An-Najah National University
Faculty of Graduate Studies

Reuse-Recycling Options for Municipal Solid Waste in Zahrat Al-Finjan Landfill

By
Mohammad Ghaleb Mohammad Al Sa'di

Supervisor
Dr. Hafez Shaheen

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This thesis was successfully defended on 26/7/2009 and approved by:

Committee Members		**Signature**
Dr. Hafez Shaheen	**Supervisor**	…………………
Dr. Amer El-Hamouz	**Internal Examiner**	23/12/09 …………………
Dr. Anan Al-Jayousee	**Internal Examiner**	…………………
Dr. Isam A. Al-khatib	**External Examiner**	…………………

DEDICATED TO MY PARENTS, WIFE, SISTERS,

BROTHERS AND MY GRANDMOTHER

ACKNOWLEDGMENT

I would like to express my sincere gratitude to my supervisor Dr. Hafez Shaheen for his helpful efforts, fruitful guidance, and continual encouragement throughout the entire research. Special thanks go also to Dr. Laiuri Machnale for the help in preparing the proposal of this study and guidance during its preparation.

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الإقـــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Reuse-Recycling Options for Municipal Solid Waste
in Zahrat Al-Finjan Landfill

دراسة خيارات اعادة تدوير واستخدام النفايات

في مكب زهرة الفنجان

اقر بأن ما اشتملت عليه هذه الرسالة إنما هو نتاج جهدي الخاص، باستثناء مـــا تمــت الإشارة إليه حيثما ورد، وان هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أية درجة علمية أو بحث علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's name: **اسم الطالب:**

Signature: **التوقيع:**

Date: **التاريخ:**

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B/C	Benefit Cost Ratio
EIA	Environmental Impact Assessment
EQA	Environmental Quality Authority
ERM	Environmental Resources Management
HDPE	High Density Polyethylene
JSC	Joint Services Council
LDPE	Low Density Polyethylene
MSW	Municipal Solid Waste
PCBS	Palestinian Center Bureau of Statistics
PET	Polyethylene Trifoliate
PP	Polypropylene
PVC	Polyvinyl Chloride
RR	Reuse and Recycling
SIA	Social Impact Assessment
SWRR	Solid Waste Reuse and recycling
SW	Solid Waste
TS	Transfer Station
UNEP	United Nation Environmental Program
ZF	Zahrat A-Finjan

Ruse-recycling options for municipal solid waste in Zahrat A-Finjan Project

By

Mohammad Ghaleb Al-Sadi

Supervisor

Dr. Hafez Shaheen

Abstract

Reuse-recycling and solid waste separation options for municipal solid waste at Zahrat A-Finjan (ZF) landfill are evaluated in this thesis; these are separation at source through curbside collection and drop-off centers; separation at transfer station; and separation at ZF landfill. Different evaluation criteria have been applied including technical; social and environmental; and financial. ZF service area was divided into five zones according to population, waste generation, distance to landfill, waste source, topography, and methods of solid waste collection and transfer. The study covered those by ZF landfill served local communities up to 31 July 2008.

The solid waste composition has been examined via pilot separation, where the percentage of waste components in different study zones has been identified. The compositions are organic and food wastes; cartoon and paper; plastic; glass; metals; textile; and others. The average percentage of

the organic fraction from the total waste in the different zones is 53.73%, whereas the percent of the other different components is 46.27%.

The technical criteria were applied to evaluate the management of the separation options and to identify the technical requirements for each. These options have been managed taking into consideration the available solid waste collection, transfer and disposal systems. The separation at source has been managed through the curbside collection and drop-off centers. A weekly separation scheme was established to collect the separated waste as two fractions; wet and dry. Four transfer stations were considered in evaluating the separation at transfer station, among which is the mechanical separation of the wastes (recycling plant) applied at Al-Syrafi transfer station of Nablus. Manual separation is considered at the other three transfer stations. Separation at ZF landfill was considered as the recycling plant, where the organic wastes are assumed to be recycled and converted to compost and other solid waste fractions.

The social and environmental criteria were applied to evaluate the recycling options as to their social and environmental impacts. Positive and negative impacts of the options and their potential significance are ranked as high, medium or minimal.

The financial criteria were covered by conducting cost analysis for the next 11 years (up to 2020) for all SWRR options. The analysis included the capital and operational costs and the revenues. The B/C ratio has been estimated assuming the JSC approved fees; based on this study estimated fees; and/or zero benefits.

The prolong time for ZF landfill is due to applying SWRR. The results show that if the percentage of the separated waste is 41%, the life time of ZF landfill will be prolonged nine years. The total lifetime of ZF landfill will be then 22 years, taking into consideration the annual increase of the population and the solid waste production.

Chapter One

1. Introduction

1.1 General

One of the most important current issues that concerns humanity is the environment and its protection. Today, the progress of human beings and the society is measured by their ability to control the environmental elements, among which is solid waste. The population increase and their industry and agriculture progress, but without following suitable ways for waste collection, transport and treatment. This has resulted in increasing solid waste quantities and consequently the pollution of the environmental elements including land, water, and air, and in exhausting the natural resources in different parts of the world. Therefore, solid waste management has become one of the vital issues to protect health and public safety (ERM, 2000).

This study examines the reuse-recycling options for Zahret A-Finjan (ZF) landfill by studying three different separation options of the solid waste collected from the local communities. Separation options include; separation at source through curbside collection and drop-off centers; separation at the transfer station; and separation at ZF landfill. Different evaluation criteria have been applied to the reuse and recycling options including technical; social and environmental; and financial. The classification of the reusable and recyclable materials was identified, as will as the percentage of the solid waste that can be separated from the total incoming waste to the ZF landfill. This will prolong the life of the landfill. In addition the effective cost for these three options was estimated. Among the other subjects covered by this study is to consider the impact of these reuse and recycling options on the environment and the society.

1.2 Zahret A-Finjan Landfill

Zahrit A-Finjan landfill, (ZF), is located in jenin governorate in Wadi Ali-Wadi between Arrabeh and A'jja, which is now called Zahret A-Finjan. It is 18 km south of Jenin City, 26 km west of Tubas, 23 km north of Nablus through jenin-Nablus road, 24 km east of Tulkarem and 50 km northeast of Qalqilyia.

Figure (1) illustrates the location of ZF landfill within the Jenin Governorate between Arrabeh and A’jja villages. ZF landfill is 1.5 km from A’Ajja villages and 2.5 km form Arrabeh Village.

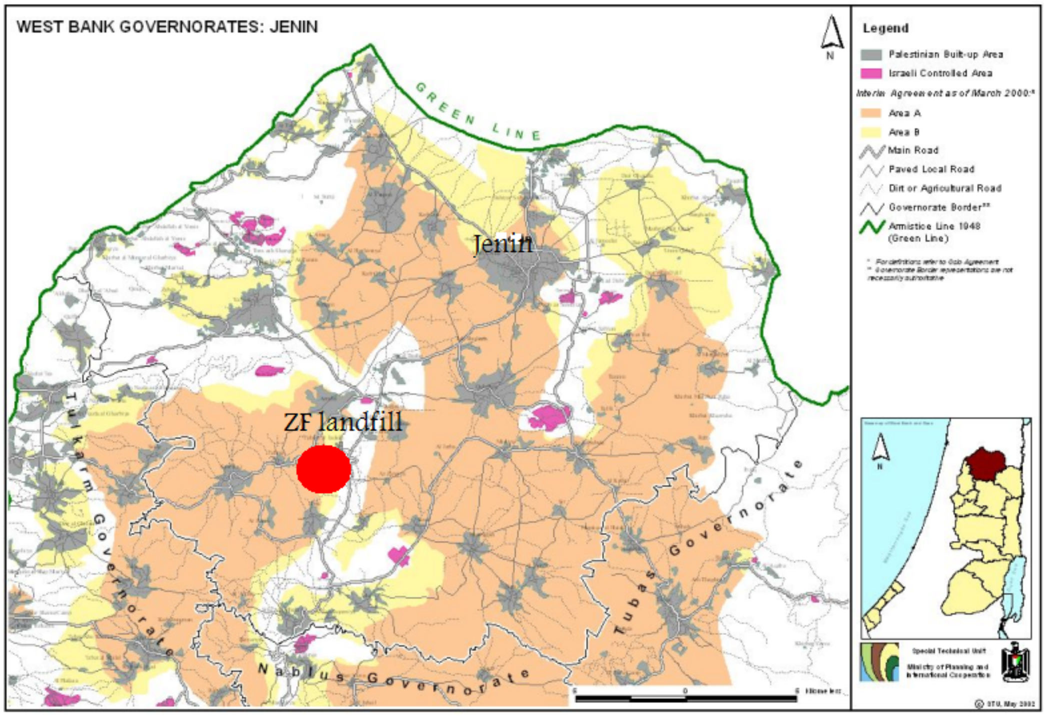


Figure (1): Location of ZF landfill in Jenin governorate (JSC, 2003).

In 1998 a comprehensive approach to improve solid waste management services in the West Bank was initiated under the Solid Waste and Environmental Management Project (SWEMP). The draft plan prepared under SWEMP includes (ERM, 1998):

- The construction of a regional strategic, sanitary landfill in Jenin Governorate. According to the strategy of the Environmental Quality Authority (EQA) and with the approval of the Ministry of Local Governments (MoLG) and the Jenin Joint Service Council (JSC) for the solid waste, the landfill became a central landfill for all of the governorates in the northern West Bank.

- The closure of all random dumpsites.

- The development of a complete system for the collection and transfer of solid waste; this includes purchasing collection vehicles, containers and other related equipment.
- Providing financial support for waste collection services and operation of the landfill.
- Providing technical assistance.
- Developing the institutional abilities of the participating municipalities.

The cost of the project is USD 14 million, including a 9 million dollar loan from the World Bank, a 1.25 million dollar as a contribution from the local governments, and a 3.75 million dollar grant from the European Union.

The land purchased for the project is 240000 m^2, which includes 90000m^2 for waste cells to serve northern governorates for about 15 years during the first stage of the project. The waste cells will be extended on the remaining land owned by the JSC. The capacity of the project is 2.25 million tons of waste.

Currently the landfill receives around 400 ton of waste each day coming from Jenin, Tubas, Nablus and some villages of Tulkarem governorate. This quantity is expected to increase to 600 ton/day when waste is received from Qalqiliya and Salfeet governorates, Tulkarem City and other villages for Tulkarem and Nablus Governorates. This will reduce the life landfill to about 10 years.

The number of the citizens which benefit from this project in the northern governorates is then to increase from 800,000 to 1 million.

1.3 Research Objectives

The objectives of this research are:

1. To manage the waste collection and separation options to implement reuse and recycling in effective manner.
2. Studying the environmental and social Consideration due to applying the reuse and recycling of the solid waste
3. Develop an effective cost analysis for reuse and recycling options.
4. To evaluate prolonging the life of the ZF landfill by diverting waste through reuse and recycling.

1.4 Study Scope and motivation

The Solid Waste and Environmental Management Project (SWEMP) recommended improving the solid waste collection and disposal in the West Bank by constructing three landfills distributed in the southern, middle, and northern parts of the West Bank (ERM, 1998). ZF landfill is located in the Jenin governorate in the northern part of the West Bank serving as the northern landfill. Studies and designs for the ZF landfill were originally made for Jenin and Tubas governorates, where the lifetime of the landfill was estimated at 30 years, with a capacity of 2.25 million ton of solid waste. The coverage area for the ZF landfill services has now been extended to include Nablus, Tulkarem, and Qalqiliya governorates. This will decrease the lifetime of the landfill to 10-15 years.

The reuse and recycling system for the ZF landfill will help prolong the lifetime of the landfill, by extracting of the reusable and recyclable wastes from municipal wastes such as, organic waste that forms around (50-60)%, plastic, papers, and etc.

Reusable and recyclable materials can be sold, which offsets the cost of waste disposal. In addition, natural resources can be conserved by reusing and recycling the separated waste, which will be an important step towards integrated solid waste management of the ZF landfill.

1.5 Methodology

A set of criteria have been developed for this study from previous related studies. Solid waste composition has been examined at the Zahrit A-Finjan landfill to identify the percentage of reusable and recyclable materials. The reuse and recycling options have been managed taking into consideration the available system for waste collection and disposal. The environmental and social considerations have been discussed for the research options to identify the positive and negative impacts and ranking the potential significance according to the degree of importance. Effective cost benefits have been considered for the research and management options taking into account the available system for solid waste collection and disposal. The results have been discussed for the different options covering the technical, environmental, social and financial issues. The service life of ZF landfill has been evaluated.

Figure (2) illustrates the options that will be discussed in this study for the reuse and recycling. These are; 1) the separation of the reusable and recyclable wastes at the source through curbside collection and drop-off center; 2) the separation at transfer station; 3) the separation at the landfill site, by applying the concept of a recycling plant. Area served by the ZF landfill is divided into five zones, illustrated by maps, population, distance to landfill, social situations, etc. The areas that are more than 15 km from the landfill are considered to use a transfer station, from which the solid waste will be transported to the ZF landfill.

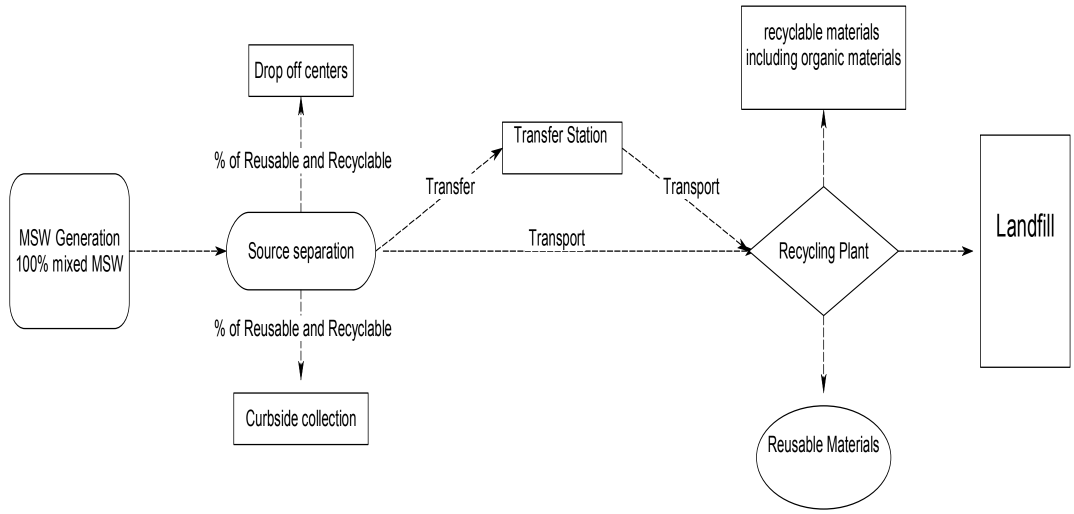


Figure (2): The reuse- recycling options covered by this study

1.6 Thesis Outline

The general structure of the thesis is as follows:

- Chapter one is the introduction.
- Chapter Two included the literature review covering solid waste reuse and recycling options. General background about the system at ZF landfill. Concentrating the solid waste reuse and recycling options of the separation at source, separation at transfer station and the separation at landfill site.
- Chapter three is reviewed the existing system for the solid waste management at national level including national and international studies.

- Chapter four explains the set of criteria for the research, which are technical, environmental, social and financial criteria. Previous related studies and interviews with persons, entities, establishments, municipalities, etc. were considered to select the criteria.
- Chapter five covers the solid waste composition at ZF landfill.
- Chapter six is about the research options with identifying all technical issues. Separation at the source, transfer station, collection, transferring, transporting, schemes, routes and maps are discussed by this chapter.
- The Environmental and social impacts are assessed in chapter seven. Positive and/or negative impacts of the options and the potential significance are ranked as high, medium and minimal.
- The financial issues are covered in chapter eight. These are discussed through estimating the capital costs and operation costs of the research options. The revenues are estimated from marketing the recyclable material and the collection fees.
- Chapter Nine discusses the results and furnishes the key conclusions and recommendations.

Chapter Two

2. Literature Review

2.1 General

Solid waste arises from human activities includes domestic, commercial, industrial, agricultural, wastewater treatment, etc. If the waste is not properly handled and treated, it will have negative impacts on the hygienic conditions in urban areas and pollute the air and surface and groundwater, as well as the soil and crops (World Bank, 1999).

A hygienic and effective system for collection and disposal of solid waste is fundamental for any community. Generally, the demands for a solid waste management system increase with the size of community and its per capita income. Residues from waste treatment processes are returned to the waste mainstream and end up in the landfill with untreated waste. Hence the backbone of any waste management system is an effective collection system and an environmentally sound sanitary landfill (World Bank, 1999).

Figure (3) illustrates solid waste handling and treatment system components; among these components are; the principal solid waste activities including collection, transportation, treatment and disposal; the principal technology such as sorting, composting and incineration; and the final products covering recycling, composting and land reclamation. The solid waste material can be recycled such as organic waste, metal, plastic, etc. The solid waste material can be changed also to energy by using incineration technology. The final destination of solid waste residue is always a disposal site.

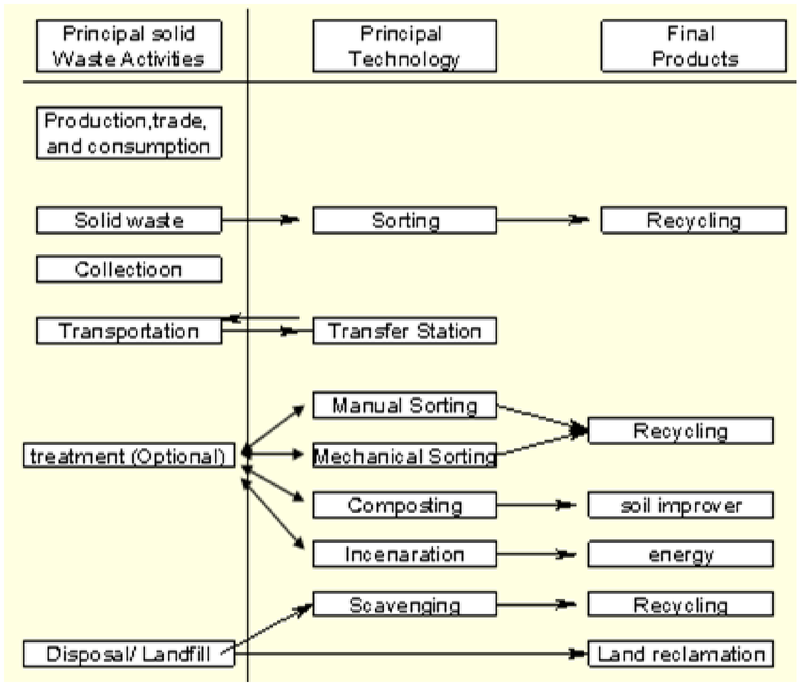


Figure (3): Solid Waste Handling and Treatment System Component (World Bank, 1999).

In this thesis, the reuse and recycling concepts are discussed and their application to ZF landfill site is investigated and researched.

2.2 Reuse and recycling concepts

Recycling has increasingly been adopted by communities as a method of managing municipal solid waste. It is the process used to convert certain waste materials to new materials or products. This achieved by the separation of the waste at the source (curbside collection or drop-off center) by the residents, waste pickers, and waste collectors, and/or separation at the site (recycling plant at a landfill). Some recycled materials have high percentage of organic waste such as leaves, grass, food waste, etc. that can be used for soil improvement due to controlled decomposition of organic materials. The conversion of waste materials into soil additives is called composting (USEPA, 2002).

Reuse is the practice of using a material more than once in its original form, preserving some or all qualities to use it again. In some societies reuse is practiced in an organized manner by the residents, waste pickers, and scavengers, who sell items again at a low price. Other societies are consider reuse as one solid waste management option, by making plans for classification, collection, and buying the reused materials (Clinton, 2002).

The materials that still have useful life can be used a second time or multiple times that preventing it from being a waste. Reuse reduces waste generation, and saves energy and finance. The common reusable materials are bottles, plastic jars and bags, electronic tools and equipment, furniture, wooden packaging items (Bonderud, 2007).

Ruse-Recycling is a series of activities, which includes separation, collection, transferring, transporting, sorting and processing. Materials disposed after use are recycled from the municipal waste stream and used as raw materials to manufacture products. Reuse-Recycling is considered as an effective method for sustainable waste management. The principle of reduction in waste disposal by separation, reuse and recycling that would otherwise end up in landfills is an effective SWM (Larney, 2004). Recycling prevents pollution, conserves resources and diverts the reusable and recyclable waste from landfills to industries. Reusable and recyclable materials are processed to be used for manufacturing to different items like paper, furniture, plastic materials and metals (USEPA, 2008).

Many studies have been made to group the reusable and recyclable solid waste materials by using different ways. Identifying the categories of reusable and recyclable materials according to composition of solid waste, collections schemes, regions, etc, will reduce the confusion for the residents and facilitate the separation of waste from the source

(Fairlie, 1992).

There are many benefits associated with applying solid waste reuse and recycling system, which are as follows (USEPA, 2008):

- Extension of lifetime of landfills through saving space
- Reducing the cost of waste disposal
- Conservation of natural resources
- Reducing emissions of gases and water pollutants from landfills and decreasing the leachate generation
- Supplying valuable raw materials to industry
- saving of energy to produce new primary material
- Creation of jobs.

The sources and types of recyclable waste are (MCMUA, 2007):

- Residential; such as cartoon, newspapers, clothing, packaging, cans, plastic bottles, food waste, yard trimmings, etc.
- Commercial from offices buildings, wholesale and retail shops, and restaurants; such as old corrugated containers (OCC), office papers, yard trimmings, wastes from food/drink vendors; food scraps, disposable tableware, paper napkins, cans and bottles.
- Institutional from schools, libraries, hospitals and prisons, Such as Office papers, books, yard trimmings and wastes from cafeteria and other food/drink vendors

2.3 Solid waste reuse and recycling options

Reusing and recycling options can be achieved by separating the reusable and recyclable materials during the collection and/or disposal of the solid waste. The source separation option is achieved by curbside and drop-off separation and collection of the separated waste. Separation option at the transfer station applied for the local communities that are more than 25 km far from landfill. The Separation option at the site is mainly at the recycling plant (Wong, 2004). In case of ZF landfill the solid waste is collected as mixed solid waste from the source, and then transferred and/or transported to the final disposal at the landfill.

To evaluate the reuse and recycling options, the quantity of waste must be identified and the waste must be classified. The recyclable materials are separated and collected from the solid waste and then processed to be used as raw material for manufacturing into new products. The composition and characterization of municipal waste is an indicator the percentages of materials that can be recycled. The characteristics of waste play an important role in recycling. Recycling depend upon the recyclable percentages from the solid waste, available facilities for processes and markets for the separated recyclables. The percentages of separated waste determine the feasibility of using recycle systems (EPD, 2007).

Collection of the separated waste depends upon many factors that are considered to identify the collection efficiency. These are

(DEFRA, 2003; Tjalfe, 2003):

- Collection types: there are many types of waste collection that have been applied at the source such as curbside, drop-off centers, and set out or set back, backyard carry, etc.
- Collection vehicles: the types and sizes of vehicles play an important role in designing the collections schemes. Selecting the types that refer to loading up these vehicles as manual or mechanical and the sizes of the vehicles depend upon the waste generation.
- Collection frequency: the collection trips per days and/or weeks, which are depending on the waste generation. Collection frequency is greater for big cities, where the trips are daily or more than trip per day. The frequency is less for small villages, where the trips are day after day or two times per week.
- Collection route design: collection routes are designed in different rules collection area, internal and external roads, generated waste, equipment and laborers. The generated waste in crowded areas should be picked up as primary collection before traffic and

congestion and then commutated in collection points or containers for collection in later time.

There are many options for reusing and recycling the municipal solid waste that has been applied in different location in the world such as source option, transfer stations option, recycling plant option

(Kincaid, et. al., 2002).

Figurer (4) illustrates the research options. The source separation options start from the point of waste generation and collection, where the residents and/or staff separate the waste through the curbside and drop-off systems. The waste is transferred by waste vehicles to the transfer stations that are normally constructed at locations, to ease the transport of the solid waste to the landfill. The waste separated at the transfer stations, in manual and/or mechanical. Then the waste is transported to the landfill. The site separation will be through a recycling plant that must be constructed to separate the waste. Enough land for sorting the separated waste and for recycling the organic waste as compost should be provided. The retained waste will be dumped at the landfill as final disposal.

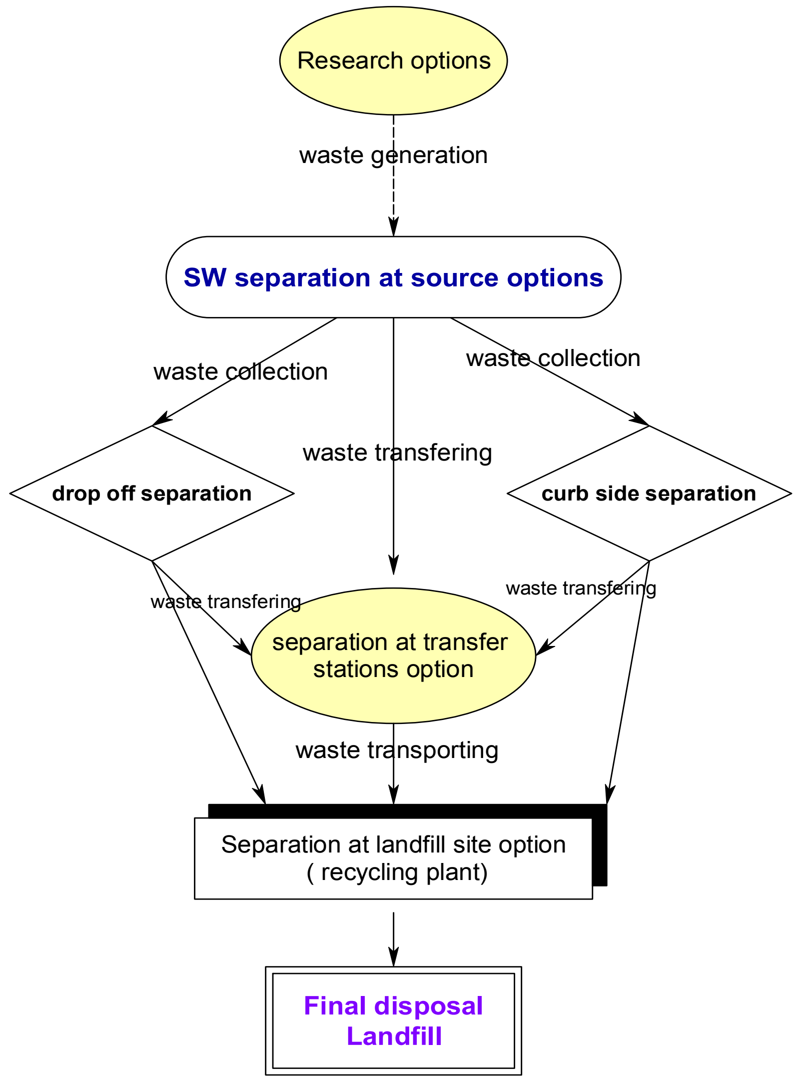


Figure (4): Schematic for research options

The selection of the reuse-recycling option is function of criteria and costs. The criteria for studying the reuse and recycling options depend on the information gathered from meeting, interviews, previous studies, etc. These criteria are grouped in categories such as environmental, social, and technical. The criteria are considered as a base to study the research options such as analyzing the required technical criteria for the different options and assessment the social and environmental criteria for each option

(DEA, 2005).

The costs of reuse and recycling options and the market costs must also be considered. A study of the costs and benefits are necessary at the first stage to determine which option (or combination of options) can be used. The costs include the costs of facilities; equipment and operation to be compared with the revenues that include the fees and marketing the recyclable materials (DEHNR, 1997).

In the following sections, the reuse-recycling options are presented

2.3.1 Separation at Source

Source separation of reusable and recyclable material start at the source of waste generation, by the residents, municipals or local governments (LG's) employees, private sector, etc. This is done in different ways and according to the considered system of waste collection such as curbside collection and/or drop off center (Lardinios, et. al., 2007).

There are many Advantages for applying separation at source

(Gould, et. al, 1992):

- Achieving high separation rates.
- Promotes clean, marketable materials

- Limiting levels of contamination.
- Not disposing of recyclable materials as solid waste
- Proper documentation is difficult when recyclables are mixed with solid waste.

On the other hand, separation at source fosters competition among recycling companies, thereby keeping costs low and quality of service high.

In this study the separation at source will be through studying the separation of solid waste by the curbside collection and drop-off centers collection only.

1. **Curbside collection:** Curbside collection system is used by residents and/or laborers to separate the waste according to the different components, and then put each component at the curbside to be collected by the waste employees (MES, 2005).

There are two main types of curbside collection (Kimball, et. al., 2000):

- **Recycling by residents:** the residents separate the solid waste and placing recyclable waste in the appropriate bins or bags. On the collection day, the bins and bags are placed on the curb. The employees collect the separated waste from curbs by special waste vehicles. This requires supplying storage containers (bins and bags) to the residents. The primary disadvantage of supplying the home storage containers is the cost, which can represent a significant investment.

- **Recycling by Staff:** curbside recycling staff is to provide the home owners with only one bin, into which recyclable materials are placed. The staff then separate the wastes as it is being picked up, placing each type of the waste into a separate compartment directly in the vehicle.

Separation at source through collecting the recyclable materials by curbside collection provide convenience for the resident, where all issues related to system such as equipment and safety tools must be provided. The curbside collection needs high residents' participation, whereas additional expenses on the residents are required in solid waste management system in addition to the expenses and costs of the collection, transportation and staff

(DSM, 2008).

2. **Drop-off centers:** Drop-off centers are centralized locations where the people take their wastes to be disposed off according to different components. The waste laborers collect and separate the waste at theses centers (Frey, 1991). The drop-off centers must be designed and constructed in suitable locations taking into consideration particular conditions that should meet the acceptable operation procedures by the community. To evaluate and select the most

appropriate drop-off system, critical factors such as location, material handled, population, number of centers, operation, and public information must be considered. Drop-off centers are preferably located at road junctions or at locations near community residents. This increases the convenience for the community residents to participate in the drop-off collection programs

(Kimball, et. al., 2000).

Drop-off centers collection and curbside collection are sometimes used as complementary. In this case wastes are collected from curbsides and transported to the drop-off centers, where separation is applied. In this case fewer and smaller drop off sites may be required than it is necessary when curbside program are not implanted.

There are two basic types of drop-off centers (NSWMA, 2005):

1. Self- service drop off centers, where there is no staff at the center and the different containers are available for the residents to dispose the recyclable material. Later the containers of different wastes are transported.

2. The site is opened only during the working hours during which the staffs are present for separating the wastes manually.

The drop-off centers that have laborers for separation are better than self-service centers. The availability of the staff reduces material contamination and protects the site from damages, thus reducing the opportunity costs. When the drop-off centers are the only recycling system used, the larger capacity is needed. Careful planning is required to accommodate traffic flow, as well as storage and collection of materials, which must be part of the site activities (Robinson, et. al., 1986).

The centers should be fenced and have signs which provide clear instructions for the residents. Containers at the centers are available in various sizes, and can be purchased or manufactured according to suitable specifications for the separation. The convenience of drop-off centers will directly affects citizen participation. The location of drop-off center in an area of high traffic flow and where the center is highly visible, will increase and courage a greater level of participation. The small villages with widely scattered population can provide good locations for drop-off centers.

2.3.2 Separation at Transfer station

Solid waste transfer station is a facility constructed to gather and later transport the waste. This is normally for local communities that are far from the landfill. The solid waste is collected by the collection vehicles and is transported, unloaded at transfer stations to be reloaded by vehicle trailers, which transport the waste to the landfill. The location of the transfer station must be selected with careful consideration such as middle location among several communities. This will minimize the travel distance that the collection and transfer vehicles will travel. It will also accesses roads to the transfer station site. Transfer stations must be properly designed and operated to decrease the problem that may occur for the residents that live nearby. This includes traffic, noise and dust that is expected around the transfer station (USEPA, 2001).

The main objective of transfer stations is reducing the cost of waste transportation. The loading of several waste collection vehicles can be transported in one trip to the landfill. The laborers and operation costs of transporting the waste a distance to the disposal site is saved. Besides reducing the transportation costs, there are many benefits from considering the system of a transfer station. These are (USEPA, 2001):

- Reduces the number of waste vehicles
- Reduce air pollution and fuel consumption
- Facilitate separation at the transfer station
- Reduce the number of trips to and from the landfill and thus reduce traffic

The transfer station site must be large enough to provide space for the collection vehicles that enter the transfer station more inside, unload its wastes and also provide place for separation. The site should have fencing to provide security and wide gate to permit passage of large vehicles. It should also have security locks. Landscaping will improve the aesthetics of the site. Provide the site with signs that describe types of solid waste accepted and hours of operation is also required (Thompson, 2007).

There are different methods of solid waste transferring using trailers or using large roll-off boxes that are hauled by special trucks to the landfill. Both can be open-top containers or closed compactable containers. The open-top containers are used to haul most types of bulky wastes such as refrigerators, washes, furniture, etc. The closed compactable containers hauled the waste and compact it into stationary compactor and a self-contained compaction trailer (Thompson, 2007).

In term of solid waste separation, there are different types of transfer station according to the method of solid waste separation such as zero separation, manual separation, and mechanical separation.

- Zero separation transfer station; This station contain concrete ground and concrete retaining walls which are high enough to place the containers below the level of the concrete. Ground and waste collection vehicles dispose the waste directly into containers from the ground level.

- Manual separation; The laborers separate the waste manually for some kind of recyclable material such as bulky items, some kind of plastic, cardboard, metals, etc. The percentage of separated waste will not be more than 5%.
- Mechanical separation is through establishing a separation plant at the transfer station.

2.3.3 Separation at landfill site

A recycling, separation and composting plant is a facility employing the required technology to process, separates, classifies municipal waste, and creates or recovers reusable materials that can be sold to or reused by a manufacturer as a substitute for or a supplement to virgin raw materials. The term "recycling facility" shall not mean transfer station or landfill for solid waste (Kunaecheva, 2006).

The solid waste is brought by waste vehicles to the recycling plant, and then the waste is unloaded in the reception area. The solid waste is fed to the plant by loaders, where the waste is mechanically treated. This includes; tearing of the plastic bags, classification on sizes, and automatic and manual separation of various components such as ferrous and non-ferrous metals, plastics, paper, board, and glass. The organic fraction is sent to the composting plant, where it undergoes aerobic fermentation during 8 to10 weeks. The compost is then purified by separation of inert elements which are sent to the landfill site. The remaining compost is clean and is of good quality and can be marketed in the agriculture sector

(Kunaecheva, 2006).

Chapter Three

3. Solid waste management in the West Bank

3.1 Introduction

Palestine is a small region with shortage of land and water. Around 2.35 million people live in the West Bank and 1.4 million people live in the Gaza Strip, where the development activities include commerce, agriculture, industry and tourism (PCBS, 2007).

The solid waste in the West Bank consists of municipal, industrial, hospital, demolition and agriculture waste. Household waste formed a high percentage at the urban area which is more than 80% of total municipal waste, while this percentage comes to less than 60% in the rural areas. The solid waste produced in 2006 by the Palestinian in the West Bank lands was around 2690 ton/day, which is divided between 620000 ton/year in the West Bank and 362000 ton/year in the Gaza Strip (PCBS, 2006).

In the West Bank, the solid waste is used to be thrown randomly outside the dumps sites, at the sides of streets, and around the garbage containers. Improper waste collection and disposal cause harmful effects to the public health and environment. Burning of waste causes harmful smoke emissions, waste leachate that polluted the groundwater, insects, birds, and rodents, which are diseases vectors (UNDP, 2006).

The common solid waste disposal method used in the West Bank is the use of unsanitary open dumpsites, where all kinds of wastes, including industrial, agricultural, slaughterhouse waste and medical waste are dumped with the municipal solid waste in open, unlined dumpsites (Monjed, 1997). The first sanitary landfill was constructed in Jenin Governorate to serve the northern West Bank. The waste is dumped there as mixed municipal waste and is covered with soil.

3.2 Waste Generation.

The daily household solid waste in the West Bank is 1,728.2 tons. In the Gaza Strip is 1,116 tons (PCBS, 2006). The average waste generation per capita in Palestine is as (Arij, 2006):

- Rural areas such as small villages, in range 0.4 – 0.6 kg/capita. day
- Refugee camps, in range 0.5 – 0.8 kg/ capita. day
- Towns/ big villages, in range 0.6 – 0.8 kg/capita. day
- Cities, in range 0.9 – 1.2 kg / capita. day

The average Palestinian household produces approximately 4.6 kg/day of solid waste in West Bank and Gaza Strip (PCBS, 2006).

3.3 Waste types and composition

There are different types of solid wastes:

- **Domestic waste:** Which is generated from the households and most of this waste is food waste. It forms around 45-50% of the total waste.
- **Industrial waste**: Which is generated from processing and non processing industries and it forms around 20-25% from the total waste.
- **Commercial waste:** Including offices, restaurants, hotels, and public services, etc. It from around 25-30%.
- **Agricultural waste:** This includes the waste that is generated from the agricultural activities such as leaves, plants, plastic pipes and the hazardous waste that is generated from using the fertilizers or pesticides. It forms around 15-20%.

All type of solid waste (household, industrial, commercial and agricultural) consists mostly of the following categories:

- Organic materials such as food waste or weeds
- Paper and cardboard including newspaper, magazines and cartons,
- Glass

- Metals
- Plastics.

Table (1) illustrates the solid waste composition in four countries including Palestine. The organic waste formed the highest percentage at these countries except at the USA, where the percentage of paper and cartoon is higher than the organic.

Table (1): Composition of solid waste stream in four countries (UNEP, 2003).

County	Organic Materials %	Paper / Cardboard %	Plastic %	Glass %	Metals %	Other %
Palestinian territory	59	15	12	4	4	6
Jordan	50-68	5-10	4-6	2-5	3-6	>5
Israeli settlements	43	22	14	3	3	15
USA	24	35	11	5	8	11

3.4 Waste collection and disposal.

The collection of solid waste in West Bank is done by the municipalities or the village councils. The solid waste is gathered from the buildings by the employees of the local communities. Some local communities are far from the public services; therefore people dump their solid waste outside their houses with no concern to how it will be removed. There are 166 local communities that do not have any solid waste collection services, which represent around 27.8% from the total local communities where as 78.5% of the local communities have collection service. There are 129 local communities in the West Bank collect their solid waste daily. In 266 of the local communities the solid waste is collected more than once a week (PCBS, 2005).

The solid waste is collected in West Bank in different ways:

- Direct collection: the waste vehicles collect the waste from the 1.1 m^3 containers or barrels. This is found in most of the West Bank local communities.
- Skip lift containers: which are commercial container in size of 5- 6 m^3 collected by skip-lift vehicles.
- Manual door to door collection: The people used the plastic bins to dispose the waste, and then the waste is collected by truck or tractors.

Solid waste disposal at random dump sites is the common method for the local communities in the West Bank. The open burning of waste is the main methodology at these dumpsites. Many environmental and health impacts may result due to the random disposal such as surface and groundwater pollution by waste leachate, air pollution due to burning, threaten the public health due to misquotes and insects (UNEP, 2003).

There were 161 dumpsites in the West Bank and 3 in the Gaza Strip. These dumpsites are not monitored or controlled by the ministry of health or any other authorities (PCBS, 2005).

Progress has been achieved after the construction of four sanitary landfill sites for solid waste, three in the Gaza Strip and one in the West Bank:

- Jaher Al-Dik landfill: which has liner and leachate collection system
- Deir Al-Balah landfill serving central Gaza
- Rafah landfill at southern Gaza.

Deir Al-Balah and Rafah landfills were built on impermeable ground outside the aquifer watershed without lining and leachate system.

- Zahret A-Finjan landfill at the northern West Bank in Jenin governorate. This landfill includes both lining and leachate systems.

3.5 Study area

The study area is divided into five zones, according to population, waste generation, distance to landfill, waste source, topography, governorates, and ways of solid waste collection and transferring.

Figure (5) illustrates these five zones and showing the served local communities by ZF landfill until the date of 31 July 2008. This includes all the local communities at Jenin and Tubas governorates, and Nablus city.

Later two other local communities has been contracted to dump their SW in ZF landfill. These are Tul-karm and Qalqelyia.

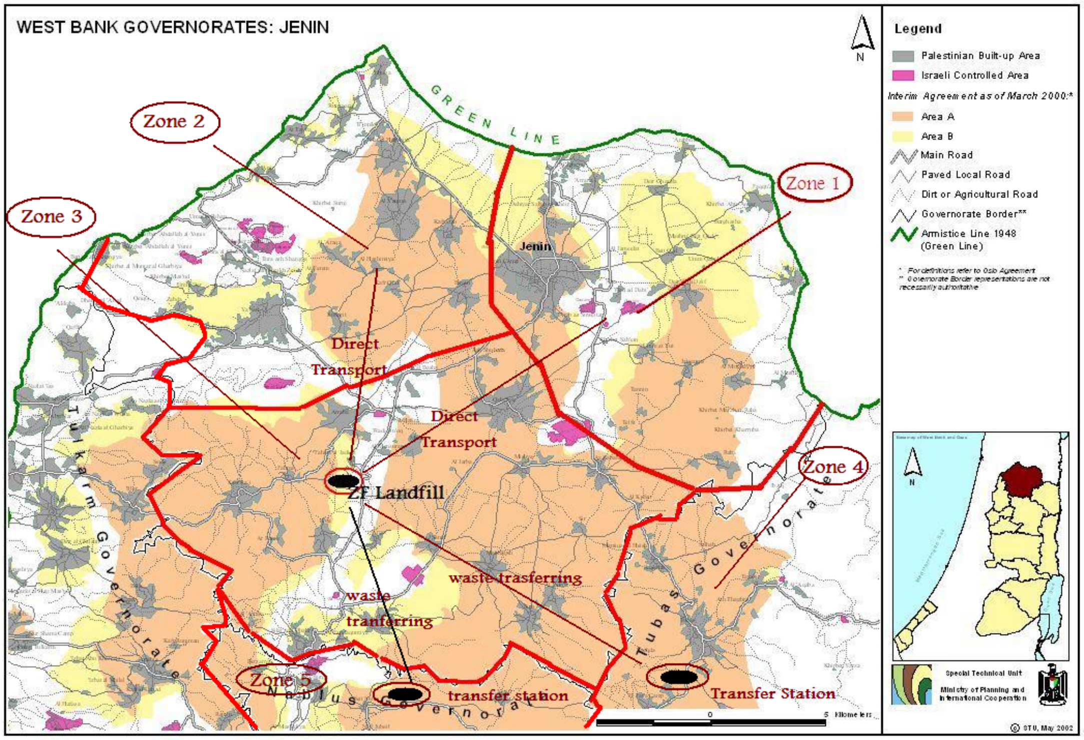


Figure (5): Zones of study area.

Zone 1: this zone includes the Jenin city and the Jenin east villages. The total population of this zone is around 77272 inhabitants (PCBS, 2008). The average solid waste generated by zone 1 is 66 ton/day (JSC, 2008).

Jenin is a central city of Jenin governorate; it has a big vegetable market, industrial region, institutions, schools, hospitals, etc.

The total population for jenin city including its refugee camp is around 50000 inhabitants, of average waste generation of about 46 ton/day. Jenin is considered as an agricultural city and is sited at the Mrag Ben Amer agriculture field. The solid waste is sent to ZF landfill directly without transfer station (PCBS, 2008).

The Jenin east villages include Al jalameh, Arraneh, Arrabuneh, Deir Ghazaleh, Jaloun, Faqoua'ah, Beat Qad, Deir Abu Di'ef, Um Al Tut, Jalqamous, Al Mugayer, Rabba, and Arab American University. The population of these communities is around 27272 (PCBS, 2008), and the average solid waste generation is 20 ton/day. These villages considered as small villages and depend on agricultural activities.

Zone 2: this zone includes the west villages of jenin and the ya'bad villages. The total population of this zone is around 74000 inhabitants, and the average waste generation is 50 ton/day (PCBS, 2008).

The villages that are included are: Alyamoun, kufr Dan, Sielt Al Harthya, Al Taybeh, Rommaneh, Zobubah, A'nen, Berqeen, Kufur Kud, Alhashmyeh, Al A'araqa, Brqeen, Ya'bad villages.

These villages depend on agricultural activities and most laborers work as employees in Israel due to its location at the green line. The solid waste form theses villages is sent to ZF landfill directly.

Zone 3: this zone includes Qabatya, Maythaloun, and Arrabeh regions, which are the villages in the neighborhood of the landfill in distance less than 15km. The total population of this zone is around 105000 habitants and the average waste generation 70 ton/day (PCBS, 2008).

The villages that are included by zone 3 are: Qabatya, Arrabeh, Merkeh, Alshuhada', Beir Al Basha, Al Zaabdeh, Meslyeh, Sanour, Aljdydeh, Seer, Maythaloun, Sanour, Serees, Jaba', Al A'sa'sa, Al Fondoqomyeh, Seil Al Daher, A'ja, Al Rami, Kufr Raa'ee, Fahmeh.

Qbatya village is considered as the largest local community at this zone, where its population is 20000 habitants (PCBS, 2008). It has central vegetable market and stone factories. The other villages of zone 3 depend on agricultural activates.

Tubas governorate is zone 4: The total population of this zone is around 50000 and the average waste generation is 38 ton/day (PCBS, 2008).

Tubas is the central city for this governorate, it has vegetable and fruit market, restaurants and is famous in agricultural activities. The other villages that are included in zone 4 are: Tamoun, A'qaba, Tayaseer, and Al Fara'a. These villages depend on agricultural activates.

The solid waste of zone 4 is transported to ZF landfill via transfer station that has been equipped with four 32 m^3 containers that are transported to ZF landfill.

Zone 5: include the Nablus city with its four refugee camps. The city is considered as the largest city at the northern part of the West Bank. The total population of Nablus city is around 172000 inhabitants.

Nablus Municipality has singed an agreement with Zahart Al Fenjan Solid Waste Joint Service Council (JSC) to enable the Municipality to dump its solid wastes. This agreement has enhanced SWM in Nablus and has reduced the public health hazards due to solid wastes. However, this agreement has also supported the JSC and supports it financially continue providing their services, which will be positively reflected on the sustainability of the landfill site.

Nablus municipality has constructed a transfer station in corporation with the private sector. The SW for Nablus city is collected and transferred to the transfer station, from which the SW is further transport via trailer to ZF landfill. At Nablus transfer station about 20% of the solid waste is separated as recyclable materials and the 80% are sent to ZF landfill for dumping.

Table (2) summarizes population, daily waste generation, way of transferring and transporting the waste and the average distance to ZF landfill. The average daily solid waste was estimated from the records of the Weighbridge of ZF landfill, where all trucks are weighted. The table also shows the average distance to ZF landfill from different zones.

Table (2): Solid waste generation and transfer system to ZF landfill.

Zones	Population	average of daily waste Ton/day	waste generation Kg/capita. day	Way of transfer & transport	Average distance km

Zone 1	77333	71.00	0.92	Direct	22
Zone 2	74166	54.00	0.73	Direct	26
Zone 3	105289	79.00	0.75	Direct	10
Zone 4	50040	41.00	0.82	T.S	28
Zone 5	172000	155.00	0.90	T.S	32
Total	**478828**	**400.00**	**0.84**		

The average waste generation of 0.84 kg/capita.day has been used to estimate future SW quantities.

3.6 Solid waste projections

The projection of future solid waste quantities and estimated composition is important in scoping and designing future solid waste collection, transport, recycling, treatment and disposal systems. The projection must take into account the population increase rate. The projecting of solid waste quantities is used to estimate the landfill capacity (UNEP, 2003).

Table (3) illustrates the future solid waste projection in the next 15 years. The projection of municipal solid waste generation in the study area has been done based on the population growth. The EIA study of ZF landfill considered 4.47% as the population for Jenin governorate in 2002 and reduced that to 2.21% in 2021. In this study an average growth rate of 3%

has been considered. For the annual increase in the solid waste generation per capita 1% increase per year has been applied. This has been used by the EIA study for ZF landfill (ERM, 1998). The increase in SW generation is expected due to the expected development and the level of the income for the residents.

Table (3): Projected population and solid waste generation up to 2023.

years	Population increase rate 3%	Waste generation Kg/capita. day (Annual increase rate 1%)	Waste quantities ton / day	Waste Quantities ton / year
2009	478828.00	0.84	402.22	146808.66
2010	493192.84	0.85	418.43	152725.05
2011	507988.63	0.86	435.25	158864.30
2012	523228.28	0.87	452.70	165234.45
2013	538925.13	0.87	470.81	171843.82
2014	555092.89	0.88	489.59	178701.05
2015	571745.67	0.89	509.08	185815.06
2016	588898.04	0.90	529.30	193195.07
2017	606564.98	0.91	550.28	200850.65
2018	624761.93	0.92	572.03	208791.69
2019	643504.79	0.92	594.59	217028.43
2020	662809.94	0.93	618.00	225571.45
2021	682694.23	0.94	642.28	234431.74
2022	703175.06	0.95	667.45	243620.63
2023	724270.31	0.96	693.56	253149.86

Chapter Four

4 Solid waste reuse and recycling criteria

4.1 Introduction

The solid waste management has developed from the simple ways that include the collection and disposal at random locations to the more complex systems. Among the several complex processes for managing solid waste are reuse and recycling (SWRR). This development in reuse and recycling was different considering different evaluating criteria. In most cases the criteria are categorized to main criteria including technical, environment, social, economic, etc, and the sub-criteria which are derived and thus promote the goal for these main criteria (Salhofer, et. al., 2003).

In most researches and studies different SWRR criteria were applied to asses the management options. These researches are useful to list criteria likely to be relevant and illustrate local constrains and concerns in looking at a range of environmental, social, technical, and economic factors that reflect the advantages and disadvantages of SWRR options. The community can be involved in determining the criteria so that their concerns and their understanding of the local solid waste management challenges are reflected (DEAT, 2005).

It is important to take into consideration the cost of reuse and recycling as a key financial criterion and to reflect the cost revenues. The cost should include the cost of facilities; equipment and operation to be compared with the revenues including the fees and marketing the recyclable materials (SWACM, 2004).

Table (4) illustrates the criteria that will be considered in studying the SWRR options. The main criteria that are selected from previous related studies are categorized as technical, environmental, social, and economic criteria. These are tabulated in table (4) specifying their goals and sub-criteria.

Table (4) has been developed using different literatures, these are Salhofer, et. al, 2003; DANIDA, 2005; Wong, 2004; Schouw, 2003; ERM, 1998; Scott, 2000; Schubeler, et. al, 1996.

Table (4): Criteria applied to the SWRR management options.

Criteria 1: Technical Criteria		
Category	**Goals**	**Sub-criteria: Equipment and vehicles**
Management and operation	Manage and operate the SWRR options in technical manner that is performed through waste separation at source; at Transfer stations; or at site separation using recycling plant.	Select the required equipment, machines, vehicles and tools that are required for the system waste separation.
Criteria 1: Environmental Criteria		
Category	**Goals**	**Sub-criteria: Environmental impacts**
Protection of the environment and human health.	1. Manage SWRR options in an environmentally acceptable manner that protects water sources, lands, air, soil, etc. 2. Protect public health.	Meets solid waste recycling options with reducing negative impacts on environment and human health: • Water quality • Odors and air quality • Noise impacts • Loss of Aesthetic value • Health and safety
Criteria 2: Social Criteria		
Category	**Goals**	**Sub-criteria: Social impacts**

Community	1. Provide and facilitate access to the collection points, transfer stations, and landfill for municipalities, residents, businesses, and institutions. 2. Work with local communities to facilitate the solid waste recycling options, through providing educational and awareness programs that promote viable participations. 3. Ensure that the SWRR system will increase quality of life for the residents and the study area.	Meets solid waste recycling options with reducing negative social impacts: • Convenience and accessibility • Participation and public awareness • Health and safety impacts • Landscape impacts • Local employments • Odors
Criteria 4: Financial Criteria		
Category	**Goals**	**Sub criteria:** **Benefit cost ratio (B/C)**
Financial, conservation of raw materials and job creation	1. Ensure the overall financial effectiveness of SWRR options through calculating the costs and benefits.	• Achieve an effective and higher B/C ratio

4.2 Technical Criteria

The technical systems include all issues related to reuse and recycling options such as equipment, machines, vehicles, constructions, etc. These technical issues should be evaluated and designed in appropriate technical manners, with careful attention to their operating characteristics, performance, and maintenance requirements. Reuse and recycling equipment, machines, constructions, etc. require data on waste composition, density and waste generation and their expected changes over time (DEAT, 2000).

The main goal of technical criteria is to manage and operate the SWRR options in technical manner by choosing the suitable equipment and machines. The sub-criteria are considered when to select the operation equipments, machines, constructions that are need for the SWRR options (Schubeler, et. al, 1996). Separation at source option includes the collection of the separated waste, transferring the waste to the transfer stations, where available, or to the landfill. Separation at transfer stations option includes the transport of the waste to the landfill. The separation via a recycling pant at the landfill site considers the final disposal for the remaining waste at the ZF landfill.

Collection systems include waste containers, primary and secondary collections vehicles and equipment, and management of the collection workers, and even providing the protective clothing. Selection of collection equipment should be based on data related to waste composition and density and local waste handling patterns. The most effective result is obtained through the participation of the concerned communities, inference to way of waste collection such as curbside and drop-off center collection. The required equipment and machines for collection the recyclable material at the source though curb side and drop of center will be listed and evaluated (USEPA, 1995).

Separations at the transfer stations include temporary waste storage at the transfer stations, vehicles and equipment for waste transfer, and operating and maintaining the equipment. Transfer station locations must be properly selected and operated to decrease problems that may occur such as noise, pollution, etc. The required equipment must meet the characteristics and design of transfer stations while the vehicles must consider the characteristics of local system. All equipment and machines for SWRR option at transfer station will be studied and listed. (USEPA, 2001)

The separation of recyclable materials at the landfill site such as paper, glass, metals and plastics, etc. is seen by constructing of a separation plant, which will include:

- land for the plant, area of waste storage, and area for compost piles
- machines and equipment for waste separation according to recycling plants specifications
- processes, operation, maintenance, and site laborers

4.3 Environmental Criteria

Improper solid waste management has impacts on the environment in several ways. Therefore these criteria are important for any development in solid waste management or for the implementation of recycling management options. It is to identify any negative environmental impacts associated with recycling and the positive environmental benefits. (salhofer, et. al., 2003).

The main categories for environmental criteria are protection of the environment and public health. These must be managed through acceptable environmental and health protection goals aiming at reducing the negative impacts on the environment. In table (4) the goals of the environmental criteria are listed as follows:

- **Safe environment:** Manage SWRR options in an environmentally acceptable manner that protects water sources, lands, air, soil, and etc.
- **Public health:** Integrates solid waste recycling management options to promote and facilitate waste separation at source and site, collection, transportation, and final disposal at landfill, in a manner that protects public health.

Safe environment: Applying the reusing and recycling options must meet the reduction of the negative impacts on the environment and reduce the water and air pollution.

Water pollution: Groundwater and surface water pollution is the most common means of environmental degradation associated with solid waste. The pollution occurs from liquids of the waste (leachate) and from rainfall mixed with the waste at dumpsites and random locations. Contamination of groundwater is caused through percolation of leachate to the groundwater. The leachate is generally toxic and may become more toxic if it becomes mixed with hazardous wastes such as household cleaners or industrial solvents (ERM, 1998). Surface waters such as streams, rivers and lakes may also become polluted from solid waste leachate. Rain water flows across the body of the waste, and into surrounding surface waters. This rain water carries the leachate with it.

Air pollution: There are two main causes of air pollution due to solid waste; waste burning and waste decomposition.

Waste fires are common at the random dumpsites and different locations near the cities, villages, streets, etc. Waste burning is controlled by enhancing the regulations which must prohibit the open burning and promote using sanitary landfills, where the soil daily covers are used above the waste (ERM, 1998).

The second cause of air pollution from waste decomposition that causes pollution when methane and other gases are released into the atmosphere, when the organic wastes are decomposes an aerobically. Methane and other gas releases are controlled by diverting the gas into a pipe where the gas can be monitored and in some instances, burned. This gas is sometimes collected at the site and sold as methane fuel or used to generate power on site (ERM, 1998).

Human health: poorly management of solid waste have many human health problems associated with many diseases vectors such as, insects, vermin, birds, and rodents, water pollution (surface and ground), and emissions from burning the waste. The pollutants that are released through solid waste burning can cause health problems for workers and for anyone living nearby. The effects may include damages to human health such as lungs, the nervous system, kidneys, and some pollutants may cause or aggravate cancer, asthma, chronic bronchitis, emphysema, and numerous other diseases and conditions. The damage to health is more serious to the neighbors or workers that are exposed to the smoke (VANR, 1990).

The operational practices for recycling system must be designed to minimize the health risks at all stages of solid waste separation. In general they include:

- Control of vermin, insects and birds by using pesticides

- Can’t waste accumulation by considering daily collection, daily separation, and daily cover of the residues waste.
- Control fires
- Using protective clothing for laborers
- Provision of first aid.
- Regular health checks for personnel.

4.4 Social Criteria

The solid waste generated from different local communities, institutions, organizations, etc., are function of people's consumptions' patterns and their social characteristics. The generated SW will be the incentive for the people to participate in the success of SWRR. This depends on the SW composition; collection and disposal practices that affect the options to be selected for SWRR (Nigbur, et, el, 2005).

The main category for social criteria is the community that plays the main role in succeeding for the recycling system through achieving the goals that should be considered and to meet the residents’ needs. In table (4) the goals of the social criteria as the follows:

Convenience and Accessibility: Establish reuse recycling system that provides the convenience and accessibility to the community.

The convenience and accessibility is essential in applying reuse and recycle system in all stages including waste storage, way of source separation, collection containers and distribution, time of maintenance and operation, location of transfer station and landfills (WDNR, 2001).

The convenience and accessibility for residents and workers will be through identifying the proper operation and maintenance time for solid waste separation. The time of waste collection and disposal can be identified for the resident through designing programs, which includes: town name; collection time; collection ways and collection point locations. The collection point locations, that include container, bins, skip-lift container, drop-off, etc., must be chosen and prepared in ways to achieve the convenience for the resident and worker such as the short distance, odors and safety control. The convenience for the workers will be through improve their working conditions and facilities, increase their earning capacity, and improve their social security, including access to housing, health and educational facilities. Proper equipments and protective clothing can reduce the health risk (Schouw, 2003).

Residents participation and awareness: Work with local communities to facilitate and succeed in the solid waste recycling options, through providing educational and awareness programs that promote viable participations.

One of the important key in applying the reuse and recycling options is the cooperation and participation of the residents that can be achieved by many ways, such as coordination with municipalities and councils, establishing committees, and implementing educational and awareness programs (Nigbur, et, al, 2005). The major barrier that is considered as big challenge of SWRR is the lack of awareness among the residents about the advantages and disadvantages, practices of the separation, waste compositions, identifying the recyclable materials, etc. Huge efforts must be done to raise general public awareness and educate the residents how to separate their waste according to the required categories. This can be done via education courses, school programs, teaching and learning materials. The directed training and motivational programs for institutions and leaders, and establishing boards from communities, businesses, institutions, and residents, are considered as an effective means for improving awareness and participation in solid waste recycling system (Klages, 2005).

Life Quality: Ensure that reuse and recycling system improves the quality of life through odors control, traffic management and conserves the aesthetic issues.

4.5 Financial criteria:

Table (4) listed the goals of the economic criteria:

- Ensure the overall financial effectiveness of waste reuse and recycling options through the adequate evaluation of economic costs and benefits

The financial costs analyses include the capital and operational cost. The expected benefits take into consideration all issues related to the environmental and social criteria. The life cycle and expected benefits will be through the financial sub-criterion that is considered as key criterion and essential to the effective SWRR options. These are:

- Capital cost for facilities and equipment
- Operation cost, and identifying the revenues and to ensure that the collected revenues are applied to their intended services.
- Revenues from the waste fees and marketing the recyclable materials

Chapter Five

5. Solid waste composition and characteristics at ZF landfill

5.1 Introduction

The information on waste composition, and the quantities generated are basic needs for managing the SWRR system. The waste composition refers to the limited list of waste components, such as paper, glass, metal, plastic and food waste, into which municipal waste may conveniently be separated (Belhrazem, et, el, 2000).

Characteristics of waste materials refer to those physical and chemical properties, which are relevant to the storage, collection, treatment and disposal of waste such as density, moisture content, calorific value and chemical composition.

- Waste composition differs according to national income, socio-economic conditions, social developments and cultural practices. Thereby it is important to obtain the data locally

  (Buenrostro, et. al., 2005).

5.2 Solid waste source

Composition of solid waste differs according to its source, which varies from place to place and from country to country. Factors affecting the variation of the solid waste are: culture, economy, population, and social factors. The following are the different sources of municipal solid waste (Hydroplan, 2004):

- Domestic waste which is generated from the household and most of it is kitchen waste.
- Agricultural waste which is includes the waste that is generated from the agricultural activities such as, plastic covers, pipes, leaves, and plants.
- Industrial waste which is generated from processing and non processing industries.
- Commercial waste including wastes from offices, restaurants, places of business, hotels, and public services.
- Hazardous waste including chemical wastes, medical wastes, household hazardous wastes, etc.

All types of solid waste (household, industrial, commercial and agricultural) consist mostly of the following categories: Organic materials, such as food waste or weeds; paper and cardboard, including newspaper, magazines and cartons, glass, metals, etc.

The sources of municipal solid wastes that arrive ZF landfill have been categorized according to source of generation and are divided as residential, agricultural, commercial, industrial, and others. Table (5) represents these generated in jenin governorate. The main source of municipal solid waste is the residential waste from the households (above 50%). The agricultural waste is mostly organic waste from the vegetable markets. The commercial and industrial waste is limited in jenin governorate.

Table (5): Municipal waste sources at Jenin and Tubas governorates (ERM, 1998).

	Residential	Agricultural	Commercial	Industrial	Others
Jenin city	50%	16%	19%	12%	3%
15 municipality 5000 - 17500 Hhs	65-70%	5-15%	10%	0-10%	0-10%
31 communities 1000 - 5000 Hhs	65-85%	5-25%	3-10%	0-10%	0-10%
60 communities less 1000 Hhs	70-90%	5-25%	0-5%	0-10%	0-10%

The density of municipal solid waste varies considerably depending upon the collection point, transfer and disposal system. The overall average density in summer can reach 0.35 ton per cubic meter, which is reflecting the soil and large quantities of heavy summer fruit. The density of commercial waste is often not higher than 0.15 ton / m^3 (ERM, 1998).

It is estimated that the average density of the solid waste upon secondary collection which causes the density to increase due to compaction and vibration during transportation is 0.25 ton/ m^3 for urban and rural wastes and 0.20 ton/m^3 for commercial and agricultural waste. The density of waste at the point of disposal (ZF landfill) is estimated

0.30 ton / m^3 (ERM, 1998).

The pre-feasibility study for ZF landfill in 1998 has identified the composition of solid waste in project area. The study covered the municipalities, villages, and small communities.

Tables (6) and (7) respectively, show the municipal solid waste composition of jenin city and at the rural area in Jenin and Tubas governorates. It is estimated that the organic components from 55-60%, paper and cardboard around 10-20%, and the around 6-10%. Hazardous waste such as medical, pharmaceutical and industrial wastes, are collected and disposed along with the municipal forming a percent not more than 1%. The other bulky items including car parts and tires are generated in small percents not more than 5%.

Table (6): Municipal solid waste compositions of jenin city (ERM, 1998).

Items	residential	agricultural	commercial	weighted mean
Organics	50%	80%	25%	55%
paper/cardboard	20%	6%	55%	20%
Metals	10%	-	-	5%
Plastics	6%	4%	10%	6%
Textile	4%	-	-	3%
Glass	4%	-	-	3%
Other waste	6%	10%	10%	8%

Table (7): Municipal solid waste compositions in rural areas, Jenin and Tubas governorates (ERM, 1998).

items	estimated % of waste stream
Organics	65%
paper/cardboard	10%
Metals	3%
Plastics (including agricultural plastic waste)	10%
Textile	3%
Glass	2%
car parts and tiers	2%
hazardous waste	1%
Other waste and bulky items	4%

5.3 Pilot composition of solid waste at ZF landfill

The solid waste composition at ZF landfill was verified via pilot separation to identify the percentage of the different waste components. The pilot covered the description of the solid waste composition of the samples taken from waste produced by the different zones (see figure 5). The samples were weighted; wastes were segregated, then weighted results have been recorded and compared accordingly. Most studies and reports has showed that the sampling percentage as function of the total daily waste is around (0.5 – 1) % (Belhrezem, 2007).

Table (8) shows the weights of the samples for each zone that have been used for separation in the pilot.

Table (8): Average weights of the pilot samples.

	Average daily waste ton/day	**Weight of samples** Kg	**%**
Zone 1	71	450	0.63
Zone 2	54	300	0.56
Zone 3	79	450	0.57
Zone 4	41	250	0.61
Zone 5	150	780	0.52

The samples program was conducted as follows:

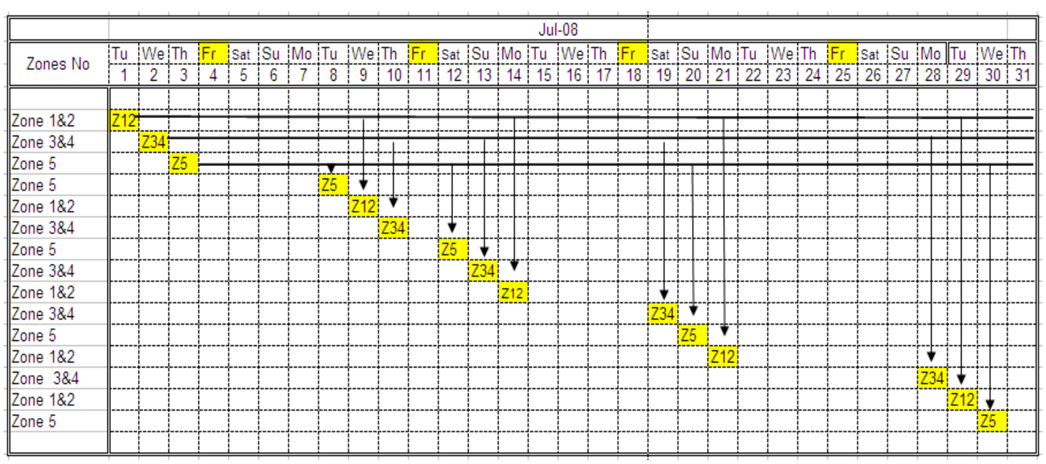
1. The sampling was conducted during a period of 3 months. Each month was divided into five periods of 3 days each.

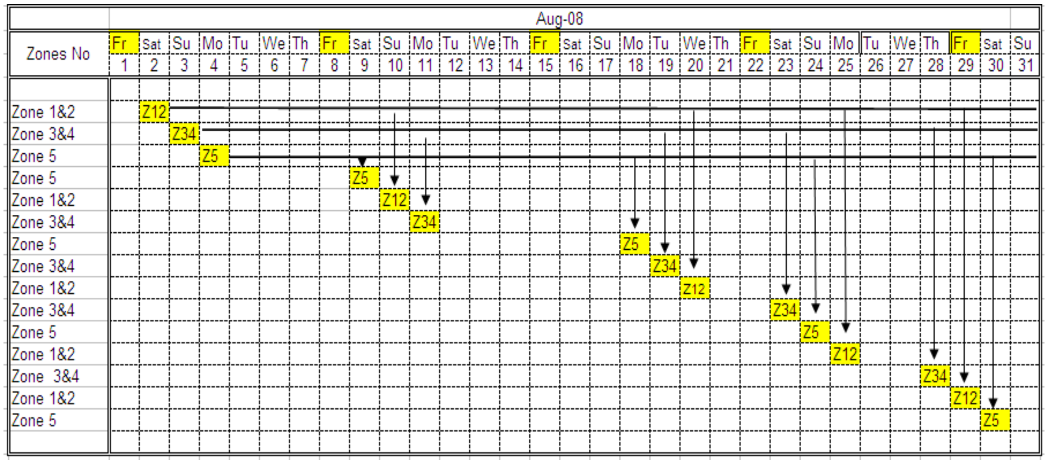
2. During each period samples were taken from the solid waste of the 5 zones. Zone 1 and 2 were mixed together and zone 3 and 4 were also mixed together while zone 5 was sampled alone.

3. Three samples (1 and 2; 3 and 4; and 5) were taken in each of the 3 days period differently. This means that 15 sets of the samples have been collected during the 3 months period.

4. The total number of samples is 45 samples, totally weight of 33450 kg.

Figure (6) represents the sampling in each of the 3 months of July, August, and September of 2008. In the figure Z12 means that the sample on that date of the month was taken mixed from zone 1 and 2. The weight of the sample Z12 is thus 750 kg, 450 kg from zone 1 and 300 kg from zone 2. As stated before, the average sampling % of 0.5-0.65 of the average daily waste generation of the each zone was applied as illustrated by table (8). The timing of the samples is as presented by figure (6). In distributing the sampling among the different days, the idea was to mix days to alleviate the temporal effects.





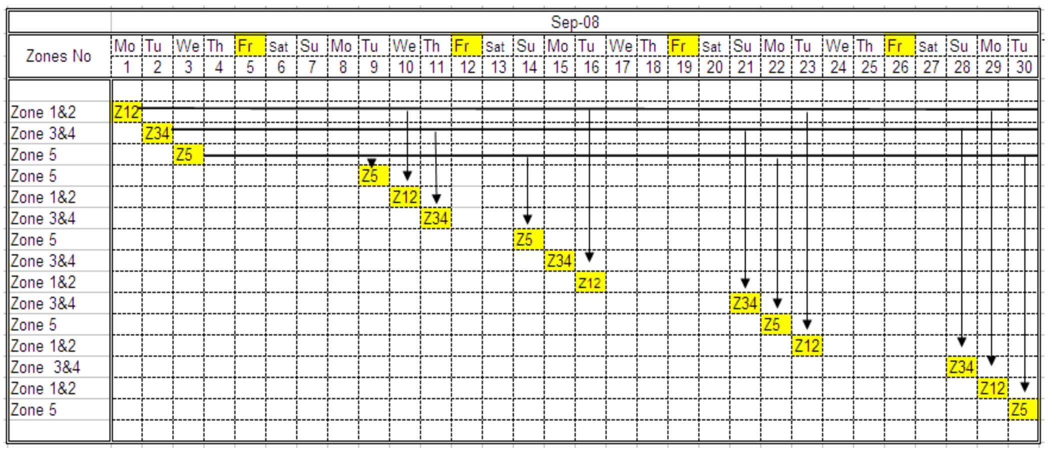


Figure (6): Sampling dates during the three months of pilot period.

The separation has been done at ZF landfill near the area where the waste daily disposed. The following apparatus were used in sampling

(see figure 7):

- Separation table of 1.8 * 1 * 0.8 m covered by steel mesh of 2 * 2 cm (see figure 6).
- Waste baskets that are labeled with each component.
- balance

- gloves, masks, and hats
- brooms and labels

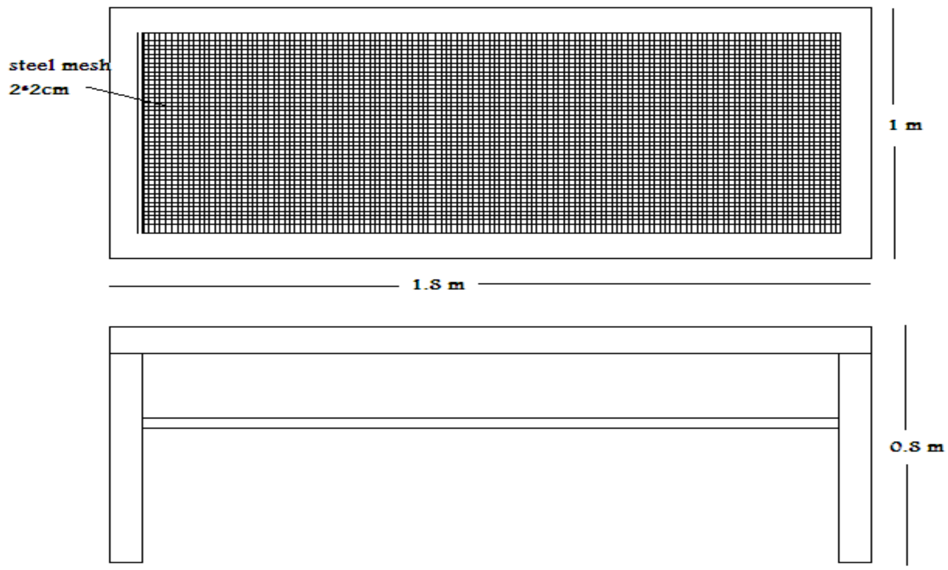


Figure (7): Separation table dimensions.

Figure (8): Apparatus of waste separation

Follow are main items that have been separated through the separation pilot:

- Organic and food waste including vegetables, fruits, meat, etc.
- Cartoon and paper including newspapers, office papers, cartoon, packaging papers, etc.
- Plastic such , PVC, LDPE, HDPE, PET, EPS, PS
- Glasses
- Metals
- Textile
- Others which are included Hazardous wastes, bulky wastes, etc.

The procedures that have been done in the separation pilot as follows:

1. The samples were selected randomly by the loader from the different zones according to the time table (see figure 6).
2. Removing the sharps wastes was the first step such as needles, broken glass, and etc, to avoid injury for the laborers.
3. solid waste items were separated by the laborers into labeled baskets.

4. The weights of samples were taken and recorded in the tables which are included: date, zone number; waste items name; samples weights.

Tables (9), (10) and (11) illustrate the average solid waste composition for each components at Zones (1 and 2), (3 and 4) and zone 3 respectively. These percentages are estimated from solid waste composition pilot for six items of solid waste components, which are: organic waste; cartoon and paper; plastic; glass; metals; textile; and others. The percentages of solid waste components vary between the different zones. This refers to the solid waste composition at source such as residential, commercial, industrial, and agricultural and the variation in the life style between the urban and rural areas. These tables as follows:

Table (9): Solid waste composition at zone 1 and 2.

type	percentage %
organic and food waste	51
Cartoon and papers	16
Plastic	12.4
Glass	2.8
Metals	3.3
Textile	8.6
Others	5.9

Table (10): Solid waste composition at zone 3 and 4.

type	percentage %
organic and food waste	62.2
Cartoon and papers	10.3
Plastic	11.2
Glass	4.2
Metals	2
Textile	7.6
Others	2.5

Table (11): Solid waste composition at zone 5.

type	percentage %
organic and food waste	49.1
Cartoon and papers	13.8
Plastic	12.5
Glass	4.2
Metals	3.3
Textile	11.9
Others	5.2

Chapter Six

6 Management Options and technical requirements

Management the study options (separation at source, at transfer station and at landfill) are discussed at this section for different zones taking into consideration the technical requirements for SWRR options. Managing the options is done by identifying the schemes, programs, and separation type according to the waste percentage components. The technical requirements were discussed for each option by identifying the required equipments, machines, vehicles and laborers. The available systems at study area are discussed to identify the equipments, vehicles, laborers for the collection, transportation and disposal. These are considered to be used for each option such as the collection vehicles and equipment at separation at source, the available transfer stations and the available facilities at landfill for separation at landfill site. In addition to that the available separation trials at the study area are discussed. This is by identifying the available options of the waste separation and types of separated wastes.

6.1 Available solid waste system at the study area

The available systems are discussed for the different zones as follows:

- Solid waste collection: which is included the available the number and capacity of solid waste collection vehicles, number and capacity of containers and number of workers.
- Solid waste transfer and transportation: this has been discussed and includes the available transfer stations, numbers, operation, location, component, vehicles, workers and the available separation at transfer station.
- Solid waste disposal at the ZF landfill: this includes the number of equipment, workers, facilities, available lands, etc. These are considered as complementary for separation at landfill.
- Available separation at study area: this has discussed the available separation at source cases at the study area, quantity, type of separated wastes and marketing.

6.1.1 Solid waste collection

The solid waste is collected from the study area by different methods (collection ways) and means (different vehicles, containers, etc). These according to the follows:

- The direct collection: this way is considered to collect the solid waste from the available 1.1m^3 wheel containers via the compactors vehicles (5 m^3, 9 m^3, 12 m^3).
- Door to door collection: this way is considered to collect the solid waste from plastic bins/bags and barrels direct to waste vehicle (compactors or tractors) or to collection points. This is applied at locations that haven't enough number of 1.1 m3 wheel containers; localities have tractors for collection; and from high density population locations, which have narrow roads.

Tables (12); (13); (14); (15) illustrate the available number and capacity of the solid waste vehicles and containers at zones 1, 2, 3 and 4 consequently. The solid waste is collecting from these zones by the direct and door to door collection. The number of wheel container 1.1 m^3 is not enough that lead to consider door to door collection, where the residents refuse the wastes by the plastic bags and/bins or barrels. These tables as follows:

Table (12) represents the zone 1 which included Jenin city and Jenin east villages. The wheel containers 1.1 m^3 at Jenin city is 200 and the solid waste vehicles (compactor vehicles) are used for collection the solid waste in two periods which are, morning and after-noon period. There are two vehicles 9m^3 used for the morning and after-noon period and one 12 m^3

used for the morning period. For the jenin east villages there are there are three vehicles $5m^3$ and one vehicle $9m^3$ and 150 wheel containers.

Table (13) represents the zone 2 which included Jenin west villages. There are six compactor vehicles with capacity five 9 m^3, two vehicles 5 m^3, one 12 m^3 and one tractor and 418 wheel containers.

Table (14) represents the zone 3 which included the villages around the landfill. There are eight compactors vehicles with different capacity, which are one vehicle 12 m^3, four vehicles 9 m^3, three vehicles 5 m^3 and three tractor and 498 wheel containers.

Table (15) represents the zone 4 which included Tubas governorate. There are four compactor vehicles three 9 m^3, one 5 m^3 and one tractor and 475 wheel containers.

Table (12): Collection vehicles and equipment at zone 1

Villages name	**Collection Vehicles**			**Collection equipment containers**	
	Vehicles	capacity	number	**Type**	**Number**
	compactor	12m	1	wheel containers 1 m	
	compactor	8m	1	wheel containers 1 m	
Jenin city	compactor	8m	1	wheel containers 1 m	200
AL Jalameh	compactor	5m	there are three compactor for these villages	wheel containers 1 m	15
A'rraneh	compactor	5m		wheel containers 1 m	15
Dier Ghazaleh	compactor	5m		wheel containers 1 m	10
Arabouneh	compactor	5m		wheel containers 1 m	10
Jalboun	compactor	5m		wheel containers 1 m	20
Beit Qad	compactor	5m		wheel containers 1 m	8

Um Al Tout	compactor	5m		wheel containers 1 m	10
Jalqamoos	compactor	5m		wheel containers 1 m	10
Al mogyer	compactor	5m		wheel containers 1 m	7
Raba	compactor	5m		wheel containers 1 m	5
Faqoua'a	compactor	8m	one for the both daily	wheel containers	0
Dier Abu Di'ef	compactor	8m		wheel containers	20
Containers			**5**	**Containers**	**330**

Table (13): Collection vehicles and equipment at zone 2.

Villages name	**Collection Vehicles**			**Collection Equipment**
	Vehicles	capacity	number	**Wheel containers 1.1 m^3**
Al Yamoun	compactor	9m^3	1	100
	Tractor	4m^3	1	
Kufr Dan	compactor	9m^3	1	30
Sielt Al Harthya	compactor	9m^3	1	50
Birqeen	compactor	9m^3	1	60
Kufr Qud	compactor	5m^3	one for the both	0
Al hashmya	compactor	5m^3		0
Ti'enk	compactor	5m^3	one for all	0
Zbuba	compactor	5m^3		15
Rommaneh	compactor	5m^3		20
Altyebeh	compactor	5m^3		17
Aneen	compactor	5m^3		10
Al A'raqa	Tractor	5m^3	1	0
Ya'bad	compactor	9m^3	1	80
Kferet	compactor	5m^3	one for all	0
Tura	compactor	5m^3		6
Al Nazleh	compactor	5m^3		0
Barta'a	compactor	12m	1	30
sum			**11**	**418**

Table (14): Collection vehicles and equipment at zone 3

<table>
<tr><th rowspan="2">Villages name</th><th colspan="3">Collection Vehicles</th><th>Collection equipment</th></tr>
<tr><th>Vehicles</th><th>capacity</th><th>number</th><th>Wheel containers 1.1 m^3</th></tr>
<tr><td rowspan="2">Qabatia</td><td>Compactor</td><td>$9m^3$</td><td>1</td><td rowspan="2">120</td></tr>
<tr><td>Tractor</td><td>$4m^3$</td><td>2</td></tr>
<tr><td>Arrabeh</td><td>Compactor</td><td>$5m^3$</td><td>1</td><td>80</td></tr>
<tr><td>Al Zababdeh</td><td>Compactor</td><td>$12m^3$</td><td rowspan="2">one for the both</td><td>50</td></tr>
<tr><td>Al Jdydeh</td><td>Compactor</td><td>$12m^3$</td><td>15</td></tr>
<tr><td>Meslyeh</td><td>Tractor</td><td>$4m^3$</td><td>1</td><td>15</td></tr>
<tr><td>Seres</td><td>Compactor</td><td>$5m^3$</td><td rowspan="2">one for the both</td><td>0</td></tr>
<tr><td>Al Fondocomyeh</td><td>compactor</td><td>$5m^3$</td><td>13</td></tr>
<tr><td>Sanour</td><td>Tractor</td><td>$4m^3$</td><td>1</td><td>0</td></tr>
<tr><td>Maythaloun</td><td>compactor</td><td>$9m^3$</td><td>1</td><td>40</td></tr>
<tr><td>Jaba'</td><td>compactor</td><td>$5m^3$</td><td>1</td><td>42</td></tr>
<tr><td>Sielt Al daher</td><td>compactor</td><td>$9m^3$</td><td>1</td><td>50</td></tr>
<tr><td>Ajja</td><td>compactor</td><td>$5m^3$</td><td>1</td><td>25</td></tr>
<tr><td>Kur Ra'ee</td><td>Tractor</td><td>$9m^3$</td><td>1</td><td>30</td></tr>
<tr><td>Fahmeh</td><td>compactor</td><td>$5m^3$</td><td>1</td><td>10</td></tr>
<tr><td>Al Shuhada</td><td>Tractor</td><td>$4m^3$</td><td rowspan="6">one for the all</td><td>0</td></tr>
<tr><td>Merkeh</td><td>Tractor</td><td>$4m^3$</td><td>0</td></tr>
<tr><td>Arami</td><td>Tractor</td><td>$4m^3$</td><td>0</td></tr>
<tr><td>Fahmeh camp</td><td>Tractor</td><td>$4m^3$</td><td>0</td></tr>
<tr><td>Almansourah</td><td>Tractor</td><td>$4m^3$</td><td>0</td></tr>
<tr><td>Bier Al Basha</td><td>Tractor</td><td>$4m^3$</td><td>0</td></tr>
<tr><td>Anza</td><td>compactor</td><td>$5m^3$</td><td>1</td><td>8</td></tr>
<tr><td colspan="3">Sum</td><td>16</td><td>498</td></tr>
</table>

Table (15): Collection vehicles and equipment at zone 4

Villages name	Collection Vehicles			Collection Equipment
	Vehicles	capacity	number	Wheel containers 1.1 m^3
Tubas	compactor	$12m^3$	2	140
Tamoun	compactor	$9m^3$	1	122
Aqaba	compactor	$5m^3$	1	90
Tayaseer	compactor	$9m^3$	1	49
Wadi Al far'a	compactor	$9m^3$	1	42
Wadi Al Bedan	compactor	$5m^3$	1	15
Seer	compactor	$5m^3$	1	17
Sum			**7**	**475**

6.1.2 Transfer stations

Four transfer stations are considered at this study. Two of these stations are available and operated which are: Tubas transfer station; and Nablus transfer station. The other two stations are proposed and the JSC is planning to construct these stations at the end of 2009. These transfer stations are: Jenin east villages transfer station; and Jenin west villages transfer station.

Table (16) illustrates the available transfer stations (Tubas and Al-Sayrafi) and the proposed transfer stations (Jenin west villages and Jenin east villages). **Tubas transfer station** is under use by Tubas governorate localities. The JSC is responsible about the operation of this station, where the solid waste is transferred daily to this station via collection waste vehicles (compactors and tractors). Then the collection vehicles loading the solid waste into containers (capacity $32m^3$) and then transported to ZF landfill by the trailer vehicles. The distance to landfill is around 28 Km through the road of Seres and maythaloun villages. **Al-Sayrafi transfer station** is located at the north east Nablus city, where the Nablus municipality has singed contract with private company to build and operate this station. The station has constructed as recycling plant for sorting the solid waste such as cartoon, plastic, metals and pilot for recycling the organic fraction. The transfer station is receiving around 150 ton/day of waste from Nablus city, Nablus camp and some villages (Salem, Zawata, kofor kallel, Biet Aeba and biet wazan**.**

Table (16): Available and proposed transfer stations at the study area

available transfer stations								
#	**Transfer station location**	**Served area**	**Waste quantity ton/day**	**Distance to landfill**	**Vehicles and equipment**	**number of trips (daily)**	**Operation**	**Notes**
1	Tubas transfer station	Tubas Governorate	**37**	28km through maythaloun-Serees road	one vehicle trailer **(5) containers (32 m3)**	one trip the trailer carrying two container in each trip	the solid waste is loading into the containers and sending daily to ZF landfill	the JSC is responsible about The operation of the T.S
2	Al-Sayrafi transfer station	Nablus city and Nablus Camps (Balata camp, A'skar camp, Bayit Al-ma' camp)	**150**	32 km through maythaloun-Serees road	two vehicles trailer **(8) containers (32 m3**)	4 trip daily to ZF landfill (each trailer making two trip and carrying two containers in each trip)	the solid waste is separated daily for some items such as plastic, paper and cartoon and metals	Nablus Municipality signed contract with private company to build and operate this T.S. the company separate the waste daily in percent 15-20%

Proposed transfer stations								
1	jenin west villages transfer station	Jenin west villages	**35**	28 km through jenin city and Jenin-Nablus road	one vehicle trailer (**5) containers (32 m3)**	one trip the trailer carrying two container in each trip	the JSC planning to operate this T.S as the Tubas T.S	N/A
2	jenin east villages transfer station	Jenin east villages	**30**	26 km through jenin city and Jenin-Nablus road	one vehicle trailer **(5) containers (32 m3**)	one trip the trailer carrying two container in each trip	the JSC planning to operate this T.S as the Tubas T.S	N/A

N/A: Not applicable

6.1.3 Available Solid waste separation at study area

There are few trails at the study area to separate the solid waste, which are limited in formal (private company) and informal private sector scavengers. The scavengers are separating some items of solid waste at the source from solid waste containers, markets, streets, etc. such as metals, plastic and cartoon. Other trail available at Al-Sayrafi transfer station by private company, which is separating around 15-20% of plastic, metals and cartoon. These separation trails are done in purpose of achieving money by sale the products (separated wastes) to the local or Israeli factories. Manual separation is done at the site of ZF landfill for the Plastic in average 600 kg/day. The separated plastic is sorted and treated at the site though crushing plant, which is crushing the plastic in small sizes 3-6 mm, then the JSC se the crushed plastic to local factories in Jenin governorate, which are recycling it as new products such as wastes packets, plastic agricultural pipes, plastic pockets, etc.

6.2 Separation at source

The separation at source option has been considered at this study through the curbside collection and drop-off centers. The main required issues for the separation at source are: containers; colored bags and bins; waste vehicles; laborers; and fenced lands in case of drop-off centers.

The separation at source has been discussed for the different zones according to the following procedures:

- Identifying the separation by the curbside or drop-off centers for the different zones.
- Considering two fractions of solid waste for separation at source. These two fractions are: wet fraction (organic wastes) and dry fraction (non-organic wastes and recyclable wastes).
- Suggest weekly schedule for separation by curbside and drop-off centers taking into consideration waste quantity, waste composition, and distance to landfill.
- Considering the direct collection (from containers 1.1 m^3) in case of curbside and skip-lift containers ($25m^3$) in case of drop-off centers separation
- Identifying the required staff and estimation the required containers taking into consideration the available laborers and containers.

Tables (17); (18); (19); (20); and (21) illustrate the weekly collection schedules for separation the solid waste at the study area. The solid waste collection is considered by curbside collection at the zones 1, 2, 4, and drop-off collection at some villages of zone 3, where the localities are situating at short distance from the ZF landfill (less than 10km). The solid waste is collected there day after day or two times per week. In case of curbside collection, two fractions (wet and dry fractions) of solid waste are separated and disposed at waste containers (1.1 m^3). Then the separated wastes are collected by the compactors vehicles and transported direct to landfill as in jenin city or transferred to the T.S as Jenin east villages, west villages and Tubas governorate. In drop-off centers cases the separated wastes are collected by laborers and store at the containers (25m^3) for collection according to the weekly schedule (day after day or two times per week) direct to the ZF landfill. the two fractions of solid waste (wet and dry) are collected in differed days, taking into consideration the average percent of wet fraction (organic waste) is 57% from the generated waste, see table (12). The tables that are illustrate the separation at source for the different at the study area as follows:

- Table (17) illustrates collection of the separated wastes at source in jenin city, which is apart of zone 1 (see section 3.5). Jenin city is divided into four quarters which are: east quarter, west quarter, north quarter and the market that is including the industrial area. The separated wastes are collected at morning period from the east, west, and north quarters and at afternoon from the market. The curbside is considered in collection and the solid waste then transported direct to the ZF landfill via compactor vehicles. The compactors that are considered for at the Jenin city are three compactors at the morning period, which are: one vehicle in capacity 12 m^3 from the east quarter and two vehicles in capacity 9m^3 for the west and north quarters.

- Tables (18), (19) and (20) illustrate the weekly time schedule for collection the separated solid waste from the Jenin east villages and Jenin west villages (zone 2) and Tubas governorate (zone 4) consequently. Three days are considered to collect the wet fraction and the other three days for the dry fraction by considering the curbside collection. Then the proposed Jenin east villages and Jenin west villages (zone 2) transfer stations are considered to receive the separated wastes from these villages according the weekly schedule. The available transfer station at Tubas governorate considered to receive the separated wastes from the different localities at the governorate. The vehicles are considered to collect the solid waste from the Jenin east villages are three compactor vehicles in capacity 5m^3. The vehicles are considered to collect the separated waste from the Jenin west villages are four compactor vehicles, which are: two vehicles in capacity $9m^3$ and two vehicles in capacity of $5m^3$. The vehicles are considered to collect the separated waste from the Tubas governorate are three compactor vehicles, which are: two vehicles in capacity $9m^3$ and the one vehicle in capacity $5m^3$

- Table (21) illustrates the weekly time schedule for collection the separated solid waste at zone 3. Drop-off centers are considered for the small villages that are transporting the solid waste day after day or two times per week. Curbside collection is considered for the villages that are sending the solid waste daily to the landfill. Through drop-off centers the laborers and/or the residents are considered to separate the solid waste as two fractions (wet and dry) into SW storage containers. The vehicles are considered to collect the solid waste from by the curbside collection are five compactor vehicles which are: three vehicles in capacity $9m^3$ and the two vehicles in capacity $5m^3$. One skip lift vehicle is considered to transport the solid waste from the drop-off centers to the landfill.

- **Table (17):** Schedule of collection the separated wastes from Jenin city

<table>
<tr><th>Quarters</th><th>Vehicles</th><th>Saturday</th><th>Sunday</th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th></tr>
<tr><td>east quarter</td><td>Compactor $12m^3$</td><td rowspan="4">organic (wet waste)</td><td rowspan="4">non organic (dry waste)</td><td rowspan="4">organic (wet waste)</td><td rowspan="4">non organic (dry waste)</td><td rowspan="4">organic (wet waste)</td><td rowspan="4">non organic (dry waste)</td><td rowspan="4">week end</td></tr>
<tr><td>west quarter</td><td>Compactor $12m^3$</td></tr>
<tr><td>north quarter</td><td>Compactor $9m^3$</td></tr>
<tr><td>market</td><td>Compactor $12m^3$</td></tr>
</table>

Table (18): Schedule for collection the separated waste from Jenin east villages.

Villages	Vehicles	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
AL Jalameh V1	Compactor $5m^3$	organic (wet waste)	non organic (dry waste)	organic (wet waste)	non organic (dry waste)	organic (wet waste)	non organic (dry waste)	week end
A'rraneh V1	Compactor $5m^3$							
Dier Ghazaleh V2	Compactor $5m^3$							
Arabouneh V2	Compactor 5m3							
Jalboun V2	Compactor $5m^3$							
Beit Qad V2	Compactor $5m^3$							
Um Al Tout V3	Compactor $5m^3$							
Jalqamoos V3	Compactor $5m^3$							
Al mogyer V3	Compactor $5m^3$							
Raba V1	Compactor $5m^3$							
Faqoua'a V1	Compactor $5m^3$							
Dier Abu Di'ef V3	Compactor $5m^3$							

V1, V2, V3: the vehicles numbers 1, 2 and 3

Table (19): Schedule for collection the separated solid waste from zone2.

Villages	Vehicles	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Al Yamoun V1	compactor 9m3	organic (wet waste)	non organic (dry waste)	organic (wet waste)	non organic (dry waste)	organic (wet waste)	non organic (dry waste)	week end
	Tractor 4m3							
Kufr Dan V3	compactor 4m3							
Sielt Al Harthya V2	compactor 9m3							
Birqeen V2	compactor 5m3							
Kufr Qud V4	compactor 5m3							
Al hashmya V4	compactor 5m3							
Ti'enk V3	compactor 5m3							
Zbuba V3	compactor 5m3							
Rommaneh V3	compactor 5m3							
Altyebeh V3	compactor 5m3							
Aneen V3	compactor 5m3							
Al A'raqa	Tractor 4m3							
Ya'bad V4	compactor 5m3							
Kferet V4	compactor 5m3							
Tura V4	compactor 5m3							
Al Nazleh V4	compactor 5m3							
Barta'a V5	compactor 12m3							

V1, V2, V3, V4, V5: the vehicles numbers 1, 2, 3, 4 and 5

Tale (20): Waste collection schedule for the separated waste at zone 4.

Villages	Vehicles	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Tubas V1	compactor 12m3	organic (wet waste)	non organic (dry waste)	organic (wet waste)	non organic (dry waste)	organic (wet waste)	non organic (dry waste)	week end
Tamoun V2	compactor 9m3							
Aqaba V2	compactor 5m3							
Tayaseer V3	compactor 9m3							
Wadi Al far'a	tractor 9m3							
Wadi Al Bedan	tractor 5m3							
Seer V3	compactor 5m3							

V1, V2, V3: the vehicles numbers 1, 2, and 3

Table (21): Waste collection schedule for the separated waste at zone 3.

Villages	Vehicles	separation	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Qabatia V1	Compactor 9m3	curbside	wet	dry	wet	dry	wet	dry	week end
	Tractor 4m3	curbside	wet	dry	wet	dry	wet	dry	
Arrabeh V2	Compactor 5m3	curbside	wet	dry	wet	dry	wet	dry	
Al Zababdeh V2	Compactor 5m3	curbside	wet	dry	wet	dry	wet	dry	
Al Jdydeh V3	Compactor 5m3	curbside	wet	dry	wet	dry	wet	dry	
Meslyeh V3	Tractor 5m3	dropp-off	wet	dry			wet	dry	

Seres V3	Compactor 5m3	dropp-off	wet	dry			wet	dry	
Al Fondocomyeh V3	compactor 5m3	dropp-off	wet	dry			wet	dry	
Sanour V3	Compactor 5m3	dropp-off	wet	dry			wet	dry	
maythaloun v4	Compactor 9m3	curbside	wet	dry	wet	dry	wet	dry	
Jaba' v4	Compactor 5m3	curbside	wet	dry	wet	dry	wet	dry	
Sielt Al daher V5	Compactor 9m3	curbside	wet	dry	wet	dry	wet	dry	
Ajja V6	Compactor 5m3	curbside	wet	dry	wet	dry	wet	dry	
Kur Ra'ee V6	Tractor 4m3	curbside	wet	dry	wet	dry	wet	dry	
Fahmeh V6	Compactor 5m3	dropp-off	wet	dry			wet	dry	
Al Shuhada T1	Tractor 4m3	dropp-off	wet				dry		
Merkeh T1	Tractor 4m3	dropp-off		wet				dry	
Arami T1	Tractor 4m3	dropp-off			wet	dry			
Fahmeh camp T1	Tractor 4m3	dropp-off			wet	dry			
Almansourah T1	Tractor 4m3	dropp-off			wet	dry			
Bier Al Basha T1	Tractor 4m3	dropp-off			wet	dry			
Anza T1	Compactor 5m3	dropp-off			wet	dry			

V1, V2, V3, V4, V5, V6: the vehicles numbers 1, 2, 3, 4, 5 and 6.

T1: tractor number 1.

Table (22) summarizes the required vehicles, staff, containers and drop-off centers for the separation at source at the study area. The required vehicles are identified for different zones, which are: eighteen vehicles compactors in different capacity (one vehicle $12m^3$, nine vehicles $9m^3$, and eight vehicles $5m^3$) for the curbside collection; one skip-lift vehicle; and four tractors at the drop-off centers collection. The required staffs are identified for curbside and drop-off centers which are: 26 drivers; 52 laborers; and 4 foremen. The containers that are considered for the curbside are 1.1 m^3 containers and the skip-lift containers (25 m^3) at the drop-off centers. The number of containers is estimated according to the number of the households in curbside collection as 1.1m3 for each twenty household taking into consideration the available container. One skip-lift container is considered for each drop-off center. Number of households at the zones (1, 2, 3, and 4) are 53,572 (PCPS, 2007), where the total number of containers are 2,679 and the available containers are 1,721. The required containers are 957. The drop-off centers are considered in six localities, where one container (25 m^3) must be available at each site daily.

(22): The required vehicles, staff, and equipment through the separation at source.

Staff (Number)			Vehicles			required Containers			drop-off centers				
										containers			a
Drivers	Laborers	Foremen	Type	volume	number	type	volume	number	number	type	volume	number	
			compactor	12 m^3	1								
			compactor	9 m^3	2								
8	16	1	compactor	5 m^3	3	Wheel	1.1m^3	280	0	………	………	………	
			compactor	9 m^3	2								
			compactor	5 m^3	2								
5	10	1	tractor	4 m^3	1	Wheel	1.1m^3	220	0	………	………	………	
			compactor	9 m^3	3								
			compactor	5 m^3	2								
			tractor	4 m^3	2								
9	20	1	Skip-lift	25 m^3	1	Wheel	1.1m^3	307	6	Skip-lift`	25 m^3	……..	
			compactor	12 m^3	0								
			compactor	9 m^3	2								
			compactor	5 m^3	1								
4	6	1	tractor	14 m^3	1	Wheel	1.1m^3	150	0	………	………	………	
26	52	4			23			957	6				

6.3 Separation at transfer station

Separation at transfer station has many forms according to different criteria such as waste quantity, waste composition, and decreasing the costs of transporting. Two main forms of separation at transfer station are considered at this study, which are:

1.Manual separation for some items of waste such as bulky waste and reusable materials, which is considered for the available Tubas transfer station and the proposed transfer stations (Jenin east villages transfer station and Jenin west villages transfer station). Separation at these stations is considered to complete to the separation at the source. The separated waste is transferred in two fractions (wet and dry fractions) to the transfer station. Trained staff is considered to separate the bulky and reu`sable waste from the waste such as furniture, trees, tires, etc. the separated wastes at these stations are stored for the market. Waste vehicles trailers transport the waste containers to landfill as the weekly schedule for the two sections of separated waste.

Figure (11) illustrates the general plan for the transfer station that is considered at the Tubas, Jenin easte villages and Jenin west villages. All parameters those are required for the manual separation illustrated which are: gates; fence; weighbridge; containers; areas for waste collection and transporting vehicles; washing facility; and buildings (Weighbridge room and storage room).

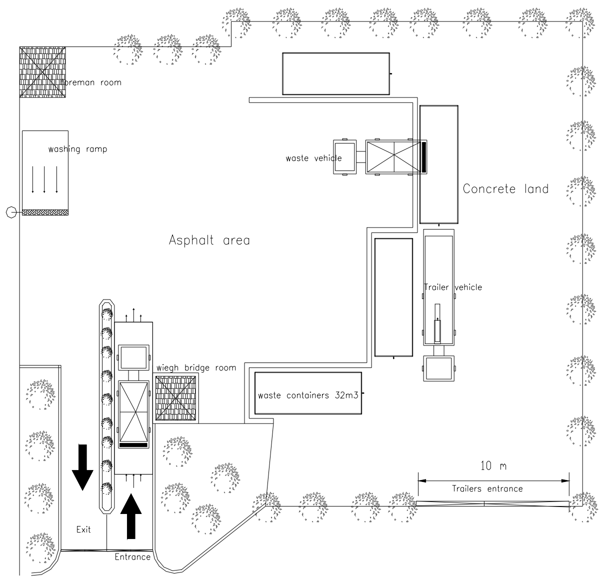


Figure (11): General plan for the proposed Transfer station.

2.Mechanical separation which is considered to separate the recyclable and reusable materials through the recycling plant at the transfer station as the available Al-Sayrafi transfer station. Private company is separating the Solid at Al-Sayrafi transfer station through recycling plant. The solid waste is sorted into cartoon, plastic, metals and pilot for recycling the organic fraction. The transfer station is receiving around 150 ton/day and the percentage of separated wastes is around (15-20%).

Table (23) summarizes the required vehicles, staff, containers and for the separation at transfer station for the available and proposed transfer station.

The required staffs (drives, foremen and laborers) are identified for these transfer stations which are: 5 drivers; 13 laborers; and 4 foremen. The laborers are considered to separate the reusable and the bulky waste from the solid waste. The containers that are considered for the curbside are steel containers 32 m^3 containers and skip-lift trailers to transport the wastes to the ZF landfill.

Table (23): Summary of technical issues related to separation at transfer station.

	Staff			Vehicles			Containers		
	Drivers	**Laborers**	**Foremen**	**Type**	**volume**	**number**	**type**	**volume**	**number**
Tubas Transfer Station	1	3	1	Skip-lift	……..	1	Steel containers	$32m^3$	5
Al-sayrafi Transfer Station	2	4	1	Skip-lift	……..	2	Steel containers	$32m^3$	10
Jenin east villages Transfer Station	1	3	1	Skip-lift	……..	1	Steel containers	$32m^3$	5
Jenin west villages Transfer Station	1	3	1	Skip-lift	……..	1	Steel containers	$32m^3$	5

6.4 Separation at landfill site

Separation at landfill site option is considered through construction recycling plant at the area of Zahret A-Finjan landfill. The available parameters at the landfill are considered in design and construct the recycling plant. These parameters are:

- Identifying the suitable location at the area of Zahert A-Finjan landfill taking into consideration the available general plan.
- equipment and lands for recycling the organic waste
- Required vehicles and such as loaders, trucks.
- Storage area
- staff
- Other facilities those are available at the landfill, such as weighbridge, vehicle washing machine, administration buildings, etc.

Required lands: the area for construction the plant at the lands of ZF landfill is available. There is 240,000 m^2 of lands for the JSC, where

120,000 m^2 is used for the landfill and the other lands is not used yet. The plant can be constructed at the unused lands in area not more than 20,000 m^2 taking into consideration site selection and the available facilities at landfill. These available facilities as weighbridge, maintenance garage, perimeter roads, fence, etc.

Figure (12) illustrates the general plan for the ZF landfill that shows the proposed location for the recycling plant at the lands of ZF landfill. the different available facilities at the ZF landfill are illustrated. the situation of the recycling plant selected near the solid waste cells, where the residues waste can be dumped and the solid waste vehicles can be used the same entrance.

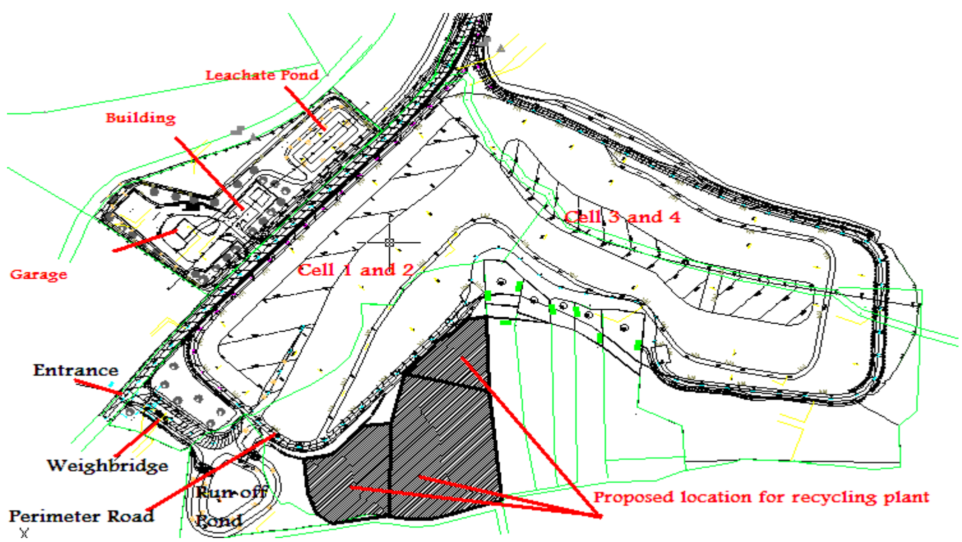


Figure (12): Proposed location for the recycling plant (Hydroplan, 2003).

The following are the main sections for the proposed recycling plant:

- Receiving area.

- Sorting and recycling machines: the waste emptying in hole, and then pass through initial conveyor for separation the bulky and reusable waste. Sifting the organic material from the waste and separation the recyclable material such as plastic, cardboard, paper, metals, glass and woods.
- equipment for compacting and packaging such as balers
- Storage area.

The organic fraction is sent to the composting plant, where the following are the main stages for recycling the organic fraction including the required equipment:

- Conveyers for transferring the organic matter and crushed wood from the preliminary sifting in the refuse reception system.
- Mechanization for turning and ventilating the compost at concrete surface.
- A plant for crushing dried compost.
- A plant for sifting crushed or uncrushed compost.
- A mixer for blending additives to the compost.
- Employing agronomist for producing admixed compost in accordance with farmer's requirements.

Chapter Seven

7 Environmental and social consideration

7.1 Environmental consideration

Environmental and technical sub-criteria are considered as a base to discuss the environmental consideration for the SWRR options. This is by identifying and evaluating the positive and negative environmental impacts resulting due to applying SWRR options for the ZF landfill. The environmental considerations are discussed according to the potential significance impacts, and ranked as: High; Moderate; and Minimal.

7.1.1 Separation at source

The following are the environmental issues that are considered for the assessment of the solid waste separation at source option:

- Odors and air pollution
- Land use and visual
- Traffic
- Health impacts

Odors and air: The generated waste is disposed by the users at special waste container, barrels, plastic bins and bags. The odors can be generated though the collection due the decaying of the cumulated waste and the air pollution from the burning of these cumulated waste. Separation at source through the curbside collection is considered by distributing enough number of $1.1m^3$ containers. The enough number of containers is estimated (see section 6.2) for the study area. The locations of these containers need special care taking into consideration the number of households and distances between containers. The sub-criteria that are considered to decrease the negative impacts are: Daily collection from most local communities; Good design for waste containers (prefer with cover); Good distribution for waste containers; and fire control. In addition to that daily mentoring is considered through this study for collection the separated waste and the containers by the foremen.

Six locations are considered as drop-off centers at the study area, where the solid waste is collected daily by the laborers and store in containers ($25\ m^3$) for transportation to landfill. Monitoring these sites are considered according to the following: fenced around each site; gates and foremen; and Scavengers control. In addition to that the container design is considered to reduce the negative impacts (odors and air quality) by preserving the waste from the fires such as covered and painted containers.

The overall impacts associated with odors and air quality from the waste burning and decomposition through the separation at source is negative.

According to this study where the collection system is controlled are the impacts will be minimized to be as minimal impacts.

The visual: the negative visual impacts at the source will be through waste commutation and burning. At this study design the collection containers 1.1 m^3 (curbside collection) is considered as painted steel containers with cover. Design the drop-off centers is including: enough area; fence around the site; and painted and covered steel container ($25m^3$). The continuous mentoring, Street sweeping, litter prevention and burning prevention are considered to enhance visual impacts. The overall visual impacts on environment according to this study are positive.

Health and safty: the separation at source through the curbside collection and drop-off enters are considered manually. Through the curbside collection the residents separate the waste at their homes for different fraction (wet and dry) before refusing it into containers. Then the trained laborers are considered to collect the separated waste directly by the compactor vehicles. At the drop-off centers the trained laborers are considered to collect the solid waste daily to drop-off centers, then separate the waste as different components at the containers. Solid waste separation at source is exposed the residents and laborers to the health risks. All protective measure are considered to reduce the human health that may result due solid waste separation, which are: training the laborers and residents in different ways; consider protective clothes; vermin control, through continuous spreading insecticide and distributing pesticide; identifying solid waste types, compositions, etc.

The overall health and safety impact through the separation at source is negative.

Solid waste vehicles movement (Traffic): In the big cities as Jenin city, the movement of waste vehicles is reducing the resident's vehicles movement at the midday especially at the markets. This is lead to consider the after-noon period for collection the separated at the Jenin city. Distribution the solid waste containers (1.1 m3) in all localities and periodic maintenance for the solid waste vehicles are considered to reduce the exhausting gases that decreases the environmental impacts increase solid waste collection efficiency.

Mentoring and daily and. The study provides positive traffic impacts.

Table (24) summarizes the impacts and significance effect of the solid waste separation at source option on the environment. There are positive potential impacts resulted due to applying the solid waste separation at source, which are: traffic impacts with non effect. Negative impacts that resulted due to applying the separation at source are: the odors and the air quality with minimal effects; the health impacts with medium effects due to the probability of exposure the residents and laborers to the risk.

Table (24): Summary of environmental impacts through separation at source

Impacts	Potential impacts	Potential Significance
Odors and air quality	**negative**	**Minimal**
Traffic	**Positive**	**non**
Visual	**Positive**	**minimal**
Health	**Negative**	**moderate**

7.1.2 Separation at transfer station

The following are the environmental impacts that are considered for solid waste separation at transfer station option.

- Impacts of land use and visual
- Odors and Air quality impacts
- Noise
- Health impacts

Impacts of land use and visual: The transfer stations that are considered at the study area are four, where two are available Nablus and Tubas transfer stations. The locations of the others two transfer stations are identified which are Jenin east villages and Jenin West villages transfer stations. The Transfer stations are located at the middle locations, which are far from the houses and near to the access roads. The available transfer stations have contracted at private land, where Al-Sayrafi T.S has constructed inside the steel structure. Tubas T.S is a concrete ramp in side a fenced land. The proposed transfer stations lands are village's council's lands. The design of transfer stations is considered mitigation measures to decrease the negative impacts on environment which are: continuous mentoring; fence around T.S; planted around T.S; paved the entrance and the yards. The locations of the Jenin east villages and Jenin west villages transfer station is at the old dumpsites. This is lead to consider the lands use and the visual impact as positive. The significance effects are minimal.

Odors and air quality impacts: the separation at transfer station is considers as manual separation at Tubas, Jenin east villages and west villages transfer stations and mechanical at the Al-Sayrafi transfer station. The manual and mechanical separation are considered for some items of wastes such as bulky waste, reusable waste, special waste such as furniture, trees, tires, refrigerators etc. the separated wastes are store at the site for marketing and other wastes are sent to the landfill by the skip-lift trailer. The odors from the decaying of waste though the manual separation and storage for the waste are affected the area around the transfer stations. The effects on air result from the dust due to the movement of waste vehicles. The overall odors and air quality impacts are negative but medium effects.

Noise impacts: the noise at the transfer stations can be noticed by the residents due to the movements of solid waste vehicles due to vehicles engine, exhausted emissions. The available solid waste collection vehicles have international standards to reduce the noise, but most of it are old vehicles and need maintenance. The overall noise impact is negative with minimal effect on environment.

Health and safety impacts: the trained scavengers are considered to separate the wastes manually at the transfer stations. This is exposing them to the health risks. Control measures that are considered to decrease the risks as the follows: training the laborers; protective clothes for laborers; vermin control, through continuous spreading insecticide and distributing pesticide.

The overall health and safety impact through the separation of at the Transfer stations is negative with minimal effect on environment.

Table (25) summarizes the impacts and significance effect of the solid waste separation at the transfer stations. The environmental impacts are negative through applying the transfer station separation for all parameters. The significance impacts illustrate the range of effects due to apply the transfer stations separation which are minimal for land use and visual and noise and health impacts. The odors and air quality impacts significance effect are moderate, where storage the separated at the transfer stations need more control to decrease the effects. There is no significance effect from the noise through the transfer station on environment.

Table (25): Summary of environmental impacts at the transfer stations

Impacts	Positive / Negative	Potential Significance
Land use and visual	**positive**	**Minimal**
Odors and air quality	**Negative**	**moderate**
Noise	**Negative**	**non**
Health	**Negative**	**minimal**

7.1.3 Separation at landfill site

The following are the environmental impacts that are considered for solid waste separation at site (landfill) through construction recycling plant:

- Water quality impacts
- Odors and Air quality impacts
- Noise impacts
- Health and safety impacts

Water quality: All issues related to the water quality impacts, surface and ground water, for ZF landfill has been assessed through the ZF landfill EIA. These are: contamination of water resources from the waste leachate, contamination of groundwater from fuel spillage and surface water contamination.

Zahret A-Finjan landfill has been constructed according to the standards that prevent the adverse effects of leachate to the groundwater; where it is lined with material prevent waste leachate leakage to the ground water. Theses lined materials are Geo-synthetic clay layer, HDPE layer, Geo-textile layer and gravel layer. The leachate is collected through perforated pipe and pumped to leachate pond. The system of leachate treatment is the re-circulation system, where the collected leachate returned to landfill above the waste. The surface water is controlled through the ring channel that has been constructed around the landfill, and then drainage directly through the run-off pond for storage. Fuel and oil from waste vehicles maintenance are drainage through the channel to oil separator tanks.

The separation at site is considered through recycling plant, which is located in place with easy link to drainage the leacahte and surface water. Waste leachate that may result through the separation at the plant can be drainage through lining channel and pressure pipes to leachate pond. The overall water quality due construction plant is positive.

Odors and air quality: The odors through the waste separation at site are generated from: waste decompositions through recycling the organic fraction and leachate Collection, storage and treatment.

In ZF landfill specified procedures has included to provide effective control of odors during waste decomposition. The disposed waste directed to the daily waste cells, where the waste is compacted and covered by soil to prevent prolonged exposure of wastes to the atmosphere.

Site separation through the recycling plant will be increased the odors, where the waste exposure more time through sorting, packaging and storage the recyclable waste. Recycling the organic fraction to compost though aerobic conditions increases the odors. Mitigation Measures are considered in construction and operation the plant to minimize the odors, which are as follows:

- The plant inside closed steel and/or concrete structure
- Closed areas for sorting, packaging and storage
- Areas for recycling the organic fraction taking into considerations minimize the odors effects.

The effective control minimizes the odors but never be eliminated it.

Noise: The sources of noise at the site are due to the operation of the recycling plant which is included: plant engines such as conveyors, screener, etc. and vehicles movements at the site, which are included: collection vehicles; vehicles of transport the separated waste; winches, loaders, compactors, etc; vehicles of debris and the remained waste at the plant.

Considering recycling plant increase the noise more that available system at the landfill, where more engines, vehicles, etc. The increased noise level as a result of operational activities is considered to be negative and of non significance effect.

Health and safety: the range of potential health and safety impacts associated with the site separation will be discussed at this section. The Operational practices at recycling plant will be considered to minimize any potential health risks through separation processes. The measures related to design and construction recycling plant will be included:

- Strict control over entry and exit to the site
- measurement documentation and inspection of incoming waste loads
- Defined standard operating procedures for waste discharge and deposition
- Control of vermin, insects and birds by compaction of deposited waste and application of cover materials in small, clearly-defined operating cells
- Training in safe working methods and good hygiene practices
- The use of personal protective equipment, as required, when working on-site
- Provision of first aid facilities

- Regular health checks for personnel

For sanitary reasons it is forbidden to allow waste scavengers on a sanitary landfill. Through the recycling plant trained scavengers and foremen are considered to separate the recyclable material manually. In order to minimize the risks the laborers need training about the safe work, waste components and providing them with equipment as required.

The solid waste through separation stages attracts the vermin like flies, bugs, rats, etc. These should be properly combated by sanitary measures as spraying with insecticides, distributing pesticide, and immediate covering of remained after separation processes at the landfill.

The health and safety impacts through the site separation are positive with moderate significance effects.

Table (26) summarizes the impacts and significance effect of the solid waste separation at the site by the recycling plant. The environmental impacts associated with odors and noise are negative through the applying the site separation according to the required standards. The significance impacts associated with odors are minimal and no significance impacts associated with noise .The water quality and health and safety impacts are positive and the significance effects are moderate in water quality and minimal in health and safety.

Table (26): Summary of environmental impacts through separation at landfill site.

Impacts	Positive / Negative	Potential Significance
Water quality	**Positive**	**Moderate**
Odors and air quality	**Negative**	**minimal**
Noise	**Negative**	**moderate**
Health and safety	**Positive**	**minimal**

7.2 Social impacts

Interviews, technical criteria and SWRR options management are considered as a base to discuss the social impacts due to applying the SWRR options. The social impacts are evaluated according to the potential significance impacts as Positive impacts; no impacts; and negative impacts.

7.2.1 Separation at source

The following are the social impacts that are considered for SW separation at source taking into consideration improving the solid waste collection schemes.

- Convenience and accessibility impacts
- Participation and awareness impacts
- Health impacts
- Local Employment

Convenience and accessibility impacts: Separation at source is considered through establishing convenience system that providing accessibility and capability for the resident. The residents need to learn about the ways of waste separation and waste components taking into considerations the collection schemes. Collection the separated waste at source is considered to divide the solid waste into two fractions, which are: organic fraction such as food waste; and the non-organic fraction such as plastic, metals, glass, etc. The collection schemes for the separated waste are included daily and weekly schedules, containers and drop-off locations, vehicles, etc. these are providing convenience for the residents. The coordination with the residents must be continuous by the municipalities, foremen, establishments, etc. The separation processes at source by the curbside and drop-off is not convenience for the residents and need effort from the laborers. The convenience and accessibility impacts through the source separation are negative.

Resident's participation and public awareness impacts: through the available system at the study area, where the waste is collected from most of local communities. In June 2007 when the ZF landfill has started receiving the waste, the coordination in high level has done with different local communities, establishment, entities, etc. This coordination was successful through comprehensive awareness program which is leading the residents to dispose their waste at container that have identified by the ZF landfill implementation unit. The available system for ZF landfill provides wide base for achieving participation by the resident in separation the waste. New coordination and public awareness programs must be considered to increase the opportunities of participations in separation at source. The coordination for achieving the participation must be through the municipalities, establishments, community leaders, etc. taking into consideration the different zones at the study area. A comprehensive awareness programs related to waste separation by different means must be considered taking into considerations available system. These awareness means are: posters; course training; workshops at the study area in coordination with municipalities, schools, universities, etc; and Continuous programs at local televisions and radios.

The participation of residents in separation at source needs strategy and big efforts and comprehensive awareness programs. The participation impacts through the source separation are negative with moderate significance

Health and safety impacts: The impacts on public health and safety during the collection separated waste at the source are reduced due to considering the safety conditions. The processes of waste separation at the source are considered the public health risk through houses, containers, collection points and drop-off centers. The separation of dry fraction of waste such as metal, glass, plastic, etc. are considered by using colored bags and/or bins. The hazardous waste is identified and delivered separately in special bins and/or safety books. Waste separation at source is expected to have negative impact on human health due to separation the wastes in different components manually.

Employments impacts: the waste separation at source at the study area currently takes place in the informal scavengers for some items of waste such as cartoon, plastic and metals. This study provides positive impacts on local employment.

Table (28): Summary of social impacts through separation at source.

impacts	Positive	No effect	Negative
Convenience and accessibility			x
Participations			x
Health			x
Employments	x		

7.2.2 Separation at transfer station

The following are the social impacts that are considered for solid waste separation at source:

- Convenience and accessibility impacts
- Health impacts
- Local Employment
- Aesthetic impacts

Convenience and accessibility impacts: Separation at transfer station is considered as manual and mechanical by the formal trained laborers for some items of waste. Daily separation is considered at the transfer stations by the trained laborers for some items of solid waste. The manual separation is considered at the Tubas, Jenin east villages and Jenin west villages transfer stations and the semi-mechanical separation at Al-Sayrafi transfer station. The convenience and accessibility impacts through T.S separation are negative with moderate significance effects on the laborers that must be separate the waste daily considering manual and semi-manual ways.

Employment: manual and semi-mechanical separation that is considered at transfer stations will provide good chance formal scavengers that must be trained and worked under supervision. The trained scavengers are considered to work in separation the solid wastes including separation the required items, storage, mentoring the sites, etc. The overall impacts related to local employments are positive.

Aesthetic impacts: Storage the separated wastes at the transfer station have negative visual impacts due to commutate the waste for reusing or marketing. Measures are considered for decreasing the negative visual impacts through consider aesthetic enhancement for the transfer stations. The overall aesthetic impacts though separation the waste at the transfer stations is negative.

Table (29): Summary of social impacts at transfer stations.

impacts	Positive	No effects	negative
Convenience and accessibility			x
Health			x
Employments	x		
Aesthetic			x

7.2.3 Separation at landfill site

The following are the social impacts that are considered for solid waste separation at site (recycling plant).

- Convenience and awareness
- Land use impacts
- Health impacts
- Local Employment

Convenience and awareness impacts: The separation at landfill site is considered by recycling plant, where the separation processes are mechanical in most stages and manual at one stage for the recyclable materials such as plastic, metal, cartoon, etc. the mechanical separation through increases the recycling rate and convince for the staff. The overall convenience impacts are positive for the laborers.

Land use impacts: construction the recycling plant is considered at the lands of ZF landfill in suitable location that take into consideration landfill entrance, waste cells, perimeter roads, etc. the required land is apart from 120000 m^2 refer to the Joint Services Council, which is bought for the any development purposes for the landfill at the next phases. All issues related to site selection for the landfill has been studied through the ZF EIA study. One of the most important issues was the distance between the landfill and the neighboring villages. The distance between the landfill with nearest local communities is 1200 m, which is Fahmah Camp, and there houses has constructed near the landfill in distance around 300m. Land use has no effects due to construct the pant at the lands of landfill.

Health impacts: the separation at recycling plants is considered the public health risk requirements for the staffs that are considered to work at the site such as laborers separation, foremen, engineers, etc. The safety measures are considered for the staffs including safety clothes, gloves, shoes, etc.

The separation processes are included storage the separated waste and recycling the organic fraction that causes attached by the insects. All measures are considered to reduce all negative impacts on the health of the staffs and residents through applying insecticides and pesticides system. The overall impacts on health risk are negative.

Employment: The manual separation for the dry fraction is considered by the laborers. The other staffs are considered to work in different stages of recycling at the plant which included engineers, technician, foremen, laborers, etc. The overall impacts related to local employments are positive.

Table (30): Summary of social impacts through separation at landfill site.

impacts	Positive	No effect	Negative
Convenience and accessibility	x		
Lands		x	
Health			x
Employments	x		

Chapter eight

8 Financial analysis

The full cost analysis was estimated to evaluate the economic costs for applying the SWRR options including:

- Capital costs included: waste vehicles; containers; lands; constructions; and recycling plant machines.
- Operational costs included: employment (salaries and wages); fuel; insurances; depreciation; and electricity.
- The revenues, which are estimated for the next 11 years from marketing the recyclable materials and fees collection from the local communities.
- Effective benefit costs are estimated in three scenarios.

8.1 Capital costs

The different issues that are considered in estimating the capital items have identified through the technical and options management section.

Table (32) summarizes the capital costs for the SWRR options. The capital costs for the separation at source summarize the costs for the required vehicles and containers through the curb side and drop-off centers. The costs for required vehicles and containers are different refer to the capacity and type, which are illustrated at the costs sheet in appendix (B). The capital costs for separation at transfer station are considered for two transfer stations which are Jenin east villages and Jenin west villages transfer stations. The costs sheet in appendix (B) illustrated the costs per each land, construction for the transfer stations. The capital costs for the recycling plant are included land preparation, plant construction, equipment and the required vehicles. The detailed capital cost for each item though the site separation is estimated through the costs sheet in appendix (B). The depreciation costs for these summarized items are the cost for each items divided on the expected life time.

Table (32): Summary of capital costs for the study options

Capital Cost			Depreciation period years	Depreciation Cost (US $)
Separation at source				
Curbside capital cost				
Items	Cost ($)			
Vehicles	1,110,000		10	111000
Containers	212,000		7	30285.71
Sub-Total		**1,322,000**		**141285.71**
Drop-off capital cost				
Lands	30,000		……	…….
Construction	150,000		20	7500
landscaping	15,000		…….	…….
Sub-Total		**195,000**		**7500**
Total		**1,517,000**		**148,786**
Separation at transfer station				
Items	Cost ($)			
Lands	14,000		…….	…….
construction	160,000		15	10666.67
Containers	26,000		5	5200
landscaping	10,000		…….	…….
skip-lift trailers	1,000,000		10	100000
Total		**1,210,000**		**115,87**

Separation at landfill site				
Items	Cost ($)			
land preparation	150,000		…….	…….
construction	1,500,000		15	100000
Equipment	2,500,000		15	166666.67
Vehicles	610,000		10	61000
Total		**4,760,000**		**327,667**
Total capital Cost		**7,487,000**		**592,319**

8.2 Operational costs

The operational costs are estimated for all issues related to SWRR options including the solid waste collection, transportation and disposal.

Table (33) summarizes the operational costs for separation at source including the costs of collection and transferring the waste to the transfer stations and/or landfill. The salaries costs have estimated for the staffs that are considered to work through the separation at source and collection, which are: drivers; foremen; and laborers. The fuel consumptions costs are estimated for all waste vehicles that are considered to collect the separated waste at the source. The fuel consumption was estimated per distance for each vehicle through the working days, taking into consideration the vehicles types and capacity and the price of fuel for each liter. The maintenance costs have estimated as a percentage from the fuel consumption for each vehicle. The depreciation costs for the available and the others new vehicles and equipment that are required for collection the separated waste have estimated. The depreciation costs depend upon the cost price of vehicles and equipments with their life time. The insurances costs are an average yearly cost for the insurances of the vehicles. All detailed of operation costs estimation are illustrated at the costs sheet in appendix (B).

Table (33): Summary of operational costs for separation at source and collection.

#	Source Separation items	cost (US $)/year
1	Salaries	817700
2	Fuel consumption	558775
3	maintenance	331874.37
4	Depreciation (Available)	330053.33
5	Depreciation (new)	148768.00
6	Insurance	30000
Total Cost		**2217170.71**

Table (34) summarizes the operational costs for the separation at transfer stations including the costs of transporting the waste to the landfill. The salaries costs have estimated for the staffs that are considered to work in separation at the transfer stations and transporting the waste which are: drivers of the skip-lift trailers; foremen; and the separation laborers. The fuel consumptions costs have estimated for all waste vehicles, skip-lift trailers that are considered to transport the waste. The fuel consumption was estimated per distance for each trailer through the working days, taking into consideration the price of fuel for each liter. The depreciation costs depend upon the cost price of each trailer and equipments with their life time. The insurances costs are an average yearly cost for the insurances of the vehicles. All detailed of operation costs estimation are illustrated at the costs sheet in appendix (B).

Table (34): Summary of the operational costs for the separation at transfer station and waste transporting.

#	Source Separation items	cost US $/year
1	Salaries	205790
2	Fuel	290625
3	maintenance	174375
4	Depreciation (available)	21666.67
5	Depreciation (new)	115867.00
6	Insurance	10000
	Total Cost	**818323.67**

Table (35) summarizes the operational costs for the separation at the site through the recycling plant. The salaries costs have estimated for the staffs that will be worked in separation at the recycling plant, which are plant manager, engineers, foremen and laborers. The fuel consumptions costs have estimated for all waste vehicles that will be required for the plant such as vehicles of the staff, trucks, loader and lifter. The maintenance costs for the required vehicles are estimated as a percentage from the yearly fuel consumption. The maintenance costs for the plant are estimated as a percentage from the yearly cost of the plant equipment. The costs the depreciation depends upon the costs price of the plant contraction, equipments and vehicles with their life time. The electricity costs are estimated through identifying the required power for the plant in Kilo Watt per hour and the price of kilo. All detailed of operation costs estimation are illustrated at the costs sheet in appendix (B).

Table (35): Summary of the operational costs for separation at landfill site

#	plant separation items	cost US $/year
1	Salaries	379600
2	Fuel	63511.25
3	maintenance	120843
4	Depreciation	327666.67
6	Electricity	130200.00
	Total Cost	**1021820.92**

Tables (36) summarize the operational costs for the landfill treatment according to the jenin-joint services council for solid waste. The salaries costs have estimated for the staffs that are working at the landfill, which are included management staff, maintenance staff, operation staff and laborers. The fuel consumptions costs have estimated for all waste vehicles that are working at the landfill such as staff vehicles, landfill operation vehicles. The depreciation costs have depended upon the costs price of the vehicles with their life time. The payment of credit is also included in the costs of landfill treatment per ton. The credit is 9.5 million Dollar and divided in twenty years to be 475000 US $ /year.

Table (36): Summary of waste disposal costs.

#	Cost Item	Disposal (US$/year)
1	Salaries	146,12
2	Depreciation	50,08
3	Fuel Consumption	53,07
4	Maintenance	42,56
5	Insurance	12,00
6	Water, Electricity & Telephone	8,00
7	Office Equipment, Hospitality& Petty	12,00
8	Administrative	46,280
9	Garage	13,49
10	Payment of Credit settlement (credit/landfill useful life)	475,00
Total		**858,60**

Table (37) summarizes the operational costs analysis for the study options, which are included the total costs for each item, the costs per the tone of waste and the costs percentages for these items. The operational costs has estimated for the study options and included the available system for the ZF landfill such waste collection and disposal. The costs per ton for each option are estimated according to the quantity of waste as the follows:

- (Cost (US $)/year)/ (waste quantity (ton/year))

The costs percentage is estimated for the all operational items. The operational cost for the waste disposal at landfill is identified according to the JSC estimation, which are including the credit payments for the World Bank.

Table (37): Summary of the operational costs analysis for the research options.

Summary of Costs operation analysis				
#	items	Cost US $/year	Cost US $/ton	percentage%
Separation at source				
1	Salaries	817700	6.59	36.88
2	Fuel consumption	558775	4.51	25.20
3	Maintenance	331874.375	2.68	14.97
4	Depreciation (Available)	330050.3	2.66	14.89
5	Depreciation (new)	148768	1.20	6.71
6	Insurance	30000	0.24	1.35
total cost		**2217167.68**	**17.88**	**100.00**
Separation at transfer station				
1	Salaries	205790	1.66	25.15
2	Fuel consumption	290625	2.34	35.51
3	Maintenance	174375	1.41	21.31
4	Depreciation (available)	21666.67	0.17	2.65
5	Depreciation (new)	115867	0.93	14.16
6	Insurance	10000	0.08	1.22
total cost		**818323.67**	**6.60**	**100.00**
Separation at landfill site				
1	Salaries	379600	3.06	37.16
2	Fuel consumption	63511.25	0.51	6.22
3	Maintenance	120543	0.97	11.80
4	Depreciation	327666.67	2.64	32.08
5	Electricity	130200	1.05	12.75
total cost		**1021520.92**	**8.24**	**100.00**
Disposal at landfill				
1	Salaries	146120	1.18	17.02
2	Depreciation	50076	0.44	5.83
3	Fuel Consumption	53072	0.43	6.18
4	Maintenance	42565	0.34	4.96
5	Insurance Expenses	12000	0.10	1.40
6	Water, Electricity & Tel.	8000	0.07	0.93
7	Office Equipment	12000	0.10	1.40
8	Administrative tools	46280	0.37	5.39
9	Garage Exp.	13490	0.11	1.57
10	Payment of Credit	475000	3.83	55.32

total cost	858603.00	6.92	100.00
capital costs	748700.00	6.04	
total cost (US $/ton)		45.68	

Figure (13) summarize the total operational costs per ton for each option, capital costs for all options and the costs of disposal. The costs separation at source with collection, at transfer station with transportations and separation at landfill site (recycling) plant are 29.1 US $/ton, which are represent the research options and their percentage is 72%. The landfill disposal cost for ZF landfill is included the World Bank credit cost recovery as estimated at by JSC.

main items	cost (US $)/ton	Percentage %
Source separation and collection	17.88	39.1
Transfer station and transportation	6.60	14.4
Plant separation	8.24	18.0
Landfill disposal	6.92	15.2
Capital costs	6.04	13.2
	45.68	100.0

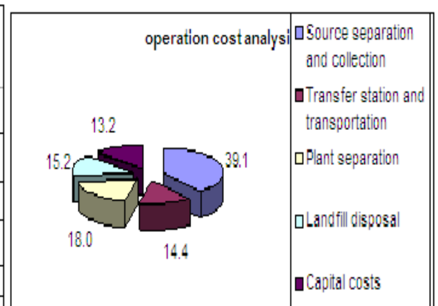


Figure (13): Total costs per ton and solid waste percentage**s.**

8.3 Costs revenues

The costs revenues are identified for this study through estimating the costs benefits from the marking the separated waste and from the fees collection.

Table (38) illustrates the quantities of separated waste per year for all zones and according to the waste compositions. The percentages of waste components tabulated for the zones according results of the study pilot that has done for ZF landfill. The percentages of the waste the will be separated through this study is considered in according to different experiences and meeting with experts persons. The percentage of separated waste is formed 41.1 from the total quantity which are included the waste that can be marketed and recycled in local market.

Table (38): Quantity and percentage of separated waste at the study area.

items	compositions %	Quantity ton/day	separation %	Quantity ton/day	Quantity ton/year
zone 1 and 2					
Organic	51	63.75	50	31.875	9881.25
Plastic	12.4	15.50	60	9.3	2883
Cartoon and papers	16	20.00	40	8	2480
Metals	2.8	3.50	50	1.75	542.5
Glass	3.3	4.13	10	0.4125	127.875
Textile	8.6	10.75	0	0	0
Others	5.9	7.38	0	0	0
	100	**125**	**41.1**	**51.3375**	**15914.625**
zone 3 and 4					
items	**compositions %**	**Quantity ton/day**	**separation %**	**Quantity ton/day**	**Quantity ton/year**
Organic	51	61.20	50	30.6	9486
Plastic	12.4	14.88	60	8.928	2767.68
Cartoon and papers	16	19.20	40	7.68	2380.8
Metals	2.8	3.36	50	1.68	520.8
Glass	3.3	3.96	10	0.396	122.76
Textile	8.6	10.32	0	0	0
Others	5.9	7.08	0	0	0
	100	**120**	**41.1**	**49.284**	**15278.04**
zone 5					
items	**compositions %**	**Quantity ton/day**	**separation %**	**Quantity ton/day**	**Quantity ton/year**
Organic	51.00	79.05	50.00	39.53	12252.75
Plastic	12.40	19.22	60.00	11.53	3574.92
Cartoon and papers	16.00	24.80	40.00	9.92	3075.20
Metals	2.80	4.34	50.00	2.17	672.70
Glass	3.30	5.12	10.00	0.51	158.57
Textile	8.60	13.33	0.00	0.00	0.00
Others	5.90	9.15	0.00	0.00	0.00
	100.00	**155.00**	**41.1**	**63.66**	**19734.14**
Total		**400.00**	**41.1**	**164.28**	**50926.80**

Figure (14) illustrates the costs revenues from marketing the separated waste through the next 10 years. The prices of each component for the separated waste are considered according to ask the experts persons through interviews, meeting, mails and calling. The yearly quantities and revenues from marketing each component in different zones have estimated and illustrated at appendix (C). The total yearly revenues have estimated for all zone and summarized in figure (16) that shows the increasing of yearly revenues due to expected increasing of separated waste quantities.

years	revenues US$/year	revenues US$/year * 10^6
2010	3530800.80	3.5
2011	3639253.68	3.6
2012	3748431.29	3.7
2013	3860884.23	3.9
2014	3976710.76	4.0
2015	4096012.08	4.1
2016	4218892.44	4.2
2017	4345459.21	4.3
2018	4475822.99	4.5
2019	4610097.68	4.6
2020	4748400.61	4.7

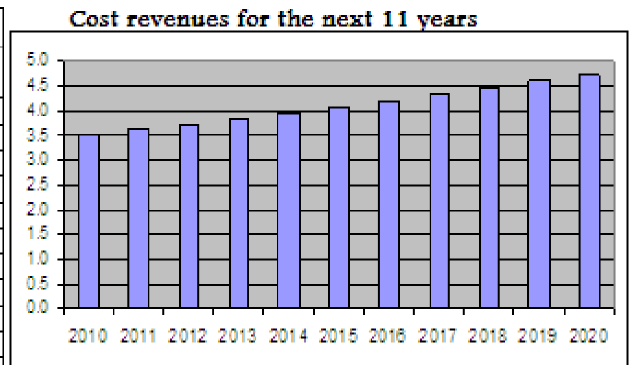


Figure (14): The expected revenues from marketing the separated waste.

Table (39) summarizes the fees revenues costs from the different local communities according to the cost of each ton and the yearly generated waste. The waste quantities are according to waste projection and the costs per each ton are according to the costs of operation that have summarized at table (37). The revenues increased yearly due to increase the waste quantities.

Table (39): Summary of fees revenues

years	Quantities ton/year	cost US $/ton	Revenues US $/year * 10^6
2010	152725.05	45.68	6.98
2011	158864.30	45.68	7.26
2012	165234.45	45.68	7.55
2013	171843.82	45.68	7.85
2014	178701.05	45.68	8.16
2015	185815.06	45.68	8.49
2016	193195.07	45.68	8.83
2017	200850.65	45.68	9.17
2018	208791.69	45.68	9.54
2019	217028.43	45.68	9.91
2020	225571.45	45.68	10.30

8.4 Benefits cost ratio (B/C)

The benefits are the differences between the costs and revenues. The scenarios of waste revenues and benefits refer to change the fees collection as the following:

1. **Scenarios one:** considering the Jenin-JSC fees collection which are around 25 US $/per ton, and including the waste collection, disposal at the landfill and the cost recovery of the World Bank Credit.

2. **Scenarios two:** consider the fees according the cost analysis of the research options and including: source separation and collection, transfer station and transporting, landfill disposal and cost recovery for the credit and the capital cost.

3. **Scenario three:** Zero revenues by decreasing the fees that lead to make the coats equal revenues.

Scenario one: The fees according to the Jenin-JSC.

Table (40) summarizes the total revenues for next 10 years which are the sum of the fees revenues and revenues of marketing the separated waste. The fees revenues is according to the Jenin-JSC revenues, which are around 25 US $/ ton for the collection and disposal the solid waste. The fees revenues is the cost of each ton multiplied with the yearly generated waste. The total revenues are the summation of revenues from marketing the fees.

Table (40): Total costs revenues for the next 10 years through the scenario number one

years	revenues (marketing) US$/year * 10^6	Fees Revenues US $/year * 10^6	Total revenues US $/year * 10^6
2010	3.5	3.8	7.3
2011	3.6	4.0	7.6
2012	3.7	4.1	7.9
2013	3.9	4.3	8.2
2014	4.0	4.5	8.4
2015	4.1	4.6	8.7
2016	4.2	4.8	9.0
2017	4.3	5.0	9.4
2018	4.5	5.2	9.7
2019	4.6	5.4	10.0
2020	4.7	5.6	10.4

Table (41) illustrates the benefits cost and benefits costs ratio for the scenario one. the costs is the operation costs for the system of separation options that are including the research options, collection, transportation and the disposal at landfill. The costs were estimated for next 11 years taking into consideration the yearly inflation for the cost which is assumed here as 5%. The benefits are the differences between the revenues and costs, where the benefits are decreased here due to fixed of revenues from the fees and marketing through these 11 years. the effective benefits cost ratio will be at the first year where the maximum benefits.

Table (41): Benefit costs ratio for scenario one

Years	revenues US$/year * 10^6	Costs US $/year 10^6	costs US$/year * 10^6	benefits US$/year * 10^6	ratio %
2010	7.3	5.95	5.9	1.35	22.74
2011	7.6	6.24	6.2	1.36	21.70
2012	7.9	6.56	6.6	1.34	20.48
2013	8.2	6.89	6.9	1.31	19.10
2014	8.4	7.23	7.2	1.17	16.19
2015	8.7	7.59	7.6	1.11	14.61
2016	9	7.97	8.0	1.03	12.92
2017	9.4	8.37	8.4	1.03	12.32
2018	9.7	8.79	8.8	0.91	10.39
2019	10	9.23	9.2	0.77	8.38
2020	10.4	9.69	9.7	0.71	7.35

Scenario two: the fees according research options that have summarized at table (37).

Table (42) summarizes the total revenues for next 10 years which are the sum of the fees revenues and revenues of marketing the separated waste. The fees revenues is according to the cost analysis of research options which are 45.68 US $/ ton.

Table (42): Total costs revenues for the next 11 years through the scenario number two.

years	revenues (marketing) US$/year * 10^6	Fees Revenues US $/year * 10^6	Total revenues US $/year * 10^6
2010	3.5	7.0	10.5
2011	3.6	7.3	10.9
2012	3.7	7.5	11.3
2013	3.9	7.8	11.7
2014	4.0	8.2	12.1
2015	4.1	8.5	12.6
2016	4.2	8.8	13.0
2017	4.3	9.2	13.5
2018	4.5	9.5	14.0
2019	4.6	9.9	14.5
2020	4.7	10.3	15.1

Table (43) illustrates the benefits cost and benefits costs ratio for the scenario two. the costs is the operation costs for the system of separation options that are including the research options, collection, transportation and the disposal at landfill. The costs were estimated for next 11 years taking into consideration the yearly inflation for the cost which is assumed here as 5%. The benefits are the differences between the revenues and costs, where the benefits are increased due to increasing of revenues. Increasing the revenues refer to consider the fees per ton that have estimated for the operation costs that take into consideration all options.

Table (43): Benefit costs ratio for scenario two

Years	revenues US$/year $*10^6$	costs US $/year $*10^6$	costs US$/year $*10^6$	benefits US$/year $*10^6$	ratio %
2010	10.5	5.95	5.9	4.55	76.54
2011	10.9	6.24	6.2	4.66	74.54
2012	11.3	6.56	6.6	4.74	72.33
2013	11.7	6.89	6.9	4.81	69.93
2014	12.1	7.23	7.2	4.87	67.38
2015	12.6	7.59	7.6	5.01	65.99
2016	13	7.97	8.0	5.03	63.11
2017	13.5	8.37	8.4	5.13	61.31
2018	14	8.79	8.8	5.21	59.32
2019	14.5	9.23	9.2	5.27	57.15
2020	15.1	9.69	9.7	5.41	55.86

Scenario three: Zero revenues by decreasing the fees that lead to make the coats equal revenues.

Chapter Nine

9 Results and conclusion

9.1.1 Solid waste composition

Figure (9) illustrates the average of solid waste composition for the different zones. Organic fraction forms the highest percent (53.73 %), which indicates that the recycling of organic fraction can be more efficiently than the other waste components. The organic fraction can be recycled to compost, this is used as good soil conditioner, enhances the agricultural soil, prolong the life time of the landfills, etc. Jenin and Tubas governorates are considered as agricultural governorates, where the compost production can be marketed to farmers directly. The average percentage of cartoon and papers is 13.47% for the different zones. The cartoon is separated at the study area in small percent from the commercial market by the informal private sectors (scavenges). The separated cartoon is marketed to the local or Israeli factories for recycling.

There are seven types of plastic that can be separated from the disposal waste in different percents which are:

1. Polyethylene Trifoliate, PET, as flexible plastic bottles.

2. High density polyethylene, HDPE, as gallons

3. Low density polyethylene, LDPE, as baby toys.

4. Polyvinyl chloride, PVC, as plastic drainage pipe.

5. Polypropylene, PP, as thin cleaner bottles.

6. Polystyrene, PS, as Quick meal dish.

7. others

The percentage of these plastic types has been examined through this pilot composition as one item, where the average percentage is 11.53%. Plastic is separated by formal and informal private sector in different types, where many local factories are available at the study area, which recycle the plastic to other forms. The glass fraction forms a small percentage which is 3.37% from the total generated waste. The glass materials can be broken through collection due to handling or broken at the source by the residents. The metal fraction also forms small fraction; this is due to its separation the source by the scavengers. The scavengers separate most kinds of metals, which include ferrous such as iron, steel and stainless steel and non-ferrous such as aluminum, copper, zinc and nickel. The textile is considered as one of an important component because it forms high percent which is 10.93% and this percent is upper than to the pervious studies. The percent of other waste materials is 4.2%, which include: medical waste; hazardous household wastes; special municipal waste as tires; and all fine waste that have passed through the mesh of the testing table.

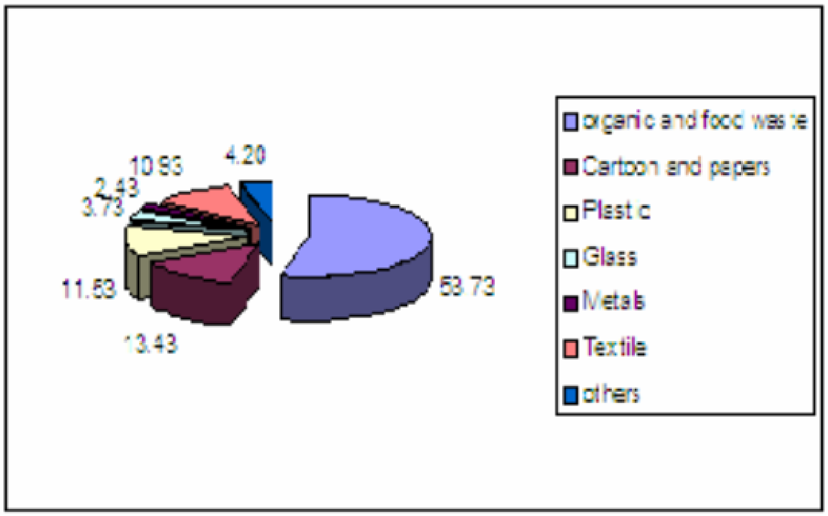


Figure (9): Average solid waste composition at different zones

9.1.2 Environmental impacts summary

This study is focused on improving the standards through applying the SWRR options at the study area. This is through considering mitigating measures to reduce the pollution potential to the environment SWRR options. These measures are included: provision an effective Solid waste collection and transferring system; effective measures at the transfer stations and landfill site to prevent the migration of contaminants out of sites; Treatment the released leachate at the landfill site; control the potential health risk; and improving the landscaping.

Evaluating the potential impact due to applying the SWRR options undertaken in this study has indicated that will give rise to a variety of potential impacts, some positive and some negative. These are summarized below in table (27), where the potential significance of these impacts is ranked as minimal, moderate and high.

Table (27): Summary of environmental impacts

#	Impacts	Potential impacts	Potential Significance		
			Minimal	moderate	High
	Separation at source				
1	Odors and air quality impacts	Negative	x		
2	Traffic impacts	Positive	x		
3	Visual impacts	Positive		x	
4	Health impacts	Negative	x		
	Separation at transfer station				
1	Land use and visual impacts	Negative	x		
2	Odors and air quality impacts	Negative		x	
3	Noise impacts	Negative	x		
4	Health impacts	Negative		x	
	Separation at landfill site				
1	Water quality impacts	Positive		x	
2	Odors and air quality impacts	Negative	x		
3	Noise impacts	Negative	x		
4	Health and safety impacts	Positive	x		

9.1.3 Social impacts summary

The social impact due to applying the SWRR options showed the positive and negative impacts for the social sub-criteria that have considered at this researched. Positive impacts are expected on local employment from the separation at source and at transfer station. The separation at landfill site by recycling plant is also expected to have positive social impacts on employment, aesthetic and not convenience.

The assessment of the potential impact due to applying the SWRR options have indicated that project development could give rise to negative impacts. These negative impacts are on the impact of separation at source and transfer station on convince, public health, participation and on aesthetic impacts. Separation at landfill has potential negative impacts on the public health however effective operation can be eliminated these negative impacts.

Table (31): Summary of social impacts

#	Impacts	Positive	No Effect	Negative
Separation at source				
1	Convenience and accessibility			x
2	Participations			x
3	Health			x
4	Employments	x		
Separation at transfer station				
1	Convenience and accessibility			x
2	Health			x
3	Employments	x		
4	Aesthetic			x
Separation at landfill site				
1	Convenience and accessibility	x		
2	Lands		x	
3	Health			x
4	Aesthetic	x		
5	Employments	x		

9.1.4 Prolong the landfill life time:

One of the most important objectives of this research is to prolong the life time of the ZF landfill. Applying the separation options will lead to decrease the quantities of daily dumped waste at landfill cells. This prolong depend upon the percentages of the separated waste from the total quantities at the study area.

The area of landfill = 90000m^2

The high of landfill = 35 m

Waste quantity = 400 ton/day (2009)

Waste quantity = 720 ton/day (2023)

Average of waste quantity according the waste projection through the next 15 years = 537 ton/day = 196005 ton/year (2009 – 2023)

Waste density at the landfill = 900 kg/m^3

Capacity of landfill = 90000 m^2 * 35 m = 3,150,000 m^3

Soil cover percent = 18% from the total capacity

The landfill of waste capacity = 2,583,000 m^3

The life time of the landfill without separation:

2,583,000 m^3 / 196005 ton/year = 13.2 years

The percentage of separated waste = 41% from the total waste

The quantity of waste that will be dumped at the landfill is 60% from the total waste = 0.6 * 196005 ton/year = 117603 ton/year

The life time of the landfill after separation:

2,583,000 m^3 / 117603 ton/year = 21.96 years (say 22 years)

The separation will prolong the life time of the landfill to additional nine years.

9.1.5 SWRR options comparison

Applying the SWRR options from the current system to one or combined of the research options (separation at source, transfer station and at landfill site) are evaluated according to the selected criteria and sub-criteria. Table (44) shows the results of evaluating the research options, which are as follows:

1. Environmental criteria: Evaluation the environmental potential impact due to applying the SWRR options showed that the options three (separation at landfill site) has more positive potential impacts. These positive impact on water quality with moderate potential significance due to consider the available leachate drainage system at ZF landfill site; and on aesthetic and public health impacts with minimal potential significance impact. Then the option one (separation at source) that have positive potential impacts on aesthetic and traffic impact with no effect water quality. Finally the no positive potential environmental impact through the option two (separation at transfer station).

2. Social criteria: Evaluation showed that the option three have more positive impacts which are on local employment and convenience impact; and no effect on participation impact. Then the Options one and two have positive impacts just on local employment.

3. The technical criteria are considered to identify the organization level to manage the research option, the technical requirements, and the risk of failure to apply these options. The results showed that the options two need low level of organization, low technical requirements and the probability of failure is also. Then the options three need high level of organization and high technical requirements. The risk of failure in option three is low due to consider recycling plant at landfill site, where the solid waste will be separated in effective manner. The option one need high level of organization to separate the solid waste at source by the residents. The technical requirements for options one is medium which are included: containers; vehicles; and drop-off centers. The probability of failure in option one is high due to need high residents participation, extensive awareness programs and effective daily solid waste collection.

4. The full cost analysis was estimated to evaluate the economic costs for applying the SWRR options. The results showed operational costs (US $/ton) for the options two with solid waste transpiration is the lowest (6.6 US$/ton). Then the operational cost for the options three is 8 US$/ton. The operational costs for option one with solid waste collection is 17.88 US$/ton.

Table (44): Comparison of SWRR options

No.	SWRR Options	Environmental criteria				
		Water quality impacts	Odors and air pollution	Traffic and noise impacts	Loss of Aesthetic value	health and safety impacts
1	separation at source	No effect	Negative (Minimal)	Positive (Minimal)	Positive (moderate)	Negative (Minimal)
2	separation at transfer station	Negative (Minimal)	Negative (moderate)	Negative (Minimal)	Negative (Minimal)	Negative (Minimal)
3	separation at landfill site	Positive (moderate)	Negative (Minimal)	Negative (Minimal)	Positive (Minimal)	Positive (Minimal)

No.	SWRR Options	Social criteria				
		Convenience and accessibility	participation	health and safety	local employment	odors impacts
1	separation at source	Negative	Negative	Negative	positive	Negative
2	separation at transfer station	Negative	Negative	Negative	Positive	Negative
3	separation at landfill site	Positive	No effects	Negative	Positive	Negative

No	SWRR Options	technical criteria		
		Options management (level)	Technical requirements	Risk of failure
1	separation at source	High	medium	High
2	separation at transfer station	Low	low	low
3	separation at landfill site	medium	High	low

No	SWRR Options	Economic criteria (operational and capital costs)		
		Cost US $/year	Cost US $/ton	percentage%
1	separation at source	2217167.68	17.88	39.14
2	separation at transfer station	818323.67	6.60	14.45
3	separation at landfill site	1021520.92	8.24	18.04
4	Disposal at landfill	858603.00	6.92	15.15
5	capital costs	748700.00	6.04	13.22
6	**Total costs**	**5664315.27**	**45.68**	**100.00**

The study showed that the solid waste management at the study area has been developed after operation the ZF landfill on an environmentally sound basis due to the JSC efforts. These efforts are through construction a controlled sanitary landfill (ZF landfill), closure of uncontrolled dumpsites, and improving the solid waste management services. The above mentioned are considered as a good base for the solid waste development at the study area as applying the SWRR options. Through this study three solid waste separation options (at source, transfer station, and landfill site) are evaluated for the ZF landfill according to the environmental, social, and economical criteria.

The results of studying the SWRR options showed that option three (solid waste separation at landfill site) is better than the other two options (options one and two). This is refers to evaluating these options according to the selected criteria and sub-criteria. The SWRR options can be applied by considering the separation at landfill site as alone separation and/or considering all of these options to complement each others.

9.2 Recommendations

Huge efforts must be done to enhance solid management in Palestine. This includes improving the existing systems such as, waste collection, waste transfer, disposal, fees collection, etc. and also developing the exiting systems by establishing sanitary landfills. Decision makers should participate in enhancing the success of SWM in Palestine.

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Interviews

1. **Eng. Hani Shawheneh,** Executive manager for Jenin Joint Services Council for Solid Waste management. 8/2008
2. **Mohammad Abu Ali,** Financial Manager for Jenin Joint Services Council for Solid Waste management. 8/2008
3. **Eng. Basel Bani Audeh,** Executive manager for Tubas Joint Services Council for Solid Waste Management. 9/2008
4. **Eng. Yaser Dwiek,** Executive manager for Hebron Joint Services Council for Solid Waste Management. 9/2008
5. **Abed Al-Jabbar Abu Al-Halaweh,** Executive Manager for Jericho Joint Services Council for Solid Waste management. 9/2008
6. **Eng. Abed Al-Mun'em Shehab,** Director of Jenin Environmental Equality Authority. 9/2008
7. **Mohammad Abu Sroor,** Director of Health department in Jenin municipality. 10/2008
8. **Zeyad Humran,** Director of Health department in Arrabeh municipality. 10/2008

Site Visits

1. Zahret A-Finjan landfill, Jenin. Site visit / available there all the period of preparing the research. January 2008 – December 2008.

2. Tubas transfer station, Tubas. Site visit / June 2008, a station for the transferring the waste from the Tubas governorate to Zahret A-Finjan Landfill.

3. Al-Sayrafee transfer station, Nablus. Site visit / July 2008, a station for transferring the waste from the Nablus municipality to Zahret A-Finjan Landfill.

4. Al Afouli recycling plant, Afouli. Site visit / December 2007, a plant for separation the recyclable waste and recycling the organic waste for compost.

5. Compost 2000 Plant, Tamrah. Site visit / December 2007, a plant for separation the recyclable waste and recycling the organic waste for compost.

6. Cartoon and paper recycling plant, Al Khderah. Site visit, October 2008. A plant for recycling the cartoon and paper as new product.

Appendices

Appendix (A): Table form for solid composition test

Date: -----------------------------

Zone #: --------------------------

type	first sample kg	second sample kg	third sample kg	sum kg	percentage %
organic and food waste					
Cartoon and papers					
Plastic					
Glass					
Metals					
Textile					
Others					
Total daily samples weight					

Appendix (B): Detailed tables for the operation costs of the research options

1. Source separation and collection

Salaries:

#	Source Separation and Collection Staff	Number	Salaries per month per laborer (US $)	Total salaries per month (US $)	Total Salaries per year (US $)
1	Drivers	30	600	18000	216000
2	Foremen	5	620	3100	37200
3	Laborers	76	550	41800	501600
	sub-total				754800
	End of work				62900
	Total Cost				**817700**

Fuel Consumptions:

#	Source Separation collection vehicles	Number	working days per year	fuel consumption liter per km	Distance km per day	cost $/liter	cost (US $) /year
1	compactor 12m3	5	310	0.5	100	1.25	96875
2	compactor 9m3	10	310	0.4	140	1.25	217000
3	compactor 5m3	11	310	0.33	150	1.25	210993.75
4	Tractors	5	310	0.25	70	1.25	33906.25
	Total Cost						**558775**

Maintenance:

#	Source Separation Maintenance	Number	Fuel cost per year (US $)	maintenance %	Cost (US $) / year
1	compactor 12m3	5	96875	60	58125
2	compactor 9m3	10	217000	60	130200
3	compactor 5m3	11	210993.75	60	126596.25
4	Tractors	5	33906.25	50	16953.125
	Total Cost				**331874.375**

Depreciations:

#	Source Separation Depreciation	Number	Price per one unit (US $)	cost per vehicles (US $)	life time years	Depreciation (US $) / year
1	compactor 12m3 (available)	2	100,000	200000	6	33333.33
2	compactor 9m3 (available)	7	60,000	420000	6	70000
3	compactor 5m3 (available)	9	70,000	630000	6	105000
4	Tractors (available)	10	50,000	500000	8	62500
5	Containers 1.1m3 (available)	1894	150	284100	5	56820
6	Containers 32m3 (available)	12	1,000	12000	5	2400
	Total Cost					**330053.33**

Cost Summary:

items	Source Separation items	cost (US $)/year
1	Salaries	817700
2	Fuel	558775
3	maintenance	331874.375
4	Depreciation (Available)	330053.33
5	Depreciation (new)	148768.00
6	Insurance	30000
Total Cost		**2217170.71**

2. Transfer station separation and transportation to landfill

Salaries:

#	T.S separation items	Number	Salaries per month per laborer (US $)	Total salaries per month (US $)	Total Salaries per year (US $)
1	Drivers	5	800	4000	48000
2	foremen	4	620	2480	29760
3	Laborers	17	550	9350	112200
	sub-total				189960
	End of work				15830
	Total Cost				**205790**

Fuel Consumptions:

#	T.S separation items	Number	working day per year	fuel consumption liter per km	Distance km per day	cost $/liter	cost $ /year
1	skip-lift trailers	5	310	1	150	1.25	290625.00
	Total Cost						**290625**

Maintenance:

#	T.S separation items	Number	Fuel cost per year $	maintenance %	Cost $ / year
1	skip-lift trailers	5	290625	60	174375
	Total Cost				**174375**

Depreciations:

#	T.S separation items	Number	Price per one unit $	cost per vehicles $	life time years	Depreciation $ / year
1	skip-lift trailers (available)	1	130,000	130000	6	21666.67
	Total Cost					**21666.67**

Recycling plant separation and final disposal at the landfill

Salaries:

#	Site separation Staff	Number	Salaries per month per laborer US $	Total salaries per month US $	Total Salaries per year US $
1	plant manager	1	2800	2800	33600
2	Engineers	3	1800	5400	64800
3	Technicians foremen	4	1000	4000	48000
4	drivers	5	800	4000	48000
5	Laborers	20	650	13000	156000
	sub-total				350400
	End of services				29200
	Total Cost				**379600**

Fuel Consumptions:

#	site separation Fuel Consumption	Number	working day per year	fuel consumption liter per km	Distance km per day	cost $/liter	cost $ /year
1	Staff vehicles	4	310	0.077	50	1.25	5967.5
2	Truck	2	310	0.4	60	1.25	18600
3	Lifter	1	310	0.67	150	1.25	38943.75
	Total Cost						**63511.25**

Maintenance:

#	site separation Maintenance	Number	Fuel cost per year $	maintenance %	Cost $ / year
1	Staff vehicles	4	5967.5	50	2983.75
2	Truck	2	18600	60	11160
3	Lifter	1	38943.8	60	23366.25
	Total Cost				**120843**

Depreciations:

#	Site separation Depreciation	Number	Price per one unit $	cost per vehicles $	life time years	Depreciation $ / year
1	Staff vehicles	4	25000	100000	10	10000.00
2	Truck	2	180000	360000	10	36000.00
3	Lifter	1	150,000	150000	10	15000.00
	Total Cost					**61000.00**

Electricity:

#	Site separation items	Power KW/hour	Power KW/Day	cost (US $)/KW	Total Cost (US $)/Year
1	Plant operation	400	3000	0.14	130200
	Total cost				**130200.00**

Appendix (C):

Quantities of separated wastes for the next 10 years

items	Quantity ton/years	Quantity 2010	Quantity 2011	Quantity 2012	Quantity 2013	Quantity 2014	Quantity 2015	Quantity 2016	Quantity 2017	Quantity 2018	Quantity 2019	Quantity 2020
zone 1 and 2												
organic	9881.25	10177.69	10483.02	10797.51	11121.43	11455.08	11798.73	12152.69	12517.27	12892.79	13279.57	13677.96
plastic	2883.00	2969.49	3058.57	3150.33	3244.84	3342.19	3442.45	3545.73	3652.10	3761.66	3874.51	3990.75
Cartoon	2480.00	2554.40	2631.03	2709.96	2791.26	2875.00	2961.25	3050.09	3141.59	3235.84	3332.91	3432.90
metals	542.50	558.78	575.54	592.80	610.59	628.91	647.77	667.21	687.22	707.84	729.07	750.95
glass	127.88	131.71	135.66	139.73	143.92	148.24	152.69	157.27	161.99	166.85	171.85	177.01
textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	15914.63	16392.06	16883.83	17390.34	17912.05	18449.41	19002.89	19572.98	20160.17	20764.98	21387.93	22029.56
zone 3 and 4												
organic	9486.00	9770.58	10063.70	10365.61	10676.58	10996.87	11326.78	11666.58	12016.58	12377.08	12748.39	13130.84
plastic	2767.68	2850.71	2936.23	3024.32	3115.05	3208.50	3304.75	3403.90	3506.01	3611.19	3719.53	3831.12
Cartoon	2380.80	2452.22	2525.79	2601.56	2679.61	2760.00	2842.80	2928.08	3015.93	3106.40	3199.60	3295.58
metals	520.80	536.42	552.52	569.09	586.16	603.75	621.86	640.52	659.73	679.53	699.91	720.91
glass	122.76	126.44	130.24	134.14	138.17	142.31	146.58	150.98	155.51	160.17	164.98	169.93
textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	15278.04	15736.38	16208.47	16694.73	17195.57	17711.44	18242.78	18790.06	19353.76	19934.38	20532.41	21148.38
zone 5												
organic	12252.75	12620.33	12998.94	13388.91	13790.58	14204.30	14630.42	15069.34	15521.42	15987.06	16466.67	16960.67
plastic	3574.92	3682.17	3792.63	3906.41	4023.60	4144.31	4268.64	4396.70	4528.60	4664.46	4804.39	4948.53
Cartoon	3075.20	3167.46	3262.48	3360.35	3461.16	3565.00	3671.95	3782.11	3895.57	4012.44	4132.81	4256.80
metals	672.70	692.88	713.67	735.08	757.13	779.84	803.24	827.34	852.16	877.72	904.05	931.17
glass	158.57	163.32	168.22	173.27	178.47	183.82	189.33	195.01	200.87	206.89	213.10	219.49
textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	19734.14	20326.16	20935.94	21564.02	22210.94	22877.27	23563.59	24270.50	24998.61	25748.57	26521.03	27316.66

Costs revenues of marketing the separated waste for the next 10 years.

items	Cost US $/ton	Revenues US$ 2010	Revenues US$ 2011	Revenues US$ 2012	Revenues US$ 2013	Revenues US$ 2014	Revenues US$ 2015	Revenues US$ 2016	Revenues US$ 2017	Revenues US$ 2018	Revenues US$ 2019	Revenues US$ 2020
zone 1 and 2												
organic	20	203553.75	209660.36	215950.17	222428.68	229101.54	235974.59	243053.82	250345.44	257855.80	265591.47	273559.22
plastic	250	742372.50	764643.68	787582.99	811210.47	835546.79	860613.19	886431.59	913024.54	940415.27	968627.73	997686.56
Cartoon	50	127720.00	131551.60	135498.15	139563.09	143749.99	148062.48	152504.36	157079.49	161791.87	166645.63	171645.00
metals	50	27938.75	28776.91	29640.22	30529.43	31445.31	32388.67	33360.33	34361.14	35391.97	36453.73	37547.34
glass	20	2557.50	2634.23	2713.25	2794.65	2878.49	2964.84	3053.79	3145.40	3239.76	3336.96	3437.07
textile	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
others	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		1104142.50	1137266.78	1171384.78	1206526.32	1242722.11	1280003.77	1318403.89	1357956.00	1398694.68	1440655.53	1483875.19
zone 3 and 4												
organic	20	195411.60	201273.95	207312.17	213531.53	219937.48	226535.60	233331.67	240331.62	247541.57	254967.82	262616.85
plastic	250	712677.60	734057.93	756079.67	778762.06	802124.92	826188.67	850974.32	876503.55	902798.66	929882.62	957779.10
Cartoon	50	122611.20	126289.54	130078.22	133980.57	137999.99	142139.99	146404.18	150796.31	155320.20	159979.81	164779.20
metals	50	26821.20	27625.84	28454.61	29308.25	30187.50	31093.12	32025.92	32986.69	33976.29	34995.58	36045.45
glass	20	0.00	2528.86	2604.72	2682.86	2763.35	2846.25	2931.64	3019.59	3110.17	3203.48	3299.58
textile	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
others	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		1057521.60	1091776.10	1124529.39	1158265.27	1193013.23	1228803.62	1265667.73	1303637.76	1342746.90	1383029.30	1424520.18

zoone 5												
organic	20	252406.65	259978.85	267778.21	275811.56	284085.91	292608.49	301386.74	310428.34	319741.19	329333.43	339213.43
plastic	250	920541.90	948158.16	976602.90	1005900.99	1036078.02	1067160.36	1099175.17	1132150.42	1166114.94	1201098.39	1237131.34
Cartoon	50	158372.80	163123.98	168017.70	173058.23	178249.98	183597.48	189105.41	194778.57	200621.92	206640.58	212839.80
metals	50	34644.05	35683.37	36753.87	37856.49	38992.18	40161.95	41366.81	42607.81	43886.05	45202.63	46558.71
glass	20	3171.30	3266.44	3364.43	3465.37	3569.33	3676.41	3786.70	3900.30	4017.31	4137.83	4261.96
textile	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
others	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		1369136.7	1410210.8	1452517.13	1496092.64	1540975.42	1587204.68	1634820.82	1683865.45	1734381.41	1786412.85	1840005.24
Total revenues		3530800.80	3639253.68	3748431.29	3860884.23	3976710.76	4096012.08	4218892.44	4345459.21	4475822.99	4610097.68	4748400.61

Appendix (D): Solid waste separation samples

The following figures illustrates the procedures of solid waste separation for the different waste samples. The samples were taken by the loader randomly and mixed near the separation table. And then the laborers separate and record the wastes according to their items. Figures (A.D.1; A.D.2; A.D.3; and A.D.4)

Figure (A.D.1)

Figure (A.D.2)

Figure (A.D.3)

Figure (A.D.4)

Figure (A.D): solid waste separation processes through the pilot.

A.D: Appendix (D)

جامعة النجاح الوطنية

كلية الدراسات العليا

دراسة خيارات اعادة تدوير واستخدام النفايات

في مكب زهرة الفنجان

اعداد

محمد غالب محمد السعدي

اشراف

د. حافظ شاهين

قدمت هذه الأطروحة استكمالا لمتطلبات نيل درجة الماجستير في هندسة المياه والبيئة بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.

2009

دراسة خيارات اعادة تدوير واستخدام النفايات الصلبة في مشروع زهرة الفنجان

اعداد
محمد غالب محمد السعدي
إشراف
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الملخص

اشتمل هذا البحث على دراسة الخيارات المختلفة لاعادة تدوير واستخدام النفايات البلدية لمشروع مكب زهرة الفنجان الصحي والمتمثلة ب: فصل النفايات عند المصدر، فصل النفايات عند محطات الترحيل و خيار فصل النفايات بالموقع بواسطة محطات تدوير النفايات، مستند ين بذلك لمعايير تم اختيارها من دراسات سابقة وهي: المعاير البيئية، الاجتماعية، الفنية بالاضافة الى المعايير المالية. حيث تم تقسيم منطقة الدراسة الي خمسة مناطق والمتمثلة بجكيع الهيئات المحلية المستخدمة للمكب لغاية تاريخ 31/ 7 / 2009 اخذين بعين الاعتبار عدد السكان، الكثافة السكانية والبعد عن المكب، الطوبوغرافيا، وطرق جمع وترحيل النفايات.

اشتمل البحث ايضا على دراسة ميدانية في موقع المكب لتحديد نسب المواد الاساسية المكونة للنفايات والتي هي: النفايات العضوية، الكرتون والورق، البلاستيك، الزجاج، المعادن، الاقمشة وغيرها من المكونات، وقد اشارت النتائج الى ان معدل نسبة النفايات العضوية في منطقة الدراسة هي 53,73% بينما فان وصلت نسبة جميع المواد المكونة المذكورة الى 46,27%.

تم اعتماد المعايير الفنية كاساس لادارة خيارات البحث بطريقة فعالة تاخذ بعين الاعتبار النظام الحالي من جمع ونقل ومعالجة للنفايات ومن ثم تحديد جميع المتطلبات الفنية لكل خيار. حيث تم ادارة خيار الفصل عند المصدر من خلال اعتماد نظامي (Curbside Collection) و(Drop-off Centers)، من خلال فصل النفايات الي قسمين وهما: النفايات العضوية (الجزء الرطب) والنفايات الاخرى (الجزء الجاف). ومن ثم تم انشاء خطة اسبوعية تاخذ بعين الاعتبار جميع المتطلبات الفنية (عمال، معدات، اليات، وغيرها). ادارة خيار الفصل عند محطات الترحيل تمت من خلال مناقشة الوضع الحالي المتمثل بمحطي ترحيل مدينة نابلس ومحافظة طوباس، وتم اقتراح محطي ترحيل في كل من قرى شرق وغرب مدينة جنين، وانشاء خطة للفصل اليدوي من خلال المحطات الثلاثة باستثناء محطة مدينة نابلس التي تقوم على اساس الفصل شبة المكانيكي. وتم دراسة خيار الفصل من المصدر من خلال دراسة انشاء محطة فصل بالموقع وادراة عمليات الفصل بهذه المحطة.

ناقشت الدراسة مجموعة من القضايا البيئية والاجتماعية وتحديد احتمالية تاثيرها بشكل ايجابي و سلبي كنتيجة لتطبيق خيارات البحث، وتم جدولة هذه التاثيرات اخذين بعين الاعتبار تقليل الاثار السلبية المحتملة. اشتملت الدراسة ايضا على تحليل مالي للخيارات المختلفة تضمن تحديد التكاليف المتوقعة من تطبيق هذه الخيارات وحساب العوائد المالية من الرسوم التي تدفعها

الهيئات المحلية و من بيع النفايات المفصولة والقابلة للتدوير والتي تشمل المواد العضوية، الكرتون، البلاستيك، المعادن والزجاج. ومن ثم تم تحديد ثلاثة سيناريوهات لحساب الارباح ونسبتها من التكاليف، حيث تقوم هذه السيناريوهات على اساس تغيير الرسوم المفروضة على الهيئات المحلية وهي: رفع الرسوم حسب تحليل التكلفة الناتج عن دراسة خيارات البحث، تثبيت الرسوم الحالية حسب ما هو معتمد لدى مجلس الخدمات، خفض الرسوم لغاية الحصول على صفر ارباح.

تم حساب الفترة الزمنية المتوقعة لاطالة عمر المشروع حيث اظهرت النتائج انه في حال فصل ما نسبته 41.3% من الكمية الكلية للنفايات فان هناك 9 سنوات تضاف لعمر المكب اخذين بعين الاعتبار الزيادة المتوقعة بعدد السكان وكمية النفايات، حيث انا عمر المكب الاجمالي سيصبح 22 عام