is needed. This is basically the need to gather waste from different areas and then educate people. So "waste separation station" shows the different area samples. Waste collected from those areas can be used in those ways shown in "components within each waste station" depending on the type of waste collected depending on different numbers and types of people living in each area. Depending on geographical location in addition to waste type, the type of treatment differs. For example, the population of "Akheau Tribe" is 62 while

the population of “Chinese Tribe” is 1000 which needed different treatment. Another example, “HNK” is Health Clinic area that is why incinerator is necessary.

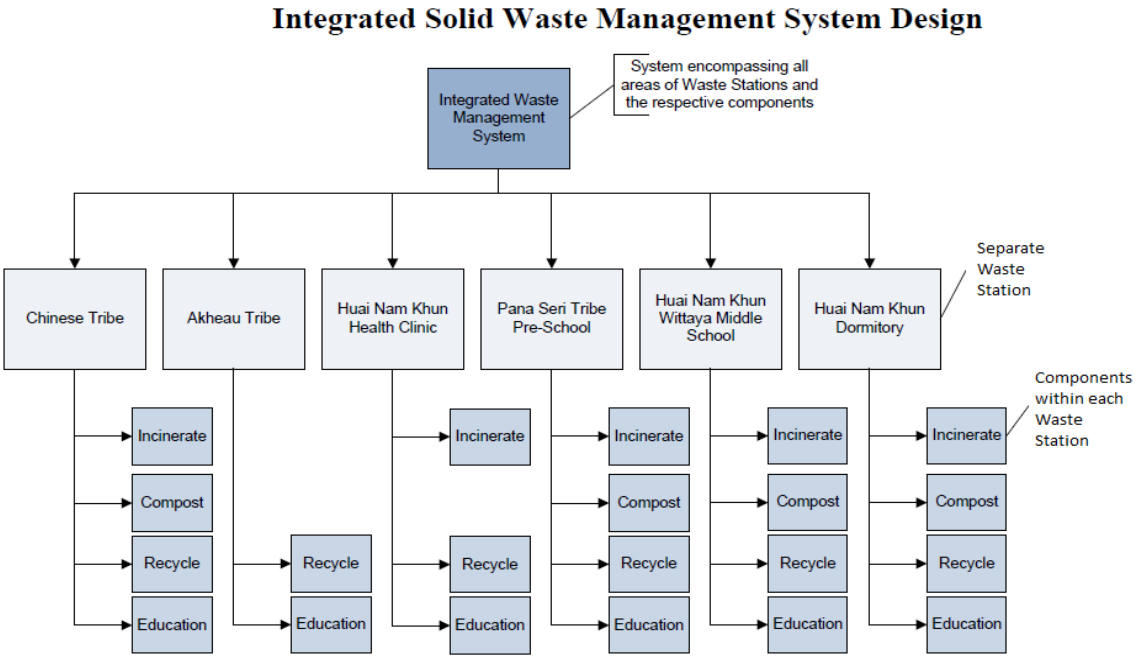

Fig. 2. 1. ISWM design.

Source: (Duong, 2010)

2-1-2- New Approaches to Solid Waste Management. (Ezugwu, 2015)

The goal of applying the new approach is to make the system Cost-effective and create value. This is done by focusing on 4Rs to create wealth and to reduce the final wastes going into the landfills, launching education programs supported by government, encourage those who deal with waste according to the rules, and applying sanitary landfilling. Some examples of the 4Rs are the following:

Reduction: typing on both sides and double line spacing method reduces paper waste four times.

Recycling: lead from used batteries could be recycled to produce new batteries.

Reuse: used tires could be shredded and used as aggregates for concrete works to repair

worn-out roads.

Recovery: “The processing of recyclable to extract or recover materials and resources, or convert to energy”

2-1-3- Sustainable waste management strategy for a campus: a case study of JUET, Guna (Shiva Shankar Y., 2017)

The researcher stresses the importance of solid waste management through ISWMS in order to minimize waste and gain economic benefit. Due to diversity, lack of financial resources and awareness among the residents, the paper stresses the role of technical institutes and higher educational institutions to nurture minds about the need to develop a sustainable society and view the waste as a resource.

They applied a recycling project at “Jaypee University of Engineering and Technology” and trained students how to do segregation and extract biogas generated from organic waste, and resource optimization through (reduce, reuse and recycle).

2-1-4- *Analysis and overview of industrial solid waste management in Kuwai*t"

(Alhumoud & Al-Kandari, 2008)

They only describe the current situation and all of them show how they don’t have a good use of the waste management. They don’t have a waste management system. According to this study what is missing is public awareness and they don’t have a good management system. As we know cooperation between institutions and people is important. That is why this paper emphasizes the importance of awareness.

2-1-5- Mathematical Models for Eco-Industrial Networks (Bissett, 2014)

The researcher shows two problems facing WMS “First is planning an eco-industrial network from a set of existing firms” which is the connection, network. “Second, provides an acceptable level of perspective in the management and evolution of an eco-industrial network already in existence.”. This means to bring all people involved in the system and bring them together. Eco-industrial network” is all about behavior and network.

After that, the study provides the Classic Factors of Sustainability model as shown in Fig. .2.2. Sustainability is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. The three main components of sustainability are "economy, environment, and society". The overlapping between economy and environment formulates Eco-economic. Also, the overlapping between society and environment formulates Eco-social. For example, economic growth is a cause of population growth, which in turn causes resource depletion, inevitably followed by disease, famine and population decline.

Fig. 2. 2. The Classic Factors of Sustainability.

Source: (Bissett, 2014)

2-1-6- **The last frontier**: **Market creation in conflict zones**, **deep rural areas and urban slums** (Anderson, Markides, & Kupp, 2010)

The case focuses on community challenges facing companies when trying to inter BOP markets due to instable economy. The traditional way was through a partnership contract while the study provides the new approach "Community Buy in strategy through a partnership with leaders-company partnership, due to leader's trust and influence in the society. Training leaders will provide them with entrepreneur abilities. In accordance with the effect and influence a leader has in his community; he will be able to market companies' products in an effective way due to the influence he has in his community as shown in Fig. 2.3.

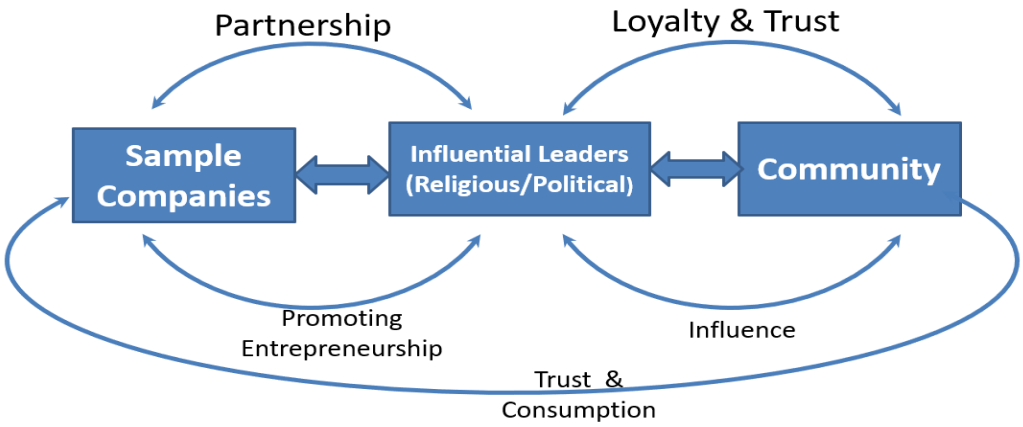

Fig. 2. 3. Community Buying-in Strategies.

Source: (Anderson, Markides, & Kupp, 2010)

This same model can be used in developing the waste management system in Lebanon, where political life plays a very important role. Having a good relationship with political people and leaders, will have a good impact on the acceptance of the suggested system and increasing commitment.

2-1-7- Design and Development Waste Management System in Hong Kong. (Lee & Wu, 2014)

The article talks about shifting Hong Kong from landfill to NFC & RFID-based waste management system. In addition, a project was applied at Polytechnic University where 3 types of smart bin (paper, metal, and plastic) were installed at university and they open by student ID. This caused the improvement of recycling rate and has a positive impact of public awareness towards the importance of separating waste. What is negative is that students increased their waste volume from 1.63 KG/day to 2.5 KG/day in order to have recognition because of the incentive the system gives depending of student ID usage. As a result, applying WMS might sometimes increase waste volume.

Applying Volume-based Waste Fee System (VBWF) helped reduce waste production by 23%. For example, to reduce food because of its high recycle cost, it has to be thrown in a special bin that opens using the password of each household and they are charged depending on the weight of food waste. This helped reduce food waste volume from, 2.8 to 1.6 KG.

Lastly, the article suggests linking the WMS with social media to encourage applying WMS by showing how much we saved the environment. For example, 1kg of recycled metal can reduce 6.9 kg carbon emission and each 85.8 kg reduction in paper usage saves 1 tree. Lastly, 28.5kg of recycled plastics can reproduce 19.5 kg of oil.

2-1-8- Waste Management Systems in Lebanon (AZZI, 2017)

The study shows that there was a good part of the waste crises in 2015. Because of the crises people learned. Before the crises, landfill was used but now it is closed. People did not know what to do that is why the crises occurred. That is why people were thinking of doing new things. As a result of the new things, WM was decentralized. People were trying to do waste management on their own instead of landfill on an individual level. But this is not effective. The reason is that they couldn't tackle those three things "final disposal, energy recovery and financing". They couldn't know how to do final disposal because the landfill was closed. Nor they could do energy recovery because it is spread, they were not able to keep it up because they need more finance. Because if it was centralized i.e. done by the government, there will be no problem. Financing will not be a problem because it is government money and there is large quantities of waste and it is possible to do energy recovery, final disposal would not have been a problem because government will take care of it. In addition, reducing the space of landfill.

Another idea the article shows is SWM solid waste management. The main concern of SWM is these three things: "public health, environmental protection, resource management". It started in the 1920s with public health because in the past when people started producing waste, it had impact on peoples' health. That is why they took waste to rural areas outside the city and started dumping it and that problem was solve. After that they realized that just dumping is not everything because it is causing environmental

problems such as pollution. Then they realized that waste is not only waste, rather it is a recourse. After that the integrated solid waste management ISWM developed by Dutch NGO went beyond those three things. ISWM has 2 things physical system and governance system. They use both to reduce waste and improve the society. So, the physical system includes public health, environmental protection, resource management; and the governance system includes user inclusivity, financial sustainability, and sound institutions. With only physical system, it is not integrated. For the system to be integrated and sustainable governance need to be included. In governance you must include as many users as possible such as households, firms, government, all should work together. Sound institutions: by making sure that every party they are dealing with has proper information what they are doing. Financial sustainability, people should know how much the cost is and how much income can be made. Achieving those three things together with the physical system, will create integrated sustainable solid waste management as shown in Fig. (2.4)

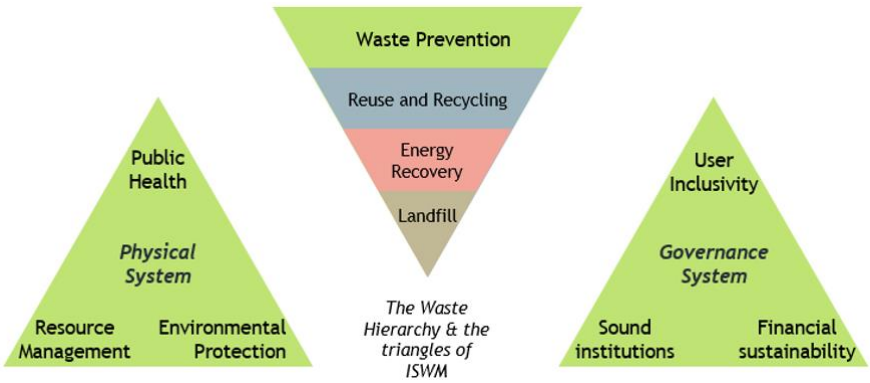

Fig. 2. 4. The two triangles of drivers in ISWM and the waste hierarchy.
Source: (AZZI, 2017)

The idea of "the waste hierarchy" is the concept. Using ISWM, using physical

system and governance system, what they are trying to achieve is “the waste hierarchy” from bottom up. They start with landfill but try to reduce and go to energy recovery. After that, try to reduce energy recovery and try to increase people using reuse and recycling. After that try to reduce reuse and recycling and increase waste prevention. Because if waste prevention can be increased all below will decrease. So, the ultimate goal is waste prevention to achieve zero waste. However, it is not definite that using this model will achieve waste prevention. But trying to improve the physical and governance system, then we can go from one step to the other. Therefore, the researcher is trying to say that ISWM is a better model compared with SWM. Applying this model in any country will help in achieving waste prevention which is the ultimate goal.

The main idea the researcher is trying to convey is trying to define the role and responsibilities of each stakeholders. On the other hand, with the centralized system Lebanon had, responsibilities were not known by the people. They didn’t know why WM is important, why it is happening, what to do, firms didn’t know how much revenue they might get, and government did not realize how much trouble it is causing to the environmental pollution.

However, currently in the Lebanese system, they are only focusing on the short-term needs. The reason is that it is not defined. The stakeholders, the firms and household do not know what the long-term goal is. That is why he suggests using the IWSM to educate people about the long-term goals and lower dependency on landfill. What is more

is that the decision-making process is discrete and done between two parties without the public information and could benefit from more transparency in public participation. That is why he is suggesting a law that decision cannot be made by just 2 parties. For the decision to be made and for that to be implemented, the public should be involved. If it is a centralized system, decision is made mainly for the private benefit of the company and the politicians. He suggested that the decision-making process, should include the participation of public like organizations, NGO's, local authorities, municipal councils …etc.

As for laws, he said that you don't make laws in such a way that it will reduce waste, by stopping people from putting waste, they need to know about treatment, reuse, recycle, energy recovery and landfilling. Another problem in the Lebanese government, there is ministerial management, each ministry is responsible for one part of WM. This causes a problem because there is not continuity. That is why he suggests having an agency of waste which is not part of any ministry rather under the central government. The aim of the agency is to try to reunite ministries, municipalities, contractors, business, industries, informal factors, and civil society. At a strategic level he is suggesting more specific goals beyond the traditional normal waste industry. For example, currently government is telling public not to put waste on the streets, but they are not telling them the goals why they are telling them to do that. If you tell them to stop putting waste, waste becomes a problem only in case of stopping collecting waste. That is why understanding

is needed. At the operational level, priority should be given to improve the collection system. For example, if collection system doesn't improve, the biggest problem will be manual separation which is too much expensive and output quality such as compost will be low. That is why if from the first place, waste is segregated, it will reduce operation cost and improve quality of items produced.

As a result of the 2015 crises, awareness increased to segregate waste. Without the crises people would not have understood that.

Suggested decentralization:

Table 2- 1 Summary of features for each component of the Lebanese SWM system

Source: (AZZI, 2017)

	Formal Central System	**Informal Central System**	**Formal Decentralised System**
Legitimacy or merit	***Basic*** collection and disposal ***services, for all***.	Social and environmental impact via ***quality resource recovery***.	Better collection and ***treatment*** services, locally.
Main support from …	Central government.	Social businesses, NGOs.	Local powers, NGOs, CBOs.
Area of expertise	GBA and dense areas.	GBA and dense areas.	Mountain & rural areas.
Dynamic	Shrinking catchment area. Internal reform.	Expanding number of clients and services.	Expanding number of projects and services.
Challenges	Higher diversion rates. ***Improved collection. Lower corruption***.	Formalisation. ***Recognition*** by central government.	***Residual waste.*** Cooperation internally and with government.
Waste Flow (tons/day)	**2500-2700** (decreasing)	**150-550** (increasing)	***100 – 200*** (increasing)

The current used system is basic collection and disposal services. He is suggesting having better collection and treatment services like moving from central government to local powers from "dense areas to rural areas". In addition to expanding

the number of projects, residual waste. This is what he means by decentralization. However, this view needs to be tested more fully.

"The responsibility of the national authorities is to recognize the multiplicity of waste actors" people who are involved to share responsibility and increase cooperation. Focus should not be only on solid waste rather on "environmental threats, energy failures, water supply and sanitation". Those things must be told to society to be done with a "clear waste decentralization framework". The main argument is "the lack of cooperation between the actors as a limiting factor to the overall efficiency". If the new municipal projects are decentralized, if you lead local authority's municipal council to do more projects, then it will cover many parts of the ISWM features. ISWM has Physical system and governance system. Regarding the physical system, the municipal projects can be implemented properly rather than with centralization, then it will "achieve higher diversion rates, ranging from 20% to 90% thanks to attempts of producing quality compost and an improved collection" Landfill space is thus saved but the options available to municipalities for proper handling of residual waste are limited". Having governance system, it achieves better user inclusivity and has seen the first attempts of financial sustainability through user fees" charging people money to create revenue to make the system sustainable

2-1-9- Country report on SWM in Lebanon (SWEEP-Net, 2014)

This report explains about the current system in Lebanon based on "bailing,

wrapping, multiple handling and landfilling, with insufficient sorting and little composting, and at costs which are substantially high" this is one problem. Today there is "no specific legislative framework that deals directly with SWM in Lebanon" i.e. no proper framework identifying to meet all these problems. Like the previous study by "Azzi" he says that "Enforcement of these laws is however relatively weak, and responsibilities are not well-defined". Because people do not know their responsibilities they don't act. Also, there is no cooperation between authorities. You can't implement ISWM because people don't know their responsibilities. The report talks also about how budget is currently allocated in Lebanon. They don't know where to get the money from. Mainly, money is allocated in four sectors: first comes allocation of budget by CDR, after that this budget is transferred from the municipal funds to the municipalities to meet required costs in addition to international aids. The last financing is by municipalities for plans and projects. The private sector is more efficient in Lebanon than the public one in both technical and financial levels. There are two companies assigned with collecting waste named Sukleen and Lavejet. The report emphasizes public awareness. There is lack of knowledge from the public about the methods and ways for SWM and decision making to develop a good strategy and successfully put it in action. There is «Not-In-My-Back-Yard» (NIMBY) syndrome which means if garbage is not in my house and in my garden, I don't care, and this is a real disease that many suffer from in Lebanon. There were attempts to implement sorting, but were not successful except in rural villages. There are

two types of waste hazardous and municipal, but they are not properly segregated rather mixed to “due to the absence of a well-defined legislation and more stringent controls”. Health care waste is another big problem where “only 2% of the private medical laboratories, 20% of the public hospitals and 32% of the private hospitals treat their infectious wastes” and the rest is not treated. So, 98% of laboratories, 80% of public hospitals, and 78% of private hospitals’ waste is infectious. That is why a proper separation and special treatment are needed to reduce its negative effect. Many international organizations and donors are playing a role and they are mainly doing those things: “feasibility studies dumpsites rehabilitation, marketing of compost; (ii) development of national strategies, provision of infrastructure, strengthening and developing the capacity of stakeholders, and increasing awareness”. The main part of this report is suggesting Sweep Net which is an international organization acting through the internet. That is why Lebanon should be able to use this website to identify their help. “Sweep-Net network will help to ensure that valuable knowledge is being linked via websites and that potential users know where and how to look for information”. They are trying to educate people, the government and everyone through the internet. So, what can be done through this Sweep net is “training and capacity building activities, workshops, e-learning, technical and advisory services, field missions and technical visits, development of guiding documents, regular reports on waste management, and support of awareness campaigns”. In order to solve SWM problem in Lebanon, “Sweep Net report

2014, P.13" results are summarized in 14 ideas: " (i) issue legal framework through the issuance of the Law; (ii) evaluate previous strategies (iii) develop and issue a specific implementable national policy and strategy; (iv) ensure an efficient and cost effective implementation of private sector participation; (v) focus on enhanced cost recovery; (vi) set the applicable decrees for cost recovery; (vii) ensure capacity development; (viii) enhance public awareness; (ix) assess the objectives of proposed projects; (x) ensure the institutional viability of any project; (xi) ensure political commitment (i) feasibility studies; (ii) development of national strategies framework; (iii) provision of infrastructure for solid waste collection; (iv) closure of existing dumps; (v) execution of SW treatment facilities; (vi) strengthening and developing the capacity of stakeholders; and (vii) awareness programs". However, the report shows that it is difficult to achieve this because there is no coordination between stakeholders and due to political and economic conditions but those what must be done according to them.

2-2- Segregation:

2-2-1- Design of a waste management model using integrated solid waste management: A case of Bulawayo City Council. (Mwanza & Phiri, 2013)

In Bulawayo there was no separation, so the author provided a system for separating and transporting garbage as shown in table 2-2

Table 2- 2 Waste Receptacle and collection method

Source: (Mwanza & Phiri, 2013)

Source	Waste generator	Waste receptacle	Collection method
Residential	Households	Black refuse bags, Hard plastic bins	Curbside, informal, Simple-emptying
Industrial	Industries	Skips, metal bins	One-way, non-systematic
Chemical	Chemical plants	Skips, metal bins	Exchange, one way
Agricultural	Farms, Vineyards	Hard plastic bins	Simple emptying
Commercial	Restaurants, stores, hotels	Hard plastic bags, plastic bins	Simple emptying
Institutional	Schools, colleges, prisons, hospitals	Metal bins, Hard plastic bins	Simple emptying

Separating at the source will make waste transportation to the disposable area an easy process. The researcher suggests as shown in table 2-2 to separate waste into 6 types according the source starting with household “residential”, industrial, chemical, agricultural, commercial and institutional. Then he suggests the receptacle for each type such as skips, metal bins for the industrial and chemical waste. And lastly, he suggests a collection method for each type such as exchange, one-way collection method for the chemical waste while simple emptying method is suggested for the agricultural, commercial and institutional waste.

Next the author suggests using the integrated solid waste management system instead of the existing systems. By studying “The Components of Solid Waste Management System in Bulawayo Municipality” and “IWM Waste Management Model”, the study provided a new model named “Conceptual Model of BCC ISWM” as shown in Fig. 2-5.

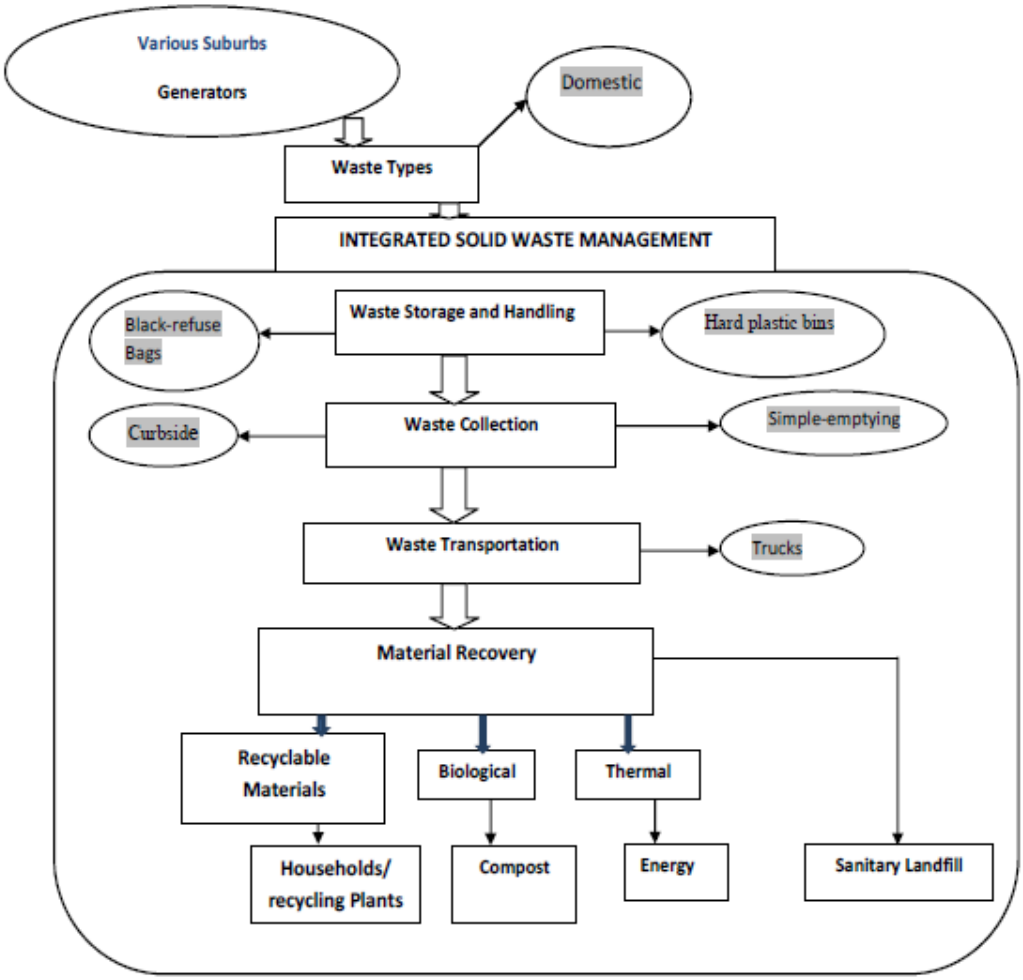

Fig. 2. 5. Conceptual Model of BCC ISWM.

Source: (Mwanza & Phiri, 2013)

2-2-2- **Designing a Sustainable Waste Management System: The Strategic Planning Model and Related Sustainability Issues.** (Elsaid & Aghezzaf, 2016)

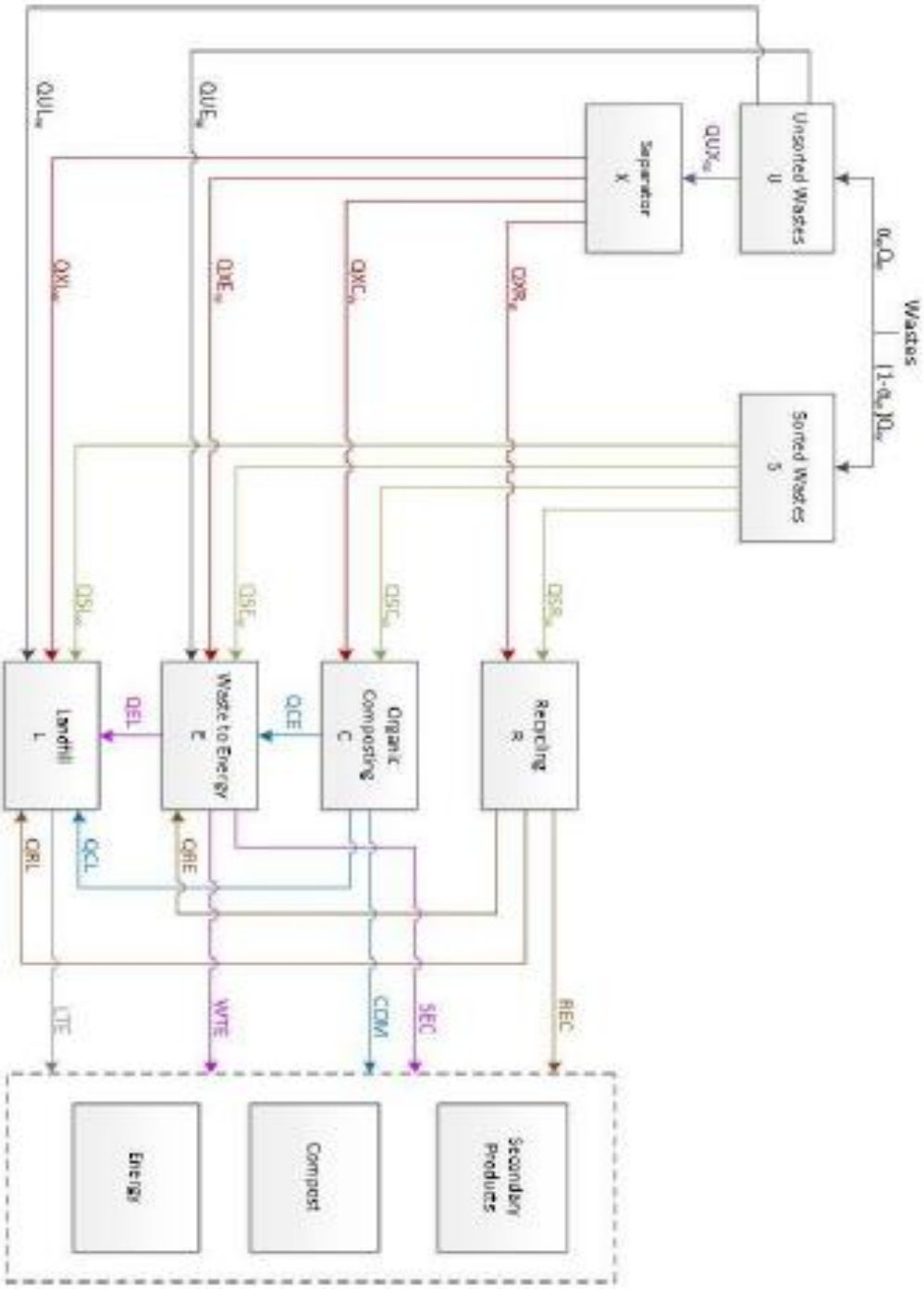

Fig. 2. 6. Flow of waste & different treatment categories.

Source: (Elsaid & Aghezzaf, 2016)

This model describes in this city what happens to both sorted and unsorted waste. If sorted then R, C, E, and L (recycling, organic composting, waste to energy, and landfill) will

follow and if it is unsorted, then it has to be sorted using x (separator) then R, C, E, and L will also follow.

aw Qw is the unsorted waste = 1. So (1-aw) Qw is the sorted waste.

If W. represents all possible types of waste and Q quantity, then Qw is the total amount of waste per year. αw represent the unsorted portion of the total amount Qw. Hence αw and Qw describe the current waste management practices in the city.

The mathematical model shows the cost related to each model. i.e. if you want to do recycle, if you want to do organic, if you want to do energy or landfill, what will be the cost?

$$ValR(REC) + ValS(SEC) + ValC(COM) + ValE(WTE) + ValL(LTE)$$

Total Value

$$- \left[\sum_{w}^{W} Sepacost(QUX_w)\right.$$
$$+ [Recycost \sum_{w}^{W} (QSR_w + QXR_w)]$$
$$+ [Compcost \sum_{w}^{W} (QSC_w + QXC_w)] + [Enrgcost(QCE + QRE$$
$$+ \sum_{w}^{W} (QSE_w + QXE_w + QUE_w)] + [Lanfcost(QEL + QCL + QRL$$
$$\left. + \sum_{w}^{W} (QSL_w + QXL_w + QUL_w)\right]$$

Total Cost

ValR, ValS, ValC, ValE, ValL represent the recycling materials. Recycled materials can be sold at different prices and generate money. Their target is to maximize profit, and this is the maximization equation. Value of recycled waste, value of recycled composite, value of recycled landfill, it all should act together and be the maximum

amount. Maximization = money received after recycling “total value” minus the sum of all related costs “separation cost + recycle cost + compost + energy cost). In short, this model shows the costs of all the entire system, QSR cost and QXR cost. Compost has QXR and energy cost because there is energy there. So, energy has two different types. i.e. those are the 4 different types of values minus the different types of cost, and each cost has its sub- cost.

2-2-3- Mahajan Niyati, 2015, A Comparative Study of Municipal Solid Waste Management in India & Japan (Niyati, 2015)

One of the main reasons of the difference between India and Japan is that population in India increased dramatically to 181 million during 2001– 2011, while it stayed almost the same in Japan 126.9 million in 2000 to 128 million in 2010

MSW in India production ranges from 0.21to 0.50 Kg per capital per day. An increase is expected from 34 million in 2000 to 221 million tons in 2030 while in Japan it decreased from 1.18 kg in 2000 to 0.97 in 2010 (52 million tons in 2000. out of which 77.4% was incinerated and 5.9% landfill and 16.7% was recycled).

- Many regulations were taken in both countries where it worked in Japan and it became a habit while it didn’t work in India. One of the reasons is that municipal authorities do not provide the service for door to door collection of waste, even though such service is mandated in the rules. They only collect from communal bins or street collection points. In Japan, citizens do separation into

combustibles, non-combustibles and recyclables in specified transparent bags and the municipality collects it from a certain place at an accurate date and time.

• Finding: necessity to broaden the scope of laws in India.

• It is difficult to apply the Japanese system in India, due to composition in waste and the expensive technology used in Japan. That is why there is the need to use HRM in the informal sector to increase the recycling rates, and "require time to time advancement in the regulatory system for achieving a sound waste management society"

2-3- Technology:

2-3-1- *Economic and Environmental Cost Analysis of Incineration and Recovery Alternatives for Flammable Industrial Waste: The Case of South Korea*. (Kim & Jeong, 2017)

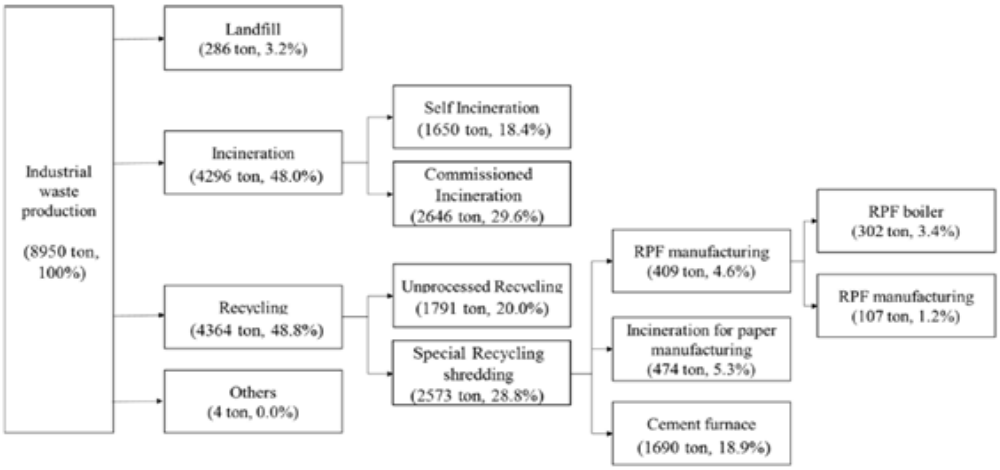

Fig. 2. 7. Treatment status of industrial waste in Korea.

Source: (Kim & Jeong, 2017)

The focus of this study is that waste management is an opportunity to produce energy. Methods differ in the amount of energy they are going to produce. In the past landfill was only used, then focus was on incinerators and now we reached a stage of energy

production. This major contribution is a model with numeric indicators that can be used to compare different waste treatment methods. Community and institutions are also necessary to do this work. The focus of this study is “To improve the environmental benefits; expanded investment in energy recovery equipment is required” That is why it is very important to invest in the mechanism.

2-3-2- Decision Making Under Stress: An Exploratory Study in Lebanon. (Hejase, Hamdar, Hashem, & Sleiman, 2017)

The article uses stress test. Stress test is usually used by banks. For example, the bank needs to keep capital requirement. Stress test checks if tomorrow there is a financial crisis, how much money you need to keep in the bank. The researcher used regression R2, significant change, normal distribution, and correlation.

In case of applying this study, a stress test can be used to study how much the cost of implementing the suggested model is and if inflation of Lebanon goes up, foreign exchange goes up, or unemployment level increases, what will happen to the feasibility study?

2-3-3- Collection of Municipal Solid Waste in Developing countries, (Coad, 2010)

The most important part of this study is the treatment of solid wastes: 1- Incineration divided into Incineration of municipal wastes and Incineration of hazardous wastes. 2- Baling 3- Size reduction

The study shows how to deal with the community and politics, strength and weakness of the informal sector, relationships with the informal sector and conflict resulted and the weakness of the informal sector (attitudes, conflicts, and integration). (p.127)

The study also tackles: collection methods, public participation, making street sweeping

efficient, safe and flexible, and emphasizing the relationship with the community.

In summary, the above models have various results that are valuable for using the current study. "Mwanza and Phiri, (2013)" introduce the different types of waste acording to the 6 categoies mentioned (residential, industrial, chemical, agricultural, commercial and institutional) and discuss possible ways receptacles and collection methods to be used. Therefore, in order to have an integrated WMS, we can't focus only on household waste, rather the 6 categories must be taken into consideration. Using maximization equation by "Elsaid and Aghezzaf, (2016)" will help to reduce the cost and increase the profit. Stress test "Hejase, Hamdar, Hashem, & Sleiman, (2017)" can be used to study how much the cost of implementing the suggested model is and if inflation of Lebanon goes up, foreign exchange goes up, or unemployment level increases, what will happen to the feasibility study. The study by "Duong, (2010)" informs this study of the Integrated Waste Management System and the fact that the most important thing to solve the roots of waste problem is through educating people. Applying this will lead to "minimizing the solid waste pool effectively by 71%."

Grouping literature review can be summarized in the following figure:

CHAPTER THREE: RESEARCH METHODOLOGY

Chapter three states the suggested model and steps to apply it:

1- Suggested model
2- Implementing the propended model in Lebanon
   - Steps of application
   - Stages of application
   - Location analysis for Eco-Town in Lebanon
   - Logistics
   - Partners to be involved.

CHAPTER THREE: RESEARCH METHODOLOGY

3-1- Suggested Model:

Based on studying the most important studies done on WMS, a new model was developed with best practices that suits the nature of Lebanon. The model was designed simple so that it will be easy to apply it.

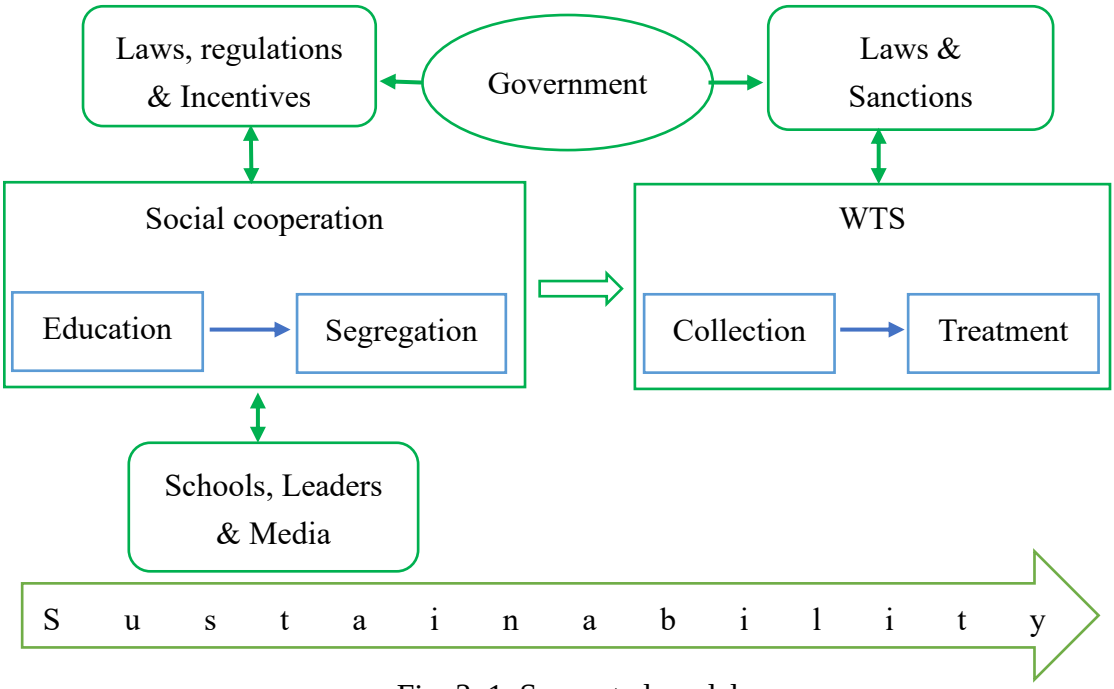

Fig. 3. 1. Suggested model.

Source: the author

The suggested model starts along with the establishment of the infrastructure, so that to focus on the three main areas shown in the literature review and the ultimate goal is to apply the model and make it sustainable. That is why the most important thing is to educate people to do the segregation and to involve them effectively. Next, establish smart trash bins, collection centers, and re-purpose point or WM shops. After having an effective segregation and collection system, waste will be transported to the Eco-Town to be treated. Involving the government is very important to monitor application.

In short, the model consists of two independent variable first social cooperation and understanding and second waste treatment system, which leads to the dependent variable sustainability. Educating society will increase awareness to do segregation effectively. This will lead to the waste treatment part to collect waste and treat it to get outcome. Applying this will lead to the dependent variable sustainability which consists of the overlapping of economy, environment, and society as mentioned in Figure 2.2. in the literature review.

Stages to do education are schools to educated children the importance of saving environment and how separating waste will have impact on saving the environment, leaders due to the influence and trust they have toward community "as mentioned in the blue ocean strategy", and media where it plays an important role in Lebanon. Collection can be done through various ways such as using smart trash bins for food waste, PET bottles and paper; or through collection centers and WM collection shops.

The suggested model focuses on the following:

1- Increasing environmental awareness and encouraging people to be active players towards the environment such as rejecting unfriendly products. In doing that, collective awareness will oblige companies to produce friendly materials. In general, the Lebanese people have a negative attitude about WM and blame the government and others. However, this study encourages changing such habits and taking an action rather than waiting for others to do something.

2- Involving people, government, organizations. Involving people through financial and non-financial activities and making them shareholders will increase their commitment. Also, involving government due to its important role in covering the whole system and involving environmental organizations and universities working in the sector are crucial elements for the success of the suggested system.

3- Financial incentive and strict law are the most important factors to have commitment in Lebanon.

4- Involving effective leaders such as deputy speakers. [Anderson, Markides, Kupp, 2010]

3-2- Implementing the proposed model in Lebanon:

3-1-1- Steps of application:

To apply the suggested model, we have first to start educating factories, then educate household, and lately using the smart trash pin in order to help with effective segregation as shown here in detail.

1- Factories: In order to reduce, go to the source. Go to factories, educate them to do the following:

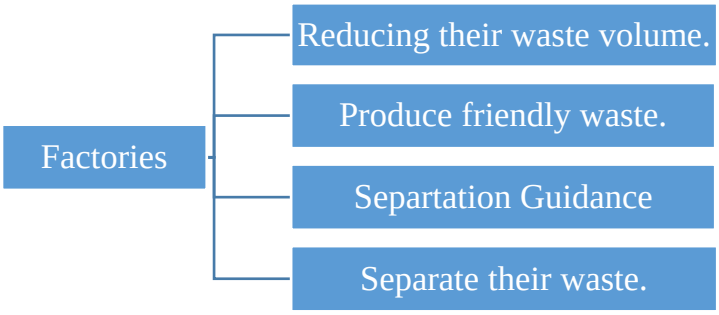

Fig. 3. 2. Factories guideline.

Educate factories how to reduce waste volume such as packaging. Produce

products that can be recyclable and reduce producing items that have negative impact on environment. Also, hazardous and non-hazardous waste must be separated properly. Second, establish guidance for household to do separation in the real sense of the word. (not to say this is recyclable and ingredients are not) as shown in Fig. 3.3. Lastly, to separate their own waste to have an effective recycling process.

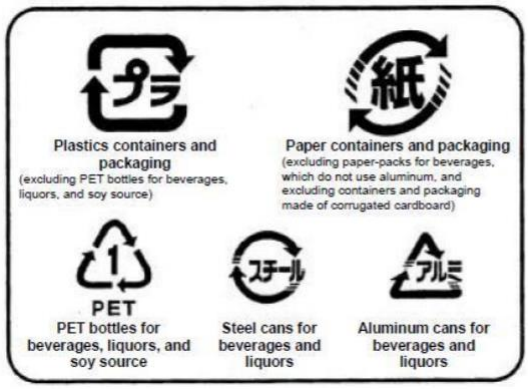

Fig. 3. 3. Identification Mark.

Source: (Yolin, 2015)

2- Household:

Educate household to do the following:

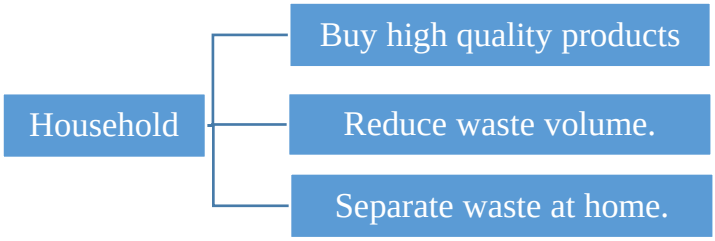

Fig. 3. 4. Household guideline.

Educate household to reduce trash volume through buying higher quality products that don't have to be replaced very often, buy things that can be repaired, and decrease buying unwanted materials in order to achieve zero waste. Lastly, do effective separation.

3- Smart waste trash bins:

Trash bins will be available in studied places near to household and do the following:

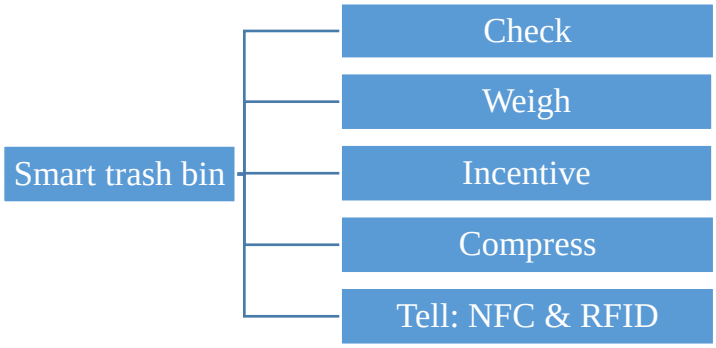

Fig. 3. 5. Smart trash bin tasks.

This trash bin is accumulation of trash bins and system done all over. The first task the bin does is checking whether this is the correct place or not. It is not enough to have separated trash bins because people will keep making mistakes even in developed countries like Japan. That is why technology is needed to reject wrong items. The trash bin will only open through a password for each house in order to weigh trash and send financial incentive as a reward for doing the effective separation. (Hong Kong case) In order to save space, the smart trash bin will have the system of the big belly. When trash arrives certain level, a sensor will detect that, and trash will be compressed. Safety factors are also taken into consideration like putting off fire and stopping the sensor when discovering a hand. (Big Belly, 2019) Lastly, to achieve the highest collection efficiency, developed NFC & RFID follow-up systems will be applied. People can also check whether a surrounding trash bin is still available or full through connected application.

For the first 6 months a guide person is needed to tell people how to do the separation. That is why in the training stage, smart trash bins will open with the guide person password. (Niyati, 2015)

4- Things will end up with the Eco-Town to maximize profit. [Elsaid Aghezzaf, 2016]

There are many techniques in waste management treatment such as compost, incineration, CAPEX, Anaerobic Digestion, biogas and many other. However, the purpose of this study is not to decide the best technology to use in the Eco-Town rather it is to open to the best technology. It is also related to the decision makers' preference. The Eco-Town Kitakyushu uses different technologies depending on waste type. They use compost and biogas for food waste. What is more important is to keep the system open to continuous development and this is known in Japan as kaizen.

An example of the inventions developed to treat organic waste is Earth Cube Composter, a trash bin developed by an environmental organization in Lebanon named Compost Baladi for treating organic waste to be changed into compost. The Earth Cube decomposes organic waste within 21-30 days and then they are taken out for maturation for one month as shown in fig. 3.6:

Fig. 3. 6. Earth Cube.

Source: (Compost Baladi , 2019)

Its capacity is 20 kg/day of total feedstocks (8-10 kg food scrap and 10-12kg cover material), with low electrical power 1 A.

For larger scales this can be used.

Fig. 3. 7. ASP.

Source: (Compost Baladi , 2019)

The modular system can treat 1 ton/day of organic waste. It is estimated that Lebanon imports around 64,000 tons/year of animal or vegetable fertilizers, whether mixed together or chemically treated with a cost of $3.5 million. Such a project will play a role to reduce import (Compost Baladi, 2019).

3-2-1. **Stages of application:**

Because there are huge amounts of waste on landfills, the study suggests to divide the project into two stages:

1- Mechanical processing: This is because currently there is no separation system and because of the huge quantities of garbage filling landfill and streets. The cost of this stage is high due to the costs of separation and mainly incinerators will be used.

2- The suggested system application: Shown earlier the high costs of separation in addition to reducing the effectiveness of recycling. For example, in London sorting effectiveness is 94%. However, sorting the 6% only costs $250,000/year (Chris & Amli, 2019). That is why with education and making it as a lifestyle system, the cost will decrease.

3-2-2. **Location Analysis for Eco-Town in Lebanon:**

In order to decide the best location for the Eco-Town, many factors are needed to be taken into consideration: first geography, second political life, third governate centralized system, and fourth lifestyle -where nobody accepted to receive the garbage of other area-. That is why the study suggests establishing 8 Eco-towns one in each governorate where Lebanon is consists of 8 governorates (Akkar, North, Mount Lebanon, Beirut, South Lebanon, Nabatieh, Beqaa, and Baalbek-Hermel) as shown in Fig. 3.8.

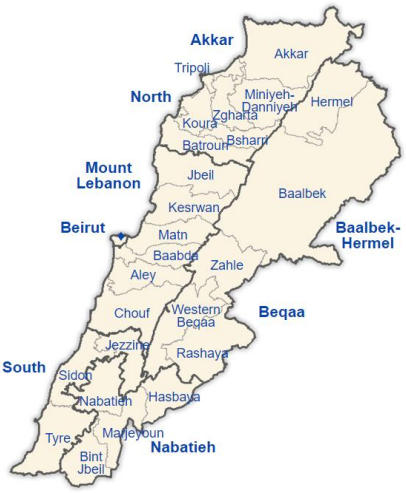

Fig. 3. 8. Lebanon governorates

Waste generation per governorates (2013):

Table 3- 1 Waste generation per governorate

Source: (Mohafaza) & (SWEEP-Net, 2014)

Mohafaza	Daily Tonnage (Tons)	Percentage of Country
Beirut	600	11
Mount Lebanon	2250	40
South Lebanon and Nabatiyeh	1,000	18
North Lebanon	1,000	18
Bekaa	750	13
Total	5600	100

This table shows the amount of waste produced in each governorate and its percentage out of the whole waste produced. However, 6500 tons is being produced a day in 2019; yet this table gives an idea.

A detailed study will be performed on North Lebanon and Beirut. Further study is needed in cooperation with ministry of environment and transportation to choose the best place and avoid traffic jam. In general, the best location is on the landfill of each governorate, yet a detailed study will be performed later on.

5-2-3-1- North Lebanon:

Staring with North Lebanon which is one of the largest governorates. It consists of 6 districts (Tripoli, Koura, Zgharta, Batroun, Minnieh-Dannieh, and Bcharreh) where Tripoli is the administrative center as shown in the map.

Fig. 3. 9. North Lebanon areas.

Source: (IDAL, 2018)

Total area size of North Lebanon is 1203 km² and it represents 11.5% of the total Lebanese territory.

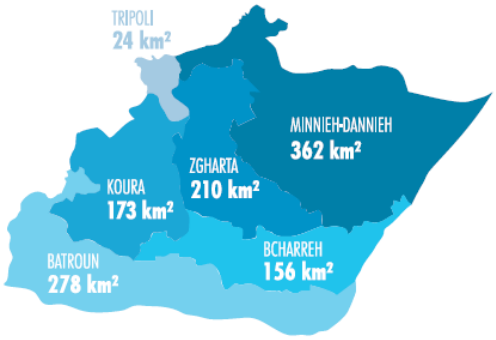

Fig. 3. 10. Space of areas in North Lebanon.

Source: (IDAL, 2018)

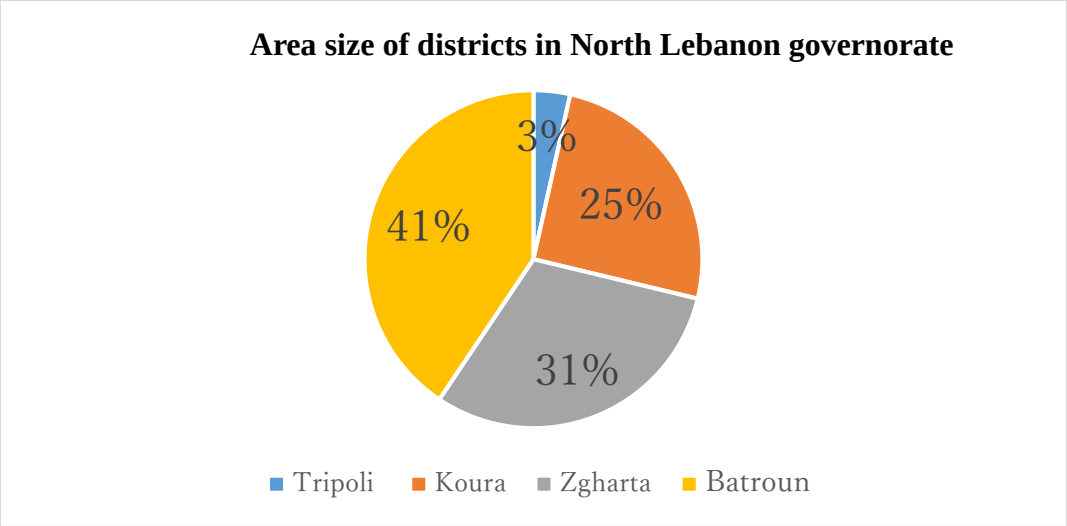

Fig. 3. 11. Area size percentage in North Lebanon.

Population: Around one million people are living in North Lebanon most of them are living in Tripoli which has the highest density as shown in the table.

Table 3- 2 Population and density in Lebanon

City	Percentage	Population	Density
Tripoli	44%	440000	14321
Minnieh-Dannieh	28%	280000	169
Zgharta	9%	90000	115
Koura	8%	80000	1277
Batroun	8%	80000	232
Bcharreh	3%	30000	433

According to (World Bank Group, 2017), unemployment rate is high in North Lebanon 9%. In addition, according to (International Labor Organization 2017), the highest poverty rate on the national level is on Bekaa 38% and North 33%. Therefore, the best location for the Eco-Town is in Tripoli according to the following reasons:

1- Highest population and highest density.

2- Lower transportation costs.

3- It takes 15 minutes to arrive from farthest area Tripoli to the Eco-town and around 45 m to arrive from Koura and Zgharta due to its mountain nature, 25 m from Batroun, and around one hour from farthest area of Minnieh-Dannieh and Bcharreh to the Eco-town. Lastly, it takes 1.5 hours from Wadi Khaled, the bordering city with Syria. In order to solve the traffic jam and enhance the collection effectiveness, the study suggests changing collection and transportation system to night shifts only. In this case time will be reduced 25 - 40% depending on the area. This is from a personal experience and from asking 10 people in different parts of Lebanon.

4- Instead of the landfill, a biological garden is suggested to be changed into a biological garden similar to the “Biological garden in Nabek, Syria” shown in the photo which is part of the CSR the company has to do to the community.

Fig. 3. 12. Biological garden, Nabek Syria, before and after.
Source: the author

5-2-3-2- **Beirut Eco-Town:**

The suggested place is in near “Naemi” landfill. This is because of the following:

1- Waste produced in the South is fully separated in factories in the area. That is why there is no need to have an Eco-town in the south. Because there is no separation at home, this causes a very bad smell causing complains from the surrounding people.

2- Some of Beirut waste is transferred to Sidon to be separated, so having an eco-town in Beirut will save transportation costs.

3- Nearly 50% of population live in Beirut and Mount Lebanon that is why it is very good to have the Eco-Town near the capital.

4- There is already a landfill there which is a good spot to be changed to a biological garden and to use a part of the landfill to bury the left unrecyclable materials.

5- Because the highest population is on Beirut and as clear from table (Waste generation per governorate) that Beirut and Mount Lebanon produce 58% of the whole waste produced in all over Lebanon.

3-2-3. **Logistics:**

Current garbage cars will be used to collect garbage on a detailed program where food waste is collected 3 times a week and carton, PET bottles, and the other materials will be collected twice a month.

Fig. 3. 13. current garbage collection cars

Changing cars is related to the decision makers. If they decided not to change cars, this car can be used but through a program to collect garbage. What is better is to have new cars provided with Crane to pull up the big belly.

Cars must be washed daily in order to avoid any hygiene problems and keep them clean. It is also possible to use cars and big belly as advertisement instruments to bring income to the recycling system as applied in Geneva. Because the smart big belly is also very clean, it can also be used for advertisement as applied in California.

Fig. 3. 14. using garbage cars and trash bins for advertisement.

“Yolin C, 2015” suggests the following model as an integrated waste management system:

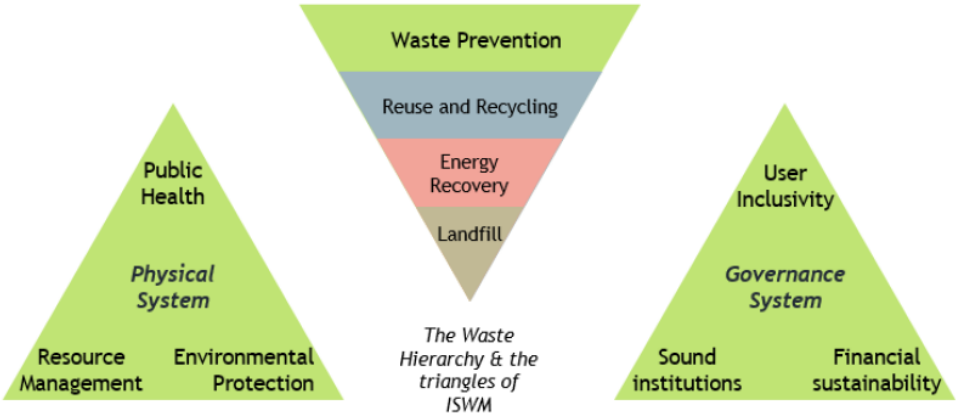

Fig. 3. 15. ISWM model.

Source: (Yolin C, 2015)

In the ISWM model, we are not creating something new, rather we are using something that is already there. According to the ISWM, there are already recycling firms, people are already educated. However, the model in this study is different because it starts with creating firms and the necessary infrastructure. Therefore, this study suggests a little modification to the ISWM model so that it can be achieved:

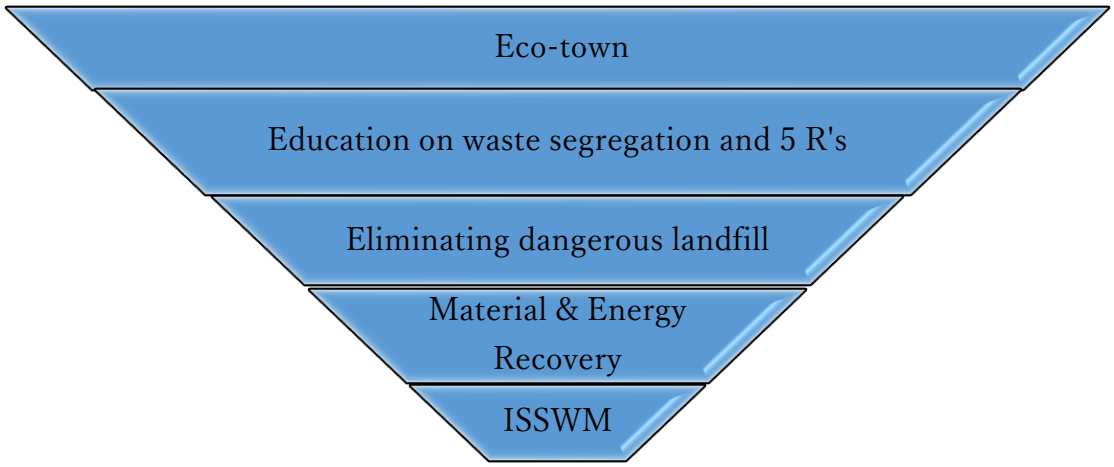

Fig. 3. 16. ISSWM.

Source: (developed by the author)

Starting from establishing Eco-Town which needs infrastructure. Then, involving people and educating people who are already ready to apply the new system because of all what they have suffered of waste problems to apply with the Eco-Town the

5 Rs: reject, reduce, reuse, recover, and recycle. Part of the education is to encourage people to use recycled materials. This is one of the most important factors for the success of WMS. The more effectively people are involved, the more the system is decentralized and successful. This is one of the main factors of the success of the Eco-Town Kitakyushu. This will decrease using landfill. The next step is to eliminate landfill by recycling waste. All of this will increase materials and energy recovery which will bring money to the system. All of this will lead to ISSWM integrated sustainable waste management system which will have positive effect on both humans and the environment.

3-2-4. Partners to be involved:

- Ministry of education to help in raising awareness.
- Ministry of health and Environment to monitor.
- Ministry of municipalities and internal affairs to monitor and implement through their agents' "municipalities".
- Ministry of finance to finance and audit.
- NGO's, Communities and the civil society as a whole
- Ministry of manufacturing and trade to monitor and educate factories and to impose sanctions if needed such as using no-recyclable raw materials for the burnable items. In addition to encouraging them to reduce chemical items and forcing them to apply ISO 14000 related to environmental management. (ISO, 2019)

- Lastly, it is necessary to mention that Lebanese law not only supports such as the suggested model rather, the government signed international treaties to treat waste.

3-3- **Research design:**

The research used both the qualitative and quantitative research design to test the model. First, a feasibility study on how the proposed model could be used in Lebanon was carried out through consultative meetings with professional consultants at the university, college of IMAT, and a consultant at Kitakyushu Eco-Town, EX Research Institute Ltd., and the resultant outcome model discussed in chapter four, section 4.1. Using this method, we will calculate the cost of recycling food waste using biogas and its possible outcomes by the means of Electricity Heat, Fertilizer (Liquid)Fertilizer - Dry Substance. Furthermore, an investment prediction with details on total income and return on investment (ROI) will be calculated in this feasibility study.

In addition to the above, we conducted a feasibility study on incineration cost which will include the unit cost as well as the process cost for this item. This will also further cover the estimates of outcome in terms of energy, fertilizers and food for animals. Lastly, the feasibility study included, calculation on cost of compost “Baladi” outcome estimation which will be fertilizers. This partially proves the sub hypothesis and analyzing questionnaire to answer the other part of the sub hypothesis. Second method, a questionnaire was designed to target 117 respondents in Lebanon and Cronbach’s Alpha, multiple regression and B correlation is used for testing the data.

CHAPTER FOUR: FEASIBILITY ANALYSIS & DISCUSSION

The chapter consists of the following points:

1- Feasibility study of:
- Biogas
- Incineration
- Compost Baladi
- Comparison to current costs of WMS in Lebanon
- Feasibility analysis

2- Questionnaire analysis.

1-5- Feasibility study:

In this chapter, we will calculate the cost of using biogas, incineration, and compost "Baladi" and the possible outcomes in addition to analyzing the questionnaire.

4-1-1- Biogas

This is a new technique used to produce electricity, heat and fertilizer through treating food waste. Here is the calculation of how much treating the food waste produced in Lebanon costs and how much the outcome is:

Table 4- 1 Biogas feasibility
Source: (Knaus, 2019)

Total quantity MSW/day	Organic fraction (in %)	Total organic (d)	Biogas yield (in m^3/ ton of organic fresh matter)	Day/year	m^3 biogas/ year
6500	0.5	3380	120	365	148044000

CH4 of biogas (in %)	m^3 of CH4 (y)	Net calorific value CH4 (in kWh/ m^3)	Energy Potential (in kWh/year)	operating Hours Cogeneration (in h per year)	Efficiency electric (eta in %)
0.6	88826400	10	888264000	7800	0.38

Efficiency Thermal (eta in %)	Own electricity consumption (in %)	Own thermal consumption (in %)
0.4	0.1	0.15

Electricity	
Gross Annual in MWh	337,540
Net Annual kWh	303,786
FIT (in USD/MWh)	94
Income from electricity	28,555,911

Heat	
Gross Annual in MWh	355,306
Net Annual kWh	302,010
FIT (in USD/MWh)	5
Income from electricity	1,510,049

Fertilizer (Liquid)	
Organic Input Biogas plant ton/d	1,233,700
Total Substrate Output (%)	0.70
Total out Substrate Output (in t)	863,590
Total liquid substrate with DM of max. 20% (in %)	0.80
Total Liquid Substrate (in t/year)	690,872
Sales Price liquid substrate (in USD/t)	10
Income Liquid Substrate (in t/y)	6,908,720

Fertilizer - Dry Substrate	
dry matter in %	0.20
Amount Dry Matter (in t / year)	172718
$/ ton dry matter	90
income dry matter	15520439

Investment prediction	
Total Power Potential (in MWh)	888,264
Operating hours/year	7800
Total Power capacity in MWh	114
Total Electrical capacity in MWh	43
CAPEX (Biogas plant) in USD per kWh electric	5000
Total CAPEX	216,372,000

Total income	52495119
initial investment	216,372,000
ROI	4

Table 4-1 explanation: Treating 3380 Ton/day requires initial investment of $216,372,000 and gives 337,540 MWh electricity /year with return on investment in 4 years**. Details:**

6500 ton /day (total waste) * 0.52 (organic waste percentage) = 3380 ton/day

1 ton of waste = 120 m^3 biogas

3250 ton * 120 m^3 * 365days = 148044000 m^3 of biogas/ year.

Note: Composition of bio gas = 60% CH_4 (it varies from 50 – 75%) and this what we use for energy + 30% CO_2 (it varies from 20 – 35%) we use to produce energy + 10% other gases (N_2, O_2 and 6% H_2O) depending of waste type and separation quality.

CH_4 composition is 148044000 m^3 * 0.6 = 88826400 m^3 of CH_4

Energy potential (how much energy we can get) = 1 m^3 CH_4 = 10 kWh energy

88826400 m^3 * 10 kWh = 888,264,000 kWh of energy/year (This energy = electricity + heat)

Note: the electrical capacity 38% + heat 50% + 10% loss.

888,264,000 kWh ÷ 7800h) = 113880 kW

(the whole plant operates from 7800 – 8000 hours/year)

Electrical potential: 113880* 0.38 (electrical potential) = 43,274 kW

43,274 kW ÷ 1000 (to get mega wat because 1MW = 1000 kWh) = 43.2744 MW electricity.

43.2744 MW * 1000 kW = 43,274kWh * $5000 kWh= $216,372,000 initial investment.

888,264,000 * 0.38= 337,540,320 kWh /year (total production of electricity/year)

Power Output:

3380 ton/day * 0.7 *365= 863,590

(70% of the organic Input will be created as substrate at the biogas plant. The 30% of masses are the gas formation)

863,590 * 0.8 = 690,872 Liquid

863,590* 0.2 = 172,718 Dry matter

172,718 * Dry matter price $90 = $15,544,620

690,872* liquid price $10 = $6,908,720

(The organic substrate after biogas can be sold as fertilizer or soil improver. The price for solid matter (a dry matter content of 60%) is higher than for liquid with a dry matter content of less than 20%. For dry matter it depends on the fertilizer price in each country).

Note: price of fertilizer, electricity and heat is tentative to change upon time preferences which can be calculated accordingly.

Despite Biogas is still expensive because it is a new technology where initial investment to treat food waste in Lebanon costs $216,372,000; however, return in investment in 4 years only. In addition, it will play an important role in solving electricity problem and reducing importing fertilizers. Heat also can be used in manufacturing or heating houses. It is also a profitable project where the net income is $ 59,146,736 a year. Moreover, its positive effect on the environment and health is much more than this. In addition to saving land especially that Lebanon is a small country.

4-1-2- Incineration

Contrary to what decision makers in Lebanon believe that incineration is the best practice for all types of waste especially because there is no separation in Lebanon, incineration is not the best way to treat organic waste because food waste contains 80% water which decreases outcome effectiveness. The output is 10 – 20% only fertilizers. The percentage of water increases in Lebanon especially in summer due to high humidity rate. (Nemoto Yasuo, 2019) In other parts of Japan such as Nagasaki incinerator, they mix different types of waste including organic materials. The construction cost is $74,703,455.93. Its capacity is 240 ton/day which produces 5200 kW of energy. Area space is 14,499.60 m 2. (Nagasaki Nishi Eco Creation Co., Ltd., 2019) Generally, in Japan incinerating in private incinerators costs $182.62/ton to produce fertilizers. However, farmers don't prefer using it because the chemical one is more effective. That is why the Japanese people are trying to export it to other parts of the world. In addition, incinerating one-ton costs $228.27/ton to produce food for pigs and this is used in Japan in private incinerator. The public incinerator costs less than $82/ton to produce fertilizer because it is supported by the government.

There are different types of incinerators with different prices. For example, upon asking Ebara Environmental Plant Co., Ltd. formally they replied: (Yasuhiko HARA, 2019)

1) "Capacity: 220T/24H (110T/D x 2 lines), Greate type incineration system with BTG 8,181,429,114

2) Price (approximate calculation); 18 billion JPY = $ 164,494,727

3) Condition; For MSW by EPC full-turn-key project (including incinerators, boilers, flue gas treatment, water & steam system, E&IC and civil)".

A very important point is that the level of separation affects outcome quality.

4-1-**3- Compost Baladi**

Earth Cube Composter costs $650 with capacity of 20kg/day.

ASP costs $25000 with capacity of 1ton/day.

In comparison with the biogas we see that the initial cost for the biogas is much lower and the outcome is also higher. Biogas costs about $200 million but we get initial investment in 4 years while ASP costs 3300*25000 = $82,500,000 and produces only compost. However, this might be good for remote places to reduce transportation costs.

4-1-4- Comparison to current costs of WMS in Lebanon:

Table 4-2 shows the current costs of waste treatment operations in Lebanon of municipal solid waste per ton:

Table 4- 2 Detailed costs of operations

Source: (AZZI, 2017)

Collection and Transport	$27.5
Sorting & composting	$ 39
Landfilling operations	$ 88
Total	$ 154.5

6500 ton/day * $154.5 = $ 1,004,250 is the daily estimated cost of waste operations in Lebanon * 365 days = $ 366,551,250 a year.

Sorting and composting alone is 6500* 39* 365= $92,527,500/year.

In addition to this, Lebanon has received so far international aids more than "$110 million in addition to waste management projects in addition to $12 million for waste strategic studies". (AZZI, 2017). According to "Sameh kassem, former manager at LAVAJET SAL.", one of the reasons why European Union is helping is to prevent waste spread to Europe through the Meditation Sea (Kassem, 2019). Despite spending all this money and yet they did not find a sustainable solution. However, this is the average, but the cost varies depending on region as shown in table 4-3.

Another study reports the cost of collection and transport by region:

Table 4- 3 Costs of SWM vary greatly in Lebanon
Source: (SWEEP-Net, 2014)

	Cost of Collection and Transport	Total Cost from Collection to Disposal with Sweeping
Total Cost from Collection to Disposal with Sweeping (except Jbeil)	32	143
Tripoli	64	92
Some rural areas	10-18	20-30

In addition, environmental degradation in Lebanon was estimated in 2000 at $565 million/year, which equals 3.4 percent of GDP. In addition, the cost to the global environment is estimated at about 0.5 percent of GDP/year.

4-1-5- **Feasibility Analysis**

Depending on the above mentioned we see that applying TWMS will reduce the collection and transportation costs, because it will be more effective and eliminate $ 301,307,500 costs of sorting and landfilling ($39 sorting & compost +$88 landfill *6500 ton * 365 days), in addition to reducing the $565 million/year on environmental degradation. It also reduces health diseases and contributes to the GDP, avoiding sanctions, gaining back trust to the government, inventing job opportunities, producing energy and heat, reducing importing fertilizers, changing landfill into gardens, and lastly changing WM from costly to profitable are other benefits.

1-6- Questionnaire analysis:

After testing the hypothesis, the suggested model that should be adopted is suitable for the context of Lebanese people as provided below. Our suggestion is based on the result of the pretest questionnaire to ask the respondents if they would accept the implementation of the suggested model. The responses showed willingness to accept but the challenge that will remain is the available market for recycled materials in Lebanon. For example, farmers in Japan are not willing to use fertilizers from the recycling factories that is why they are thinking of exporting fertilizers to other countries. In other countries they give fertilizers for free, but 80% goes to the landfill because farmers don't use it. So, it is only a cost.

Analyzing Cronbach's Alpha shows the following:

Table 4- 4 Stability factor using Cronbach's alpha

Reliability Statistics	
Cronbach's Alpha	N of Items
.662	18

Table 4-5 shows that the result of Cronbach's alpha factor = (0.66) which is higher than 60 percent and signifies the ability of the tool of the study to measure the cause for which it is formed. This also means that in case of applying the questionnaire later in similar circumstances then we will get somehow the same results.

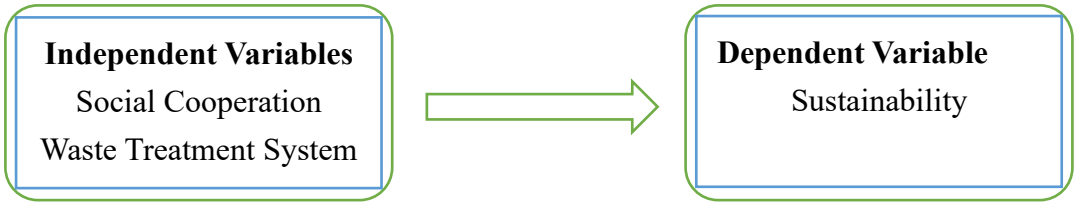

Fig. 4. 1. Dependent and independent variables.

Figure 4.1. indicates that change in the independent variables (social cooperation and waste treatment system) will lead to an increase in the dependent variable

Table 4- 5 Correlations

Correlations

		Social	WTS	Sustainability
Social	Pearson Correlation	1	.243**	.421**
	Sig. (2-tailed)		.008	.000
	N	117	117	117
WTS	Pearson Correlation	.243**	1	.930**
	Sig. (2-tailed)	.008		.000
	N	117	117	117
Sustainability	Pearson Correlation	.421**	.930**	1
	Sig. (2-tailed)	.000	.000	
	N	117	117	117

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4-5 indicates that there is significant and strong correlation between independent and dependent variables at 0.01 level which proves the two hypothesis and the sub-hypothesis.

Table 4- 6 Model Summary

Model Summary[c]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.421[a]	.177	.170	.31126
2	.930[b]	.865	.864	.12609
a. Predictors: (Constant), Social Cooperation				
b. Predictors: (Constant), Social Cooperation, Waste Treatment System				
c. Dependent Variable: Sustainability				

Table 4-6 R square shows that social variable is responsible for 17% increase in suitability and waste treatment system variable is responsible in 86% increase in suitability.

Table 4- 7 ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.395	1	2.395	24.719	.000[b]
	Residual	11.141	115	.097		
	Total	13.536	116			
2	Regression	11.708	1	11.708	736.419	.000[c]
	Residual	1.828	115	.016		
	Total	13.536	116			
a. Dependent Variable: Sustainability						
b. Predictors: (Constant), Social Cooperation						
c. Predictors: (Constant), Social Cooperation, Waste Treatment System						

Table 4-7 indicates that sig. is less than 0.05 which shows the acceptance of the two hypotheses.

Table 4- 8 Coefficients

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.649	.163		3.968	.000
	Social Cooperation	.610	.123	.421	4.972	.000
2	(Constant)	.414	.040		10.380	.000
	Waste Treatment System	.673	.025	.930	27.137	.000
a. Dependent Variable: Sustainability						

Table 4-8 indicates that T is more than 2 and sig is less than 0.05 and this proves the two hypotheses.

Lastly, a detailed analysis of each question is available in appendix -C- for acquaintance.

CHAPTER FIVE CONCLUSION

Chapter five consists of the following:

1- Application comparison between Kitakyushu Japan and Lebanon
2- Conclusion
3- Recommendations

CHAPTER FIVE DISCUSSION AND CONCLUSION

5-1- Comparison between the application in Kitakyushu and Lebanon:

The success of Kitakyushu Eco Town in Japan does not necessitate that it is going to be successful in Lebanon. What is important is the cultural factor. In general, Japanese people respect the law without questioning. Community also looks down at the one who breaks laws and even sometimes rejects them. Japanese people don't like confrontation with others especially with neighbors. In addition, the government is playing a very important role in law enforcement. So, it is an integrated system between Eco Town, government, firms and people. In short, one of the important messages of the Kitakyushu Eco town is that WMS needs the commitment of people to be successful. On the other hand, the idea of shame is not common in Lebanon and the social responsibility is lower than Japan. People are not used to do waste segregation and caring about the environment. In addition, the government is not able to impose law and people do not seriously follow the law. Many beneficiary politicians and companies do any attempt to reinforce such a system. Applying the suggested model before waste crisis in 2015 was not possible. However, now people are ready to a certain extent to apply an integrated system because of the suffering they have been facing of the current waste management practices. Second, in order to solve the previous problems, educating people is very important. Also, for the people to follow the complicated separating processes, educating them by experts is needed until it becomes a habit. In order to guarantee the effectiveness of segregation,

providing smart trash bin is needed. Giving a financial incentive will also help. Involving politicians is also very important so that they would support the system. In addition, having 8 eco towns will help solve the problem of political and religious related problems and will prevent the problem of transferring garbage from other regions.

5-1- Conclusion:

Before establishing any WMS, there are prerequisites to be taken into consideration: proper well-defined infrastructure, public awareness, and financial support (Meiji, 2019). The literature review focused on three main components of a successful WMS: education, segregation and technology. The experience of the Kitakyushu Eco-town shows that to apply a sustain WMS, public awareness must be increased through educating people and involving them effectively so that they segregate their waste correctly. This will contribute in increasing the effectiveness of the collection system, the effectiveness of treatment, and will increase the value of outcomes. Government has a very important role to monitor the system through sanctions and laws related. Depending on this, a model was developed applying the knowledge and successful experience of the Eco-town to Lebanon. Because the first variable of the suggested model has to do with the level of cooperation of people, a questionnaire was conducted to test the hypothesis. Literature also proves the hypothesis that waste crisis in 2015 in Lebanon changed peoples' attitudes from "not in my backyard" to taking actions to save the environment. The researcher names this decentralization as mentioned above. In addition, people and government are

now looking for a long-term solution that is why they are willing to apply such a model.

In order to prove the second variable WTS, a feasibility study was conducted which showed the cost of establishing different types of treatment depending on waste type. The feasibility study shows applying the suggested system is financially feasible, will play a role in solving energy problem in Lebanon, in addition to its contribution to the environment and public health. According to a study (McDougall, White, Franke, & Hindle, 2001) " for a waste management to be sustainable it has to be "environmentally effective, economically affordable and socially acceptable." This is similar to what (Bissett, 2014) mentioned above that sustainability is the intersection between the three components environment, economy and society.

However, being successful in Japan does not mean that it will be successful in Lebanon. The main difference is economy and peoples' attitudes and behavior. That is why financial incentive and educational programs are needed. Therefore, the success of the suggested model depends on different factors such as:

- The level of cooperation of people.
- The level of coordination between the government, political people, and stakeholders.
- Having implemented proper transparent laws by the government.

Lastly, to substitute technology for landfill, it is necessary to:

- Use variable technologies such as compost, biogas, incineration, and big belly.

- Decentralize waste management where people do the 5 Rs on their own on small quantities to reduce going to the landfill.

5-2- Recommendations:

The current situation related to waste management in Lebanon is dangerous for humans and the environment. That is why taking urgent steps is essential. As mentioned above that taking partial steps or focusing on one technology such as incineration doesn't solve the problem. That is why developing a green waste management system for the whole country is needed. This system needs involving all partners, NGO's, and civil society. The next step is to educate people to do the separation effectively and involving them to be active player for the success of the system. The next step is to involve international organizations and stakeholders to finance establishing Eco-towns in Lebanon. Initial investment can be POT partnership, issuing bonds, and involving people in the investment so that the project can encourage their support. Actually, Lebanese people can finance such a project. For example, establishing biogas costs $216,372,000÷ 6,068,814 the total population of Lebanon = $35.65. $35.65 ÷ 4 years= $8.9. It can be a great campaign for political people to solve food waste problem for ever for $8.9 per person a year. Not only that but to get your money back after 4 years. Once the system is applied, the Lebanese government must encourage Lebanon Eco-town to keep up to date through R&D and buying the most developed innovations. Lastly having a third party such as Eco-town Kitakyushu is also needed to monitor and keep the system up to date.

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Appendix

Appendix -A- Lebanon:

A-1- Background:

Lebanon is an Arabic country boarded with Syria from North and East 376km, South Palestine (Israel) 79km, West Mediterranean Sea 220km. Total Area 10,452 Km² (160 Km² sea) as shown in fig. apps.1

Fig. appx. 1. Lebanon Map

Ethical and political life plays a very important role in Lebanon as shown in fig. appx.2. This is a very important factor this study must take into consideration.

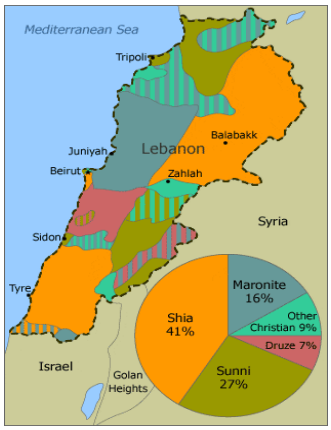


Fig. appx. 2. Lebanon map.

Source; (AZZI, 2017)

Temperature varies between 0°C in winter and 40°C in summer with yearly average 20°C. Average humidity is rather high, around 70%. Winter is cold and rainy, while summer is hot and dry. (My weather, 2019)

Population as of 23/5/2019/ is 6,068,814, out of them 2,000,000 Syrian and 450,000 Palestinian. Almost half the population are in the capital Beirut 1,916,100. Density 593 person/Km². number is expected to decrease to reach 5,411,830 by 2050. (worldometers, 2019) GDP/capital 7197.60. (Trading Economics, 2019) Unemployment Rate 6.30 percent in May 2019. (Trading Economics, 2019). However, if we compare it with one island in Japan such as Shikoku which is almost double the space Aria 18,800 km2. Population is almost the same as Lebanese 3,845,534 (2015) but they don't have problems such as Lebanon in waste management.

A-2- Side effects of waste:

According to Sweep Net "Average person in Lebanon produces 1.05 kg a day on average. 52% of it is organic materials. 60% of waste is produced in the capital Beirut and a nearby reason named Lebanon Mount". Total production is 6500 ton/day of household solid waste: 52% organic, 16% paper, 11% plastic, 6% metal, 4% glass, 11% other as shown in Fig. appx. 3.

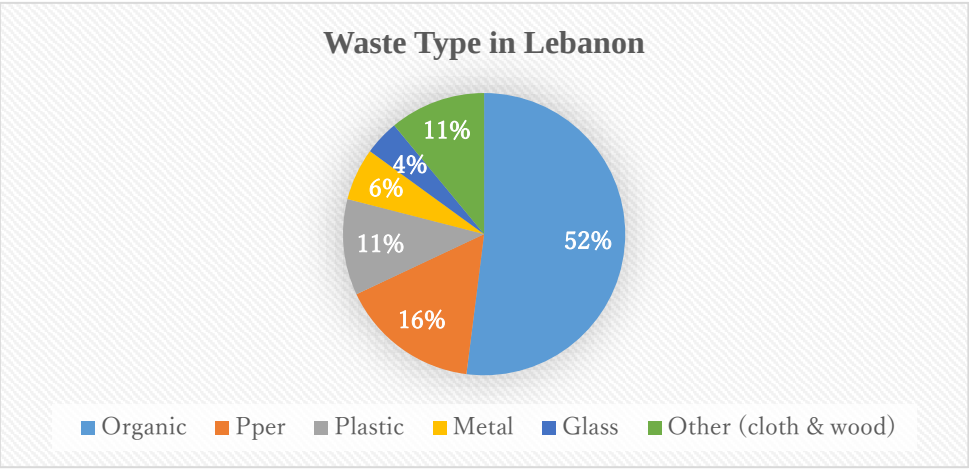


Fig. appx. 3. Solid waste composition.

Source: (SWEEP-Net, 2014)

The expected increase according to European Commission, is 6700 ton/day in 2020 and 7600 ton/day in 2025 (EN, 2017).

Out of the 6500 ton /day, 50% of goes to random/ unsystematic landfill in 940 places, 35% goes to healthy landfill in 3 places, and 15% goes to material recovery in around 50 centers through separating it to materials able to be used such as paper, glass, plastic, wood... etc. or changing it to fertilizers or improved soil materials . In addition to the household waste, Lebanon produces 50,000 ton/year of dangerous solid waste including dangerous waste out of chemicals manufacturing, electronic waste, outdated medicine, waste of hospitals and medical centers, used oil, used batteries, olive oil production waste, slaughterhouses, building waste …. etc. Out of those only hazardous and infectious health waste is treated in special way in accordance with the provisions of Decree 13389/2004. Also, some dangerous waste through transferring it outside the country in accordance with Basle treaty such as low 389/1994. (Sustainable policy for integrated solid waste management)

This is a main reason for the dramatic increase in CO2 emission as shown in fig. appx. 5. which is even higher than similar countries in income.

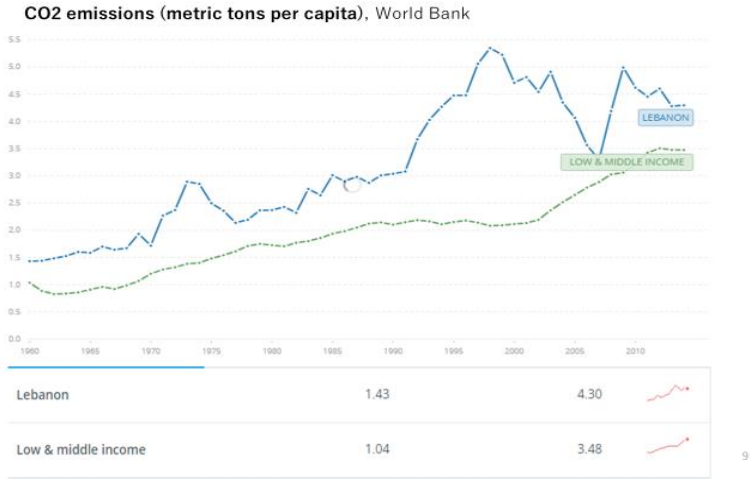


Fig. appx. 4. CO2 emissions.

Source: (worldbank, 2019)

One the contrary we find developed countries with decreasing CO2 emission as shown in table appx- 1.

Table appx- 1 CO2 emission

Source: (worldbank, 2019)

Country	1960	2014
Austria	4.37	6.87
Denmark	6.50	5.94
France	5.79	4.57
Germany		8.89
Lebanon	1.43	4.30

Appendix- B- Eco-Town Kitakyushu:

The modern industry has had a huge positive impact on the Japanese economy since 1960s. On the other hand, it caused serious negative results on the environment, changing sea into what was known as “Sea of Death” where it became not suitable for

fishes to live and many species of fish died. To overcome this problem the Eco-Town project was launched in 1997. The name came from Ecology + Economy and because of the Eco-Town the situation changed dramatically as shown in the photo below (figure 1.4). Many species of fish returned, and sea seeds revised. In 2011, Kitakyushu was nominated as a "Green Asia International Strategic Comprehensive Special Zone" (Japan for Sustainability)

Fig. appx. 5. From a Grey City to a Green City.
Source: (Muto, 2015)

The Eco-Town is an outsourcing project of 26 companies working in 8 business arias with approximately 1020 workers and investment is 60.5 billion yen i.e. $ 560,835,000.00. (GEC, 2005). However, the role of government is monitoring as shown in Fig. appx. 5.

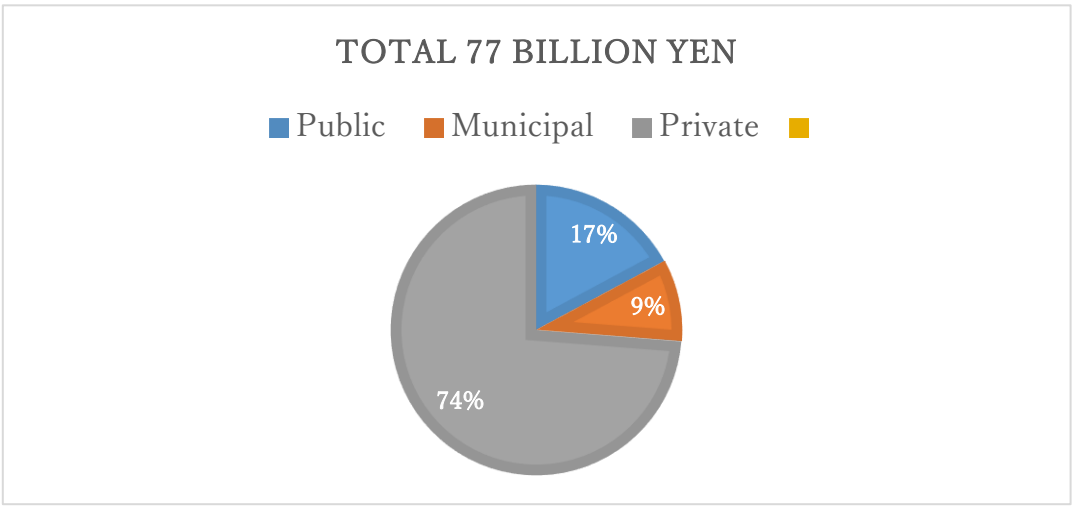


Fig. appx. 6. Eco-Town Finance.

Source: (Data from Kitakyushu Eco Town, October 2019)

This is a very good example for Lebanese because in general the mindset is that only the government can take the burden. Also, Kitakyushu Eco Town are operated through cooperation with local residents and industries. that is why this is a call for Lebanese people to depend on themselves.

At the beginning local companies working in recycling were invited to move to one place named later Eco Town. Their goal was zero-emission and formulating a cluster. It was mandatory to share experiences, “knowhow”. Kitakyushu was the first Eco Town in Japan. After that a framework for Eco-Towns in allover Japan to involve partners as shown in fig. apps.9. Were ministry of Environment and Ministry of Economy were involved. On of the most important things to support Eco Towns in Japan is the legislations by the government.

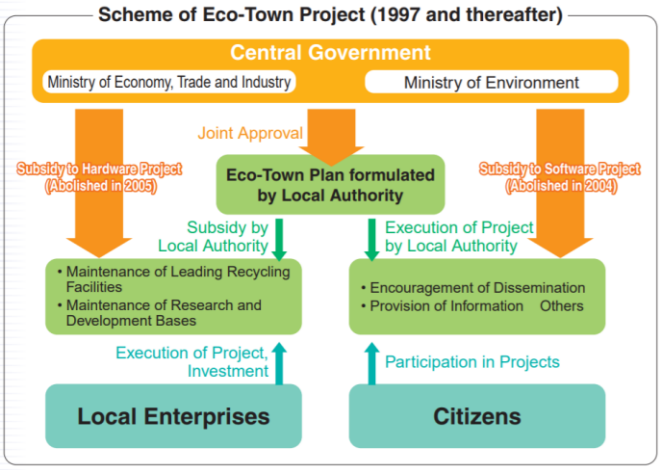


Fig. appx. 7. Framework of Eco-Towns in Japan

Source: (GEC, 2005)

B-1- Why Eco-Town Kitakyushu

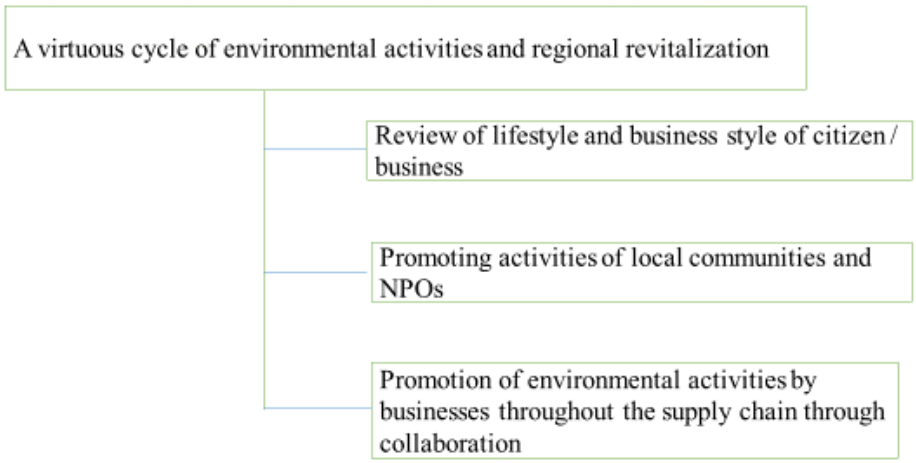
The reason of choosing the Eco-Town Kitakyushu is that it is a good example to be taken into consideration. Kyushu suffered for high percentage of pollution and is a

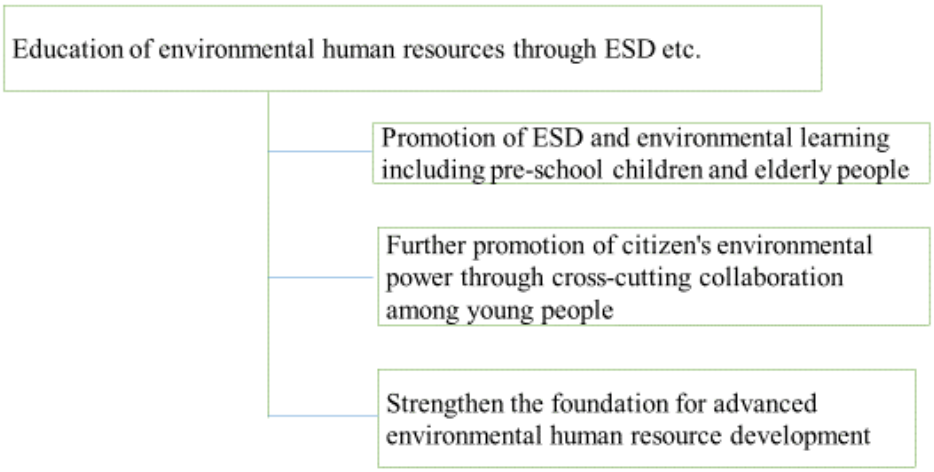
successful example to show that people's participation and behaviors towards WM has the most important impact on the success of the project.

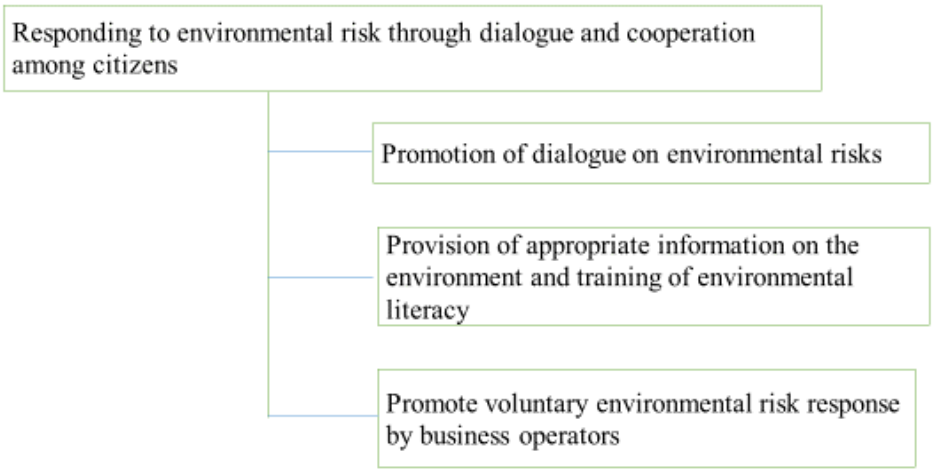
Details about the Eco-Town Kitakyushu: (Kitakyushu website)

Every year, 300 million plastic bags are used in Kitakyushu city. The energy required to manufacture one plastic bag is about the same as lighting a 60 W bulb for one hour. This shows the importance of using personal bags to decrease the recycling process. That is why each environmental action is important: To effectively utilize limited resources and leave a better global environment in the future; they launched an initiative known as "campus seal", to support the My Bag movement. At the beginning in (December 2006,) 148 stores were participating and the number increased to 217 stores by (March 2015). Also, plastic bag refusal rate increased from 9.5% (Dec 2006) to 30.3%

B-2- Japan Application:




Education of environmental human resources through ESD etc.
Promotion of ESD and environmental learning including pre-school children and elderly people
Further promotion of citizen's environmental power through cross-cutting collaboration among young people
Strengthen the foundation for advanced environmental human resource development


Responding to environmental risk through dialogue and cooperation among citizens
Promotion of dialogue on environmental risks
Provision of appropriate information on the environment and training of environmental literacy
Promote voluntary environmental risk response by business operators

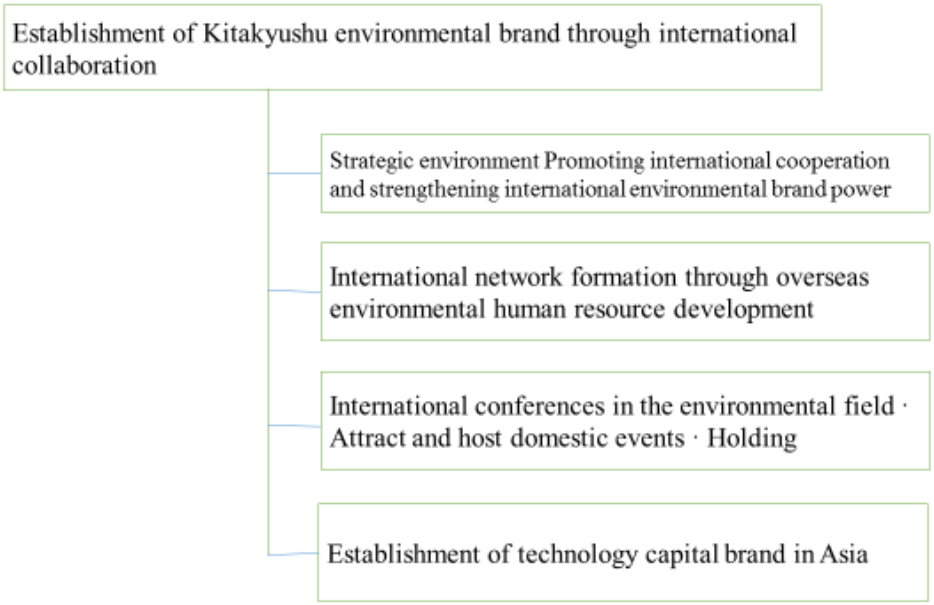


Fig. appx. 8. Models used in Kitakyushu Eco-Town.

Source: [kitakyushu, 2019]

They also use “10 Principles of Environmental Action of the People of Kitakyushu,”

1. “Intensifying the environmental power of the city through the laughter and strength of the people”. They don’t want it to be imposed on people, boring activity rater make it interesting. For example, they invented named “Passport” whenever you use your page instead of the plastic bag supermarket people will seal your passport.

2. “Advocating the advancement of exceptional environmental human resources”. They give chances to do environmental activities such as how to cultivate, grow plants, plant trees, and separate garbage.

3. “Valuing the significance of visible local ties.”

4. Encouraging the symbiotic relationship with all living things through a

deeper understanding of nature

5. Protecting our valuable urban assets in the quest for beauty

6. Reducing the urban load on the environment

7. Stimulating the market for innovative environmental technology with the participation of local actors

8. Advocating the use of recycled resources in socio-economic activities

9. Sharing environmental information for further actions

10. Channeling the concept of a model environmental city to all people of the world.

Eco-Town Projects/ Environmental Industries in Progress (Tsuyoshi, 2006)

Kitakyushu municipality want to make it as an international base. It is not just doing recycling but trying to make a business out of the Kitakyushu project. They want to make more industries in Asia to come to Kitakyushu. They also want to give their support to industries in Asia. They are focusing on the "three aspects of education/fundamental studies, technology/experimental studies, and commercialization".

1- Education and fundamental studies: To make Kitakyushu Eco-Town as a place where people can use it for education and see the technology they use; part of it is Kitakyushu museum.

2- Technology experimental studies: they want other companies to do experiments in the Kitakyushu Eco-town.

3- Commercialization: To attract more business to come to Kitakyushu to start business.

Fig. appx. 9. Kitakyushu Museum.
Source: Kitakyushu Museum

They aim to further achieve zero emission and the realization towards comprehensive industrial complex and its continuous progress accordingly. So, they already achieved the physical system for environmental protection and their target of zero emission. Then they started to make industrial complex for more environmentally friendly businesses with zero emission in Kitakyushu. For that they are still improving their infrastructure. They are building new rail ways and more rods so that companies to surrounding cities can connect with the Kitakyushu. At the beginning it was mainly an experimental studies working as an entity that connects the environment and industries while achieving a balance between request of parties to observe and those to be observed

so it can be a model. I.e. Kitakyushu City government is trying to be in between the industry and the environment. At the same time, 80,000 people visit Kitakyushu every year. The purpose is to observe and learn.

Kitakyushu Model: (Kitakyushu Model Waste Management English)

Kitakyushu doesn’t want to do basic promotion of recycling, rather they want to focus on "low carbon" and coexistence with nature. To make people aware and for everyone to know regarding cost and related things, they publish annual report in the "Kaeru Press", which is an environmental information magazine issued three times annually. The report explaining about “residential waste volumes, recycling rates, and treatment costs”. Kitakyushu doesn’t publish it on their own rather through Press company so that it reaches more people.

“Kitakyushu educational measures are: Kitakyushu future environment learning system includes environment learning, distributing separation guidebook, collaborate with education council, Internships at companies partnerships with Kitakyushu, proactive acknowledge of 3R activities and efforts by individuals, attaching stickers and denial of collection for homes that do not follow collection date and separation rules”. However, Kitakyushu distributes detailed schedule with detailed information how to do separation process including the color of the related bag and the sign of the recycling guide whether burnable or pet bottle or nonrecyclable, maximum size of the item, and time as shown in Fig. appx.8

Fig. appx. 10. Garbage disposal rules.

Source: (City ok Kitakyushu, 2019)

They also provide information on the final product of recycling so that people understand how the system work as it is shown in Fig. appx. 9.

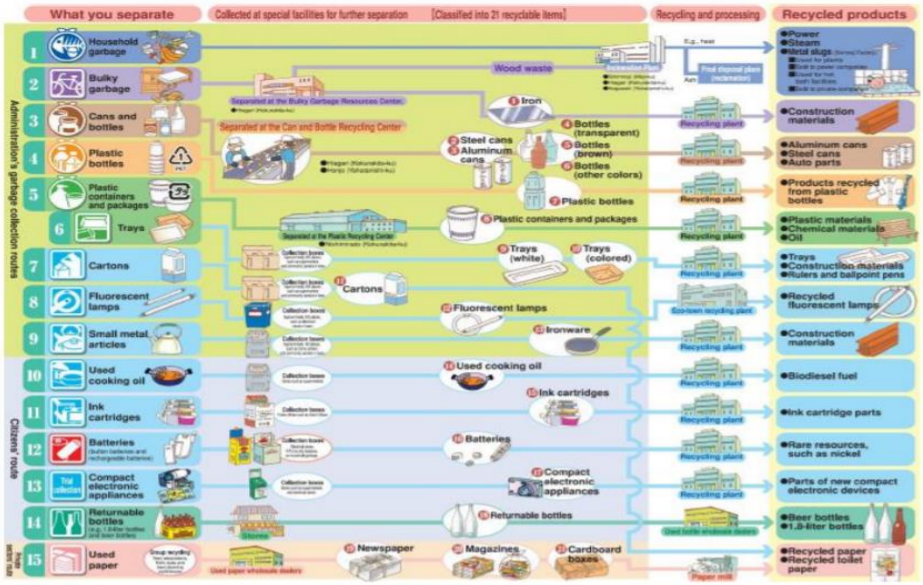


Fig. appx. 11. Waste separation types in Kitakyushu city.

Source: (Establishing a Sound Material-Cycle Society: Experience of Kitakyushu City, Japan, 2019)

So those are lessons learned from Kitakyushu that are very important to apply in Lebanon. Part of decentralization is to inform people basic ideas such as “residential waste volumes, recycling rates, and treatment costs”. In Japan there is the idea of shame

where if the company puts yellow sticker on your garbage which shows that you have made a mistake in separation or timetable such as taking out pet bottles in the green waste schedule. Following the rules of the society is very important for people in Japan.

In accordance with waste collection and transportation efficiency three incinerators were established. Long distance transport is not needed where vehicles capacity load is 2-3 tons. Time needed for a single collection is approximately 30 minutes and repeated 5 times a day. In addition, the final disposable facility is in the city.

There is clustering materials where companies are not separated rather, they are situated based on the type of material where if there is a certain material, then all related companies will be located in one area. In addition to the environmental benefits, the system brings social and economic benefits to the area through creating “employment opportunities, realization of cost-savings and competitive advantage for businesses, attracting inward investment and growth in the environmental industries sector”. Such a system can lead to the development of areas through attracting enterprises who are looking to contribute to the development of clean industries and technology.

B-3- Resident participation and attitude reform:

At the beginning residents rejected the idea of bringing in waste to their region. The Eco-town administrators explained that waste is a resource that would help promote local development. Also, they let residents to have a tour inside factories in the Eco-town to reduce their concerns. To provide support of Kitakyushu Eco-town businesses; an Eco-

town Centre was established to provide serves for conducting “environmental education, training, and seminars”.

B-4- Identifying roles:

Identifying the role of all partners. The role of residents is to promote re-evaluation of lifestyles. Environmental education, participation and cooperation in environmental preservation. The role of business is “Fulfil social responsibilities as a business promote information disclosure”. NPOs: "group collection" and other activities. Partnerships and collaborations between groups Environmental learning, social business. Local government: Act as coordinator to promote action. Eco-town also support SME small medium enterprises. They tried to promote SME by improving collaboration with SME”.

Meeting professor Meiji: Upon meeting professor Meiji he said “enhancing manufacturing efficiency decreases waste. So, if we have 100 raw materials and produce 100 products then there is no waste, but 100 materials and 90 products then 10 is waste. On a household level, husband is at work most of the time and it was difficult to tell housewives to stop pollution. Letting them to laboratories and making experiments to measure pollution and teaching them, this helped a lot. Now household in Kitakyushu city make separation at their houses for 15 places each type goes to a recycling center and some goes to the Eco-Town. In addition all kids go to the incinerator for one hour and learn the technological system, then when they are 10 years they go to the Eco-town

museum and learn for 2 hours in that case they will become the incentive for parents to encourage them to do the separation process. Upon asking professor Meiji how they convinced people to use recycled products he said, recycled materials are used in the industry because Kitakyushu is an industrial city and price varies depending on the quality. There are entrance program and exit program. For entrance program is the separation and amount of waste and the exit program is how to sell. If both entrance and exit were ok, then the system will be successful.

What is unique about Kitakyushu Eco Town is the effective involvement of people in accordance with using technology. The better segregation process is, the lower separation costs is, and the better outcomes are. So, it is an integrated system that starts from establishing the eco town, developing a clear waste management system to be followed, educating people how to do separation effectively in addition to educating them environmentally so that they understand the effect of the whole process on their life and on environment.

Appendix -C- Detailed analysis of questions:

Table appx- 2 Waste type

1- What type of facility do you represent					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	a house	93	79.5	79.5	79.5
	Institution/ Laboratory	23	19.7	19.7	99.1
	Government entity	1	.9	.9	100.0
	Total	117	100.0	100.0	

Table appxx-2 shows the representation type of waste was household waste which is mainly green waste, while Industrial waste is usually (chemical solvents, paints, sandpaper, paper products, industrial by-products, metals, and radioactive wastes) (Awuchi Chinaza Godswill, 2017), and government entity waste is mainly paper. 79.5 percent of the respondents are household and 19.7 are institution/ laboratory in addition to 0.9 percent government entity.

Table appx- 3 Work condition

2- Are you currently employed (working)?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	78	66.7	66.7	66.7
	no	39	33.3	33.3	100.0
	Total	117	100.0	100.0	

Table appxx-3 shows that nonworking people is 33.3 which shows higher rate than the average rate mentioned above 6.30. This is also reflected on waste type and increases waste volume. Such a system might play a role in decreasing the unemployment rate.

Table appx- 4 Nationality

3- What is your nationality?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Lebanese	65	55.6	55.6	55.6
	Foreigner	52	44.4	44.4	100.0
	Total	117	100.0	100.0	

Table appxx-4 shows that 55.6 percent of respondents are Lebanese and 44.4 are foreigners, which is similar to foreigners'' percentage in Lebanon 40 percent "as mentioned above". This indicated that the questionnaire is a good representation of all people living in Lebanon.

Table appx- 5 Waste Impact

4- Does current waste management practices negatively affect your life?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes / significantly	78	66.7	66.7	66.7
	Yes, very little	29	24.8	24.8	91.5
	It has no negative effect	10	8.5	8.5	100.0
	Total	117	100.0	100.0	

Table appxx- 5 shows that 66.7 percent of respondents were highly affected by negative practices of waste management and 24.8 percent were affected a little. This shows that the majority of people 91.5 percent of people were affected by the negative practices of waste management which is an indicator of the importance of finding a solution.

Table appx- 6 Understanding of Eco-Town term

5- Are you familiar with Eco-Town term technology?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	38	32.5	32.5	32.5
	agree	49	41.9	41.9	74.4
	I do not know	30	25.6	25.6	100.0
	Total	117	100.0	100.0	

Table appxx-6 shows that only 32.5 percent of people are fully aware of the Eco-Town term and 41.9 are somehow familiar while 25.6 percent have no idea which necessitates the importance of environmental education.

Table appx- 7 Taking action to save environment

6- Do you like to actively participate in saving the environment?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I would definitely like to participate	72	61.5	61.5	61.5
	Maybe I am participating	40	34.2	34.2	95.7
	Never interested	5	4.3	4.3	100.0
	Total	117	100.0	100.0	

Table appxx-7 shows that 95.7 of the participants showed a positive attitude towards taking action toward saving the environment where 61.5 percent said we'd definitely like to participate and 34.2 may participate while only 4.3 were never interested. This has a positive impact for the success of the suggested model.

Table appx- 8 Participation in forming a sustainable system.

7- Do you like to be engaged in forming a sustainable system that solves the problem of garbage disposal?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, I would like to	106	90.6	90.6	90.6
	no, it is not related to me	11	9.4	9.4	100.0
	Total	117	100.0	100.0	

Table appxx-8 shows that 90.6 of people are eager to be engaged in forming a sustainable system to solve garbage disposal problems while only 9.4 are not interested.

Table appx- 9 Trash separation

8- Do you want to make an effort in separating trash at your house?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes sure	105	89.7	89.7	89.7
	Yes, but for a financial incentive	12	10.3	10.3	100.0
	No	0	0	0	100.0
	Total	117	100.0	100.0	

Table appxx-9 shows that all people are going to separate trash were 89.7. They are going to separate their trash at home without financial incentive and only 10.3 percent will make it if they received financial incentive. Actually, this is contrary to the expectation of the author where he thought before running the questionnaire that most people will separate if they received money as an incentive. Maybe this is also related with the centralization where people are ready to act towards saving the environment.

Table appx- 10 Others' response toward waste separation.

9- Do you think that people in Lebanon can be committed to a waste separating plan on the long run?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, if they are advised how to quit	81	69.2	69.2	69.2
	No, they will not care	36	30.8	30.8	100.0
	Total	117	100.0	100.0	

In comparison with table appxx-9 table appxx-10 shows that the percentage towards others' commitment to do separation, decreased to 69.2 for yes if there was advice and the rejection increased to 30.8. This is an indicator of the importance of training how to do separation which is an indicator for the success of the suggested model.

Table appx- 11 Using recyclable materials

10- Do you mind using recycled materials such as bag, clothes?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, if that contributes to saving the environment	106	90.6	90.6	90.6
	I do not want to buy recycled materials (they are made from garbage)	11	9.4	9.4	100.0
	Total	117	100.0	100.0	

Table appxx-11 shows that the majority 90.6 percent of people are willing to use recyclable materials. This is an indicator of the success of the suggested model where it is not enough to succeed in input, but also output (Meiji, 2019). However, 9.4 percent of respondents will not buy recycled materials.

Table appx- 12 Monthly payment for recycled materials

11- If you answer 1 to 10, how much will you willing to pay monthly for recycled products?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10 – 50$	93	79.5	79.5	79.5
	70 - 150	10	8.5	8.5	88.0
	200 – 300$	3	2.6	2.6	90.6
	No answer	11	9.4	9.4	100.0
	Total	117	100.0	100.0	

Table appxx-12 shows that 79.5 percent of respondents are willing to pay $10-50 a month. Despite it is a little bit low amount yet in comparison with salaries in Lebanon, which is $500 on average, it is a positive indicator the feasibility of the project. In accordance with table appxx-11 we see that the 9.4 percent who said they are not willing to pay for recycled stuff, they did not answer Q11 which shows credibility.

Table appx- 13 Attending separating garbage workshop

12- Would you like to attend a workshop on how to separate garbage?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	92	78.6	78.6	78.6
	no	25	21.4	21.4	100.0
	Total	117	100.0	100.0	

Table appxx-13 shows that 78.6 percent of respondents are willing to attend a workshop telling how to separate garbage. However, 21.4 percent are not willing to attend. Education is a positive indicator for the success of the suggested model.

Table appx- 14 Sanctions

13- After 6 months of applying the system, do you think strict measures should be applied to those people who don't properly separate garbage?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	103	88.0	88.0	88.0
	no	14	12.0	12.0	100.0
	Total	117	100.0	100.0	

Table appxx-14 shows that 88 percent agree to take strict measures for people who commit mistakes in garbage separation. As mentioned above that the highest cost in waste management is about separation. That is why after 6 months of applying the system, strict measure has to be taken because mistakes cost extra money to separate in addition to reducing the quality of the outcomes.

Table appx- 15 Willingness to invest money.

14- Are you willing to invest money in a profitable waste management project?"					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	50	42.7	42.7	42.7
	I do not have the money	59	50.4	50.4	93.2
	I do not want to pay even though I have money	8	6.8	6.8	100.0
	Total	117	100.0	100.0	

Table appxx-15 shows that 42.7 percent of respondents are willing to invest money in a profitable waste management project. In addition, 50.4 percent are willing to invest, but they don't have extra money. This means that 93.2 percent are willing to invest money currently or when they have money. Yet, only 6.8 percent are not willing to invest money in such a project.

Table appx- 16 Work conditions

15- To what extent do the following factors represent importance to you to work at a recycling factory? (After applying the house separation system) Rank factors according to importance without repeating the scale please (1=very important, 2=Moderate, 3=not important, 4=I'm not interested in this job)		
Particulars	mean	median
Salary	1.70	2
Safety and work environment	1.46	1
Social Recognition	1.86	2

Table appxx-16 shows that Safety and work environment was the most important factor to work at a recycling factory, then comes salary, and least is social recognition. This is an indicator to be taken into consideration when applying the suggested model. The reason of asking this question is that the majority of

Table appx- 17 Effectiveness of the suggested model

16- Current garbage collection system is not effective and wastes resources. Having a new system that depends on separating garbage with the help of technology to reduce waste and increase impact, do you think such a system is feasible?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	114	97.4	97.4	97.4
	no	3	2.6	2.6	100.0
	Total	117	100.0	100.0	

Table appxx-17 shows that 97.4 percent of participants agree that the suggested model is feasible. Only 2.6 percent find that it is not feasible. This is an indicator of the feasibility of the suggested model.

Table appx- 18 Correlation

	Type	Employment	Nationality	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q16
Type	1														
Employment	-0.3090**	1													
Nationality	-0.1244	0.3527**	1												
Q4	0.1398	-0.0094	0.0861	1											
Q5	-0.1123	0.0159	0.0579	0.146	1										
Q6	-0.0236	0.1052	0.2328*	0.2556*	0.3020**	1									
Q7	-0.0239	0.0207	0.1834*	0.1544	0.1447	0.4230**	1								
Q8	-0.1024	0.0598	0.1512	0.2615**	0.0675	0.0427	0.0842	1							
Q9	-0.1159	0.1571	0.2609**	0.0553	0.1820*	0.1165	0.1025	0.2019*	1						
Q10	-0.0239	0.0207	0.0065	-0.0276	-0.0096	0.0662	0.2976**	-0.0124	0.039	1					
Q11	-0.1249	0.0408	-0.0418	-0.0561	0.0348	-0.1806	-0.005	0.0244	0.1037	-0.0343	1				
Q12	-0.0650	-0.0147	0.0793	0.1143	0.0195	0.1203	0.2607**	0.03	0.1043	0.1179	0.0368	1			
Q13	0.0587	-0.0354	0.2029*	0.2947**	0.2769**	0.1864*	0.1502	0.1339	0.2250*	0.0598	-0.1224	0.2014*	1		
Q14	-0.0641	0.2649**	0.2993**	0.0603	0.0205	0.2159*	0.2414**	0.1559	0.0826	-0.0493	-0.0808	0.2344*	0.09	1	
Q16	0.0445	0.002	0.0745	-0.0225	0.1564	0.0693	-0.0527	-0.0553	0.1255	-0.0527	-0.0578	0.0509	0.11	0.0086	1

* = Significant at 5% level

** = Significant at 1% level

The aim of correlation is to see correlation and significance between questions level

focusing on linking questions from 4 to 16 with questions 1,2, and 3.

Table appxx-18 shows the following:

Employment and type are negatively correlated, and significance level is 1%.

Nationality and type are negatively correlated and not significant.

Nationality and employment are positively correlated, and significance level is 1%.

Q4 is positively correlated with type, negatively related with employment, and positively related with nationality but not significant.

Q5 is negatively correlated with type, positively related with employment, and positively related with nationality but not significant.

Q6 is negatively correlated with type, positively related with employment and positively related with nationality and significant at 5%.

Q7 is negatively correlated with type, positively related with employment, and positively related with nationality and significant at 5%.

Q8 is negatively correlated with type, positively related with employment, and positively related with nationality but not significant.

Q9 is negatively correlated with type, but positively related with employment and positively related with nationality and significant at 1%.

Q10 is negatively correlated with type, but positively related with employment and positively related with nationality but not significant.

Q11 is negatively correlated with type, positively related with employment, negatively

related with nationality but not significant.

Q12 is negatively correlated with type, negatively related with employment, positively related with nationality but not significant.

Q13 is positively correlated with type, negatively related with employment, positively related with nationality with significance level 5%.

Q14 is negatively correlated with type, positively related with employment, positively related with nationality with significance level 1% with employment and nationality.

Q16 is positively correlated with type, positively related with employment, positively related with nationality but not significant.

According to written respondents' answers to question 17, their answers focused on the following:

A- Respondents summarized problems with the following that there are mistrust between the Lebanese people and their government ignorance about how to separate, ignorance of the importance of saving the environment, selling valuable garbage, and some are already doing separation but there is no point because there is no treatment and whole system.

B- Suggestions according to respondents are the following:

1- The importance of developing a whole sustainable system. Not to depend on incineration due to that its harm exceeds the benefit.

2- The importance of holding workshops to show the importance of such a project for the environment and human health, to teach the correct way how to do separation process.

3- The importance of training human forces able to accomplish such a project.

4- The importance of supervision of government.

5- Involving organizations to play a role.

6- The importance of financial incentive and strict roles.

7- Importance of cooperation between all parties for the success of such a project.

8- Start the separation process with public and private hospitals so that other organizations will follow.

9- Some emphasized the importance of the religious speech where Islamic religion emphasizes cleanness.

10- Treating hazardous waste is the most important.

11- The most important is that politicians must have profit other than that it won't be possible.

12- Some others were very enthusiastic and wrote their phone number to be part of the project.

Lastly Figure appxx.1-2 questions are normal distributed

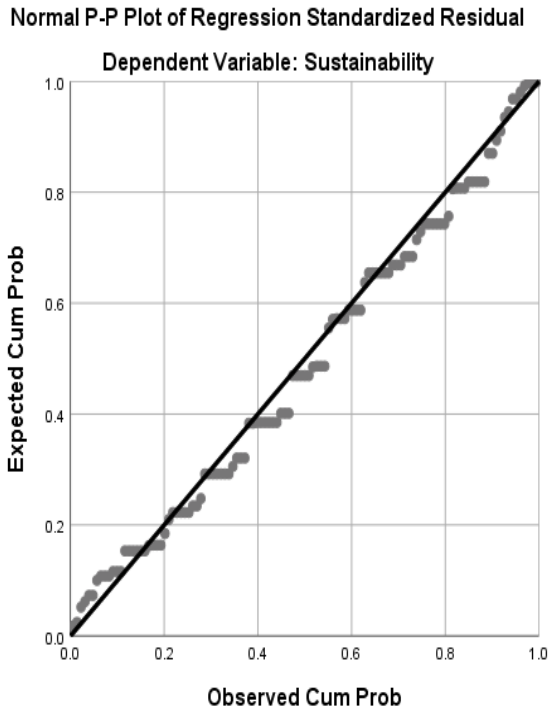


Fig. appx. 12 Normal distribution

The end.