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Faculty of Graduate Studies

Cost Analysis of Solid Waste Management for the City of Qalqilia

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Dedication

To my parents, wife, daughter and to the soul of my friends

To all the people who support me especially my teachers throughout my learning

and education life

Acknowledgment

First of all, praise be to Allah for helping me in completing this thesis, and for all the beautiful gifts Allah bestowed upon me.

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I would like to thank my mother, my wife, my brothers, and all who gave me great support and encouragement.

الإقـــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Cost Analysis of Solid Waste Management for the City of Qalqilia

دراسة تحليل التكاليف لإدارة النفايات الصلبة لمدينة قلقيلية

اقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء ما تمت 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:**

List of abbreviations

BCA	Benefit Cost Analysis
B/C	Benefit Cost Ratio
DEP	Department of Environmental Protection, Florida
EMP	Environmental Management Plan
DHV	DHV Consultants nd Engineering
EQA	Environmental Quality Authority
FCA	Full Cost Accounting
HED	Health and Environmental Department of Qalqilia Municipality
MD	Mechanical Department in Qalqilia Municipality
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
PCBS	Palestinian Central Bureau of Statistics
PHG	Palestinian Hydrauligy Group
RTSU	Research and Technical Support Unit in Qalqilia Municipality
SW	Solid Waste
SWM	Solid Waste Management
SWMP	Solid Waste Management Program
SWMS	Solid Waste Management System
UG	Universal Group for Engineering and Consulting
ZFSL	Zahrit Al-Finjan Sanitary landfill

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Cost Analysis of Solid Waste Management for the City of Qalqilia

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Abstract

Solid Waste Management (SWM) is of great concern for municipalities in the West Bank / Palestine especially after the transpired environmental problems of the low cost malpractices related to the existing dumps that pollute the environment.

Cost studies have played an important role in evaluating waste disposal methods and advocating one option over another. This thesis aims at quantifying the benefits and costs of the solid waste management options in Qalqilia City in order to help future policy decisions, evaluating the existing SWM system and estimating the least cost option for managing solid waste in the City.

Four options were discussed for the municipal solid waste (MSW) disposal in Qalqilia City and these are: Maintaining the existing situation (The do-nothing option); constructing a transfer station and transport MSW to Zahrat Al-Finjan Sanitary Landfill in Jenin District; constructing a sanitary landfill for Qalqilia City operated by the Municipality; making partial recycling to separate the recyclable materials and partial compost generation and then transfer the remaining part of the solid waste to Zahrat Al-Finjan sanitary landfill.

Solid waste disposal options for Qalqilia City were evaluated based on cost analysis, where it was found that the first option which is maintaining the existing situation (the do-nothing option) has the largest cost which is 71.1$/ton, in addition to the negative environmental impacts on the groundwater and air pollution. This option also causes the most effect on the local property devaluation. In the absence of enough area for agricultural and housing purposes this option is considered detrimental economically and environmentally. If we ignore the local property devaluation, the environmental externalities and the cost of closure and post closure of the existing landfill then the cost drops to 42.6 $/ton.

The second option; constructing a transfer station and transport the MSW to Zahrat Al-Finjan sanitary landfill, seems to be more economic than the first option where the cost of Municipal Solid Waste Management (MSWM) is 58.7 $/ton. Environmentally this option appears to be friendlier to the environment as the vulnerability of the groundwater and air pollution is less than that of the first option. If we ignore the cost of environmental externalities the cost becomes 57 $/ton.

Making partial recycling for recyclables material and compost and transferring the remaining solid waste to Zahrat Al-Finjan sanitary landfill seems to be the most economical and environmental friendly from the other options. The cost of MSWM can be from 45.9$/ton to 52.3$/ton. This cost is according to the amount of municipal solid waste to be separated and recycled. This option provides more jobs and reduces the vulnerability of

groundwater and air pollution. This option reduces the travel distance and fuel consumption by reducing the amount of MSW to be transported and land filled.

Construction of sanitary landfill for Qalqilia City is conflicting with Environmental Quality Authority (EQA) policy, with highest capital cost in addition to lack of the required land, this option and privatization option need detailed study which is not covered in this thesis.

Finally it was recommended that Qalqilia Municipality should have a specific project for the proper closure and post closure of the existing solid waste landfill. This project will eliminate the local property devaluation at the landfill area and protect the groundwater.

It is recommended that Qalqilia Municipality starts to have pilot programs for solid waste separation and recycling in addition to the generation of compost especially that the city is located in an agricultural area. This will reduce the cost of SWM by reducing the amount of land filled waste and improves the environmental conditions in the city.

Chapter One

Introduction

Chapter One
Introduction

1.1 Background

One of the very important factors in keeping the environment clean and aesthetic is the efficient Solid Waste Management (SWM). The proper disposal of Municipal Solid Waste (MSW) becomes more acute as the population of the cities becomes larger and larger (Tin et al., 1995). The improper disposal of the solid waste causes pollution to the environment. In the absence of efficient collection of MSW, it will be dumped randomly in open spaces, streets, valleys and water bodies. The unsupervised process of dumping solid waste becomes a source of diseases, leachate from the decomposition which infiltrates into the soil and percolates into the aquifers. In addition, the improper management of MSW causes harmful effects to the public health and environment (Lah, 2002).

SWM involves activities associated with generation, storage, collection, transfer and transport, processing and disposal of solid waste which are environmentally compatible, adopting principles of economy, aesthetics, and energy and conservation. It encompasses planning, organization, administration, financial, legal and engineering aspects involving an interdisciplinary relationship (Flintoff, 1984). Cointrean (1982), estimated that solid waste related processes consume about 20% to 40% of municipal revenues in developing countries.

SWM in the West Bank has been a problem for the municipalities and village councils for the past decades. The Palestinian Central Bureau of

Statistics (PCBS) estimated that 67% of the solid waste is collected (UNDP/PAPP, 2006). The collection is carried out randomly and the wastes are thrown on the ground outside the streets and around garbage containers (UNDP/PAPP, 2006).

Qalqilia City produces about 50 tons per day of MSW which is about 18,000 ton per year and additional 14,500 ton per year solid waste of construction and building works. The individual average daily solid waste generation is 1.1 kg/d based on a study carried out by the Municipality of Qalqilia in August 2007 (Qalqilia Municipality, 2007).

In another study which was conducted in June 2009 it was found that Qalqilia City produces 50 tons per day of MSW and another 13.5 ton per day of building works waste. This means that the total collected solid waste is 63.4 ton per day and the individual average daily MSW generation is 1.15 kg/d. The population of Qalqilia city was 41,739 in the year 2007 (PCBS, 2007) and is estimated at 43,446 for the year 2009 (Research and Technical Support Unit (RTSU), Qalqilia Municipality, 2009).

According to the Research and Technical Support Unit (RTSU) in Qalqilia Municipality, the municipality has the responsibility for the collection and disposal of the solid waste. Currently Qalqilia Municipality disposes of MSW in a landfill that was constructed without any environmental precautions or health measures after the Israeli closures of the city in the beginning of 2002 and after the closure of Jayyouse Village solid waste dumpsite. After the deterioration of the environmental

conditions and after the Municipal Council became aware of the environmental and health hazards of the existing landfill and the corresponding practices, it was decided to consider an alternative for MSW disposal (RTSU Qalqilia Muniucipality, 2009).

Having a good SWM plan reduces the costs of collection and disposal of the solid waste and the harmful effects on the environment.

Cost studies have played an important role in evaluating waste disposal methods and advocating one option over the other. Our goal is to quantify the benefits and costs of the SWM options in Qalqilia City in order to help future policy decisions.

1.2 Research Objectives

Solid waste collection and disposal become in the concern of all communities especially after the transpired environmental problems of the low cost malpractices related to SW such as burning dumps that pollute the air in addition to the unsafe working conditions resulting in numerous injuries. While the public prefers the low cost options for garbage disposal they are not aware of the many costly problematic consequences these practices cause.

The research objectives are as follows:

1. Investigate and evaluate the existing MSW management system in Qalqilia City.

2. Identify the least cost SWM option for QalqiliaCity using cost analysis system.

1.3 The Potential MSW Management Options in Qalqilia City

The potential MSW management options for Qalqilia City are:

1. Maintaining the existing situations (The do-nothing option). Currently, Qalqilia Municipality collects the municipal and construction solid wastes, and then all of the collected waste is sent to the existing landfill in the city. A loader is then used to cover the solid waste partially with soil.

2. Constructing a transfer station and transport the MSW to Zahrat Al-Finjan Sanitary Landfill (ZFSL) in Jenin area. In the transfer station, waste is collected from smaller collection vehicles to larger transfer vehicles such as trailers and tractors. Transfer station can be quite simple or they can be complex facilities. The design of the facility is based on its intended use. The decision “build” versus “no build” of a transfer station is often an economic-based decision. If the one way haul distance from the point of full collection vehicle to the disposal point is short then it is likely that no transfer station is required. On the other hand, if the disposal point is far away and the collection vehicle will have to be away from its primary role of refuse collection for too long, then a transfer station might be warranted (Vesilind et al., 1987). The relationship is illustrated in Figure 1, where the two curves cross is the

breakeven point. Longer distance will warrant the construction of the transfer station while shorter hauls will make it uneconomic.

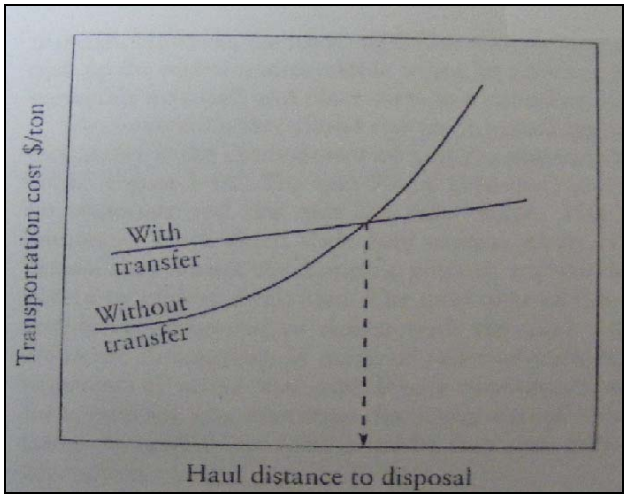

Figure (1): Breakeven point of transfer station (Vesilind et al., 1987)

3. Constructing a sanitary landfill for Qalqilia City operated by the Municipality.

Regardless of how much reuse, recycling and energy recovery is achieved, a landfill is an engineered method for the land disposal of solid or hazardous wastes in a manner that protects the environment. Figure 2 shows photos for transfer station and Zahrat Al-Finjan Sanitary Landfill.

4. Making partial recycling to separate recyclable materials and partial compost generation then transfer the remaining part of the solid waste. Many cities in the West Bank are starting this practice such as Nablus City in Al Sairafi Transfer Station and the recycling of Plastic material in Zahrat Al-Finjan Sanitary Landfill near Jenin City (Figure 3).

Transfer station in Jenin District

Transfer station in Jenin District

Zahrat Al-Finjan Sanitary Landfill

Zahrat Al-Finjan Sanitary Landfill

Figure (2): Transfer station in Jenin District and Zahrat Al-Finjan Sanitary Landfill

Zahrat Al Finjan sanitary landfill

Al Sairafi transfer station in Nablus City

Figure (3): Al Sairafi transfer station in Nablus City and plastic recycling in Zahrat Al-Finjan Sanitary Landfill in Jenin District

1.4 Research Methodology

A cost analysis based procedure is to be used to investigate and identify the least-cost option and to compare and differentiate between the proposed and existing systems.

A literature review was carried out to study and review researches done in this field and related subjects. Data collection was performed regarding MSW management system in Qalqilia City. Field trips for storage sites, the existing landfill, maintenance sites, and the proposed site for the transfer station were made, in addition to interviews with the vehicular collection crew and municipality related departments.

All the data collected from the field, interviews and other discussions were analyzed using MS Excel. Finally recommendations and conclusions were presented. The entire methodology is depicted in Figure 4 bellow while benefit cost analysis and cost considerations depicted in Figure 5.

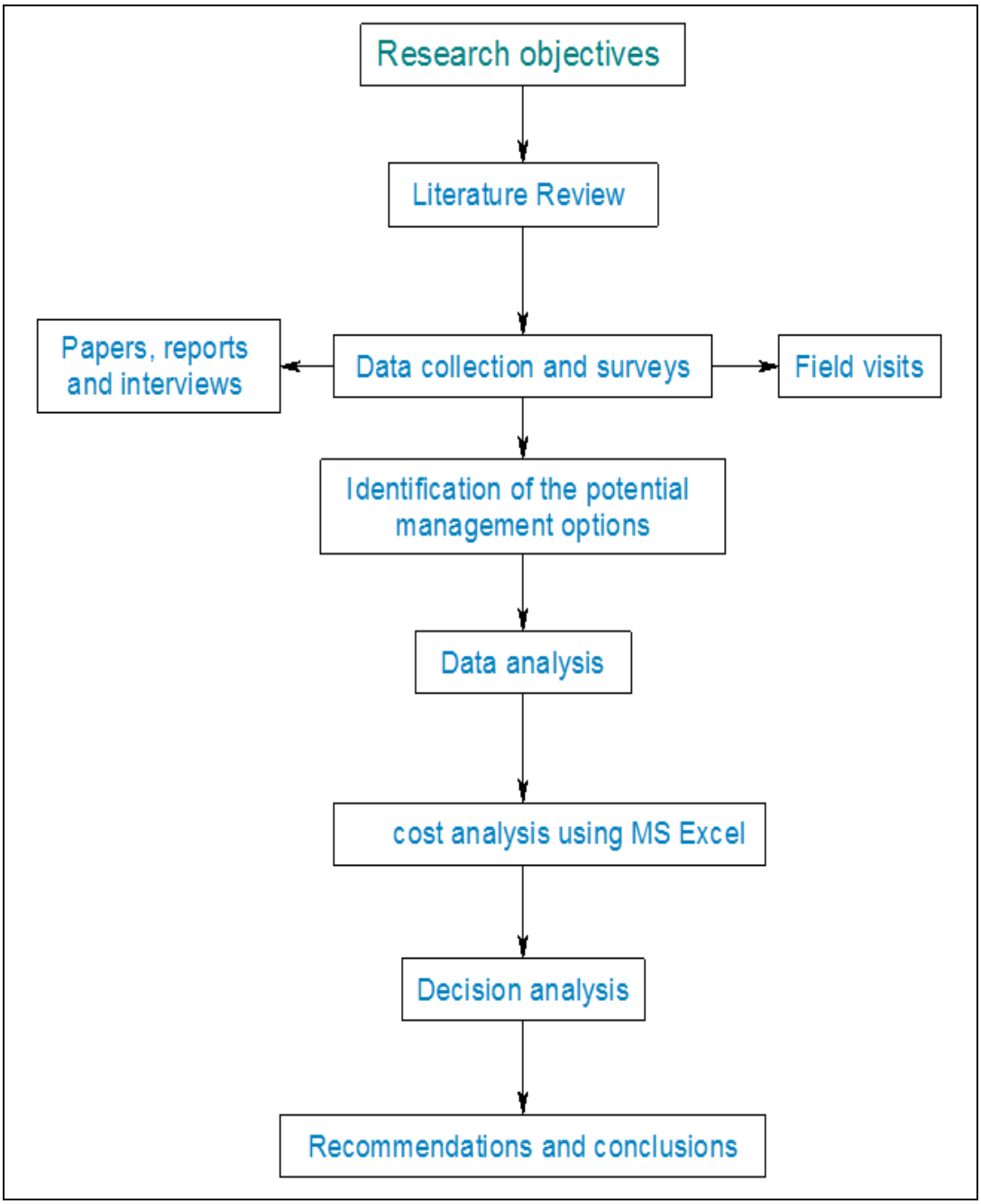

Figure (4): Research methodology

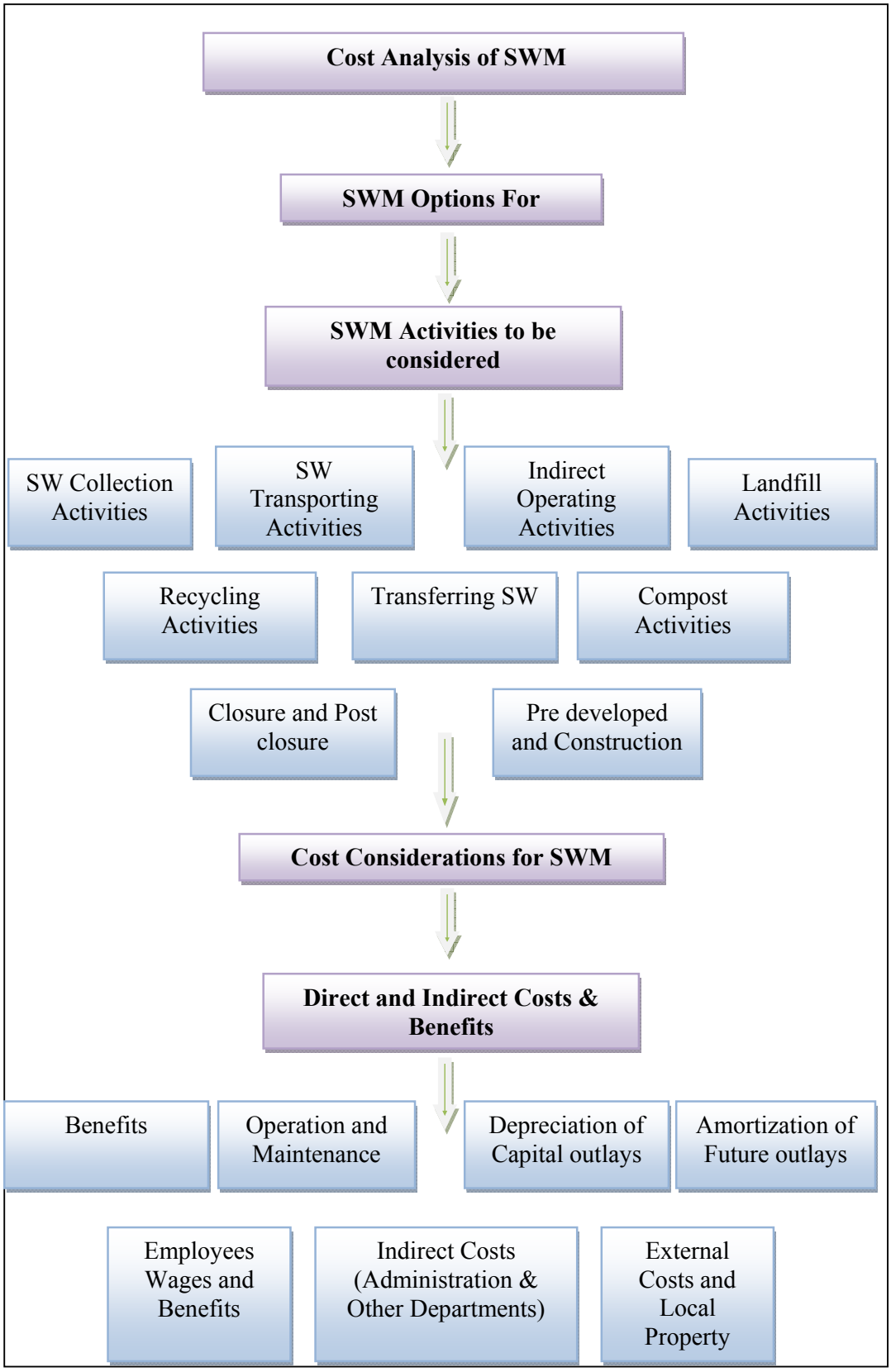

Figure (5): Research methodology, benefit cost analysis and cost considerations

1.5 Thesis Outline

The subject of the thesis is the benefit cost analysis of SWM for the city of Qalqilia. The thesis consists of seven chapters.

In chapter one an introduction is introduced about solid waste management and the research objectives, in addition to a description for MSW management options in Qalqilia City. Chapter two provides a general background about Qalqilia City. Chapter three contains the literature review, the related researches and reports were reviewed. Chapter four introduces a description for the SWM system in Qalqilia City. Chapter five describes the cost analysis of SWM. Chapter six discusses the MSWM options for Qalqilia City based on cost analysis considerations. The conclusions and recommendations of the research furnished in chapter seven.

Chapter Two

A General Background for Qalqilia City

Chapter Two
A General Background for Qalqilia City

2.1 Location

The City of Qalqilia is located in the north-west of the West Bank, Palestine. It is situated about 12 km from the Mediterranean coast. Qalqilia City is the main city within Qalqilia district, wich is connected to the neighboring District of Nablus from the east, Tulkarm District from the north and to Salfeet District from the south. Figure 6 shows Qalqilia City location in the West Bank.

According to the Engineering Department of Qalqilia Municipality, the area of Qalqilia City boundary was 27.5 km^2 before the year 1948. This area was reduced to 10 km^2 after the 1967 war. Finally and after the construction of the Israeli Separation Wall, Qalqilia's land was reduced to 8.2 km^2. The buildup area in the city is 4.3 km^2 (RTSU Qalqilia Municipality, 2009).

Qalqilia City is connected to the near cities and villages by one main road which is the eastern entrance (the main entrance of the city). It is also connected to the southern villages by a tunnel leading to Habla Village and Salfit Disrict in the south. Figure 7 is an areal image for Qalqilia City where the Seperation Wall can be seen (RTSU Qalqilia Municipality, 2009).

Figure (6): West Bank and Gaza Strip

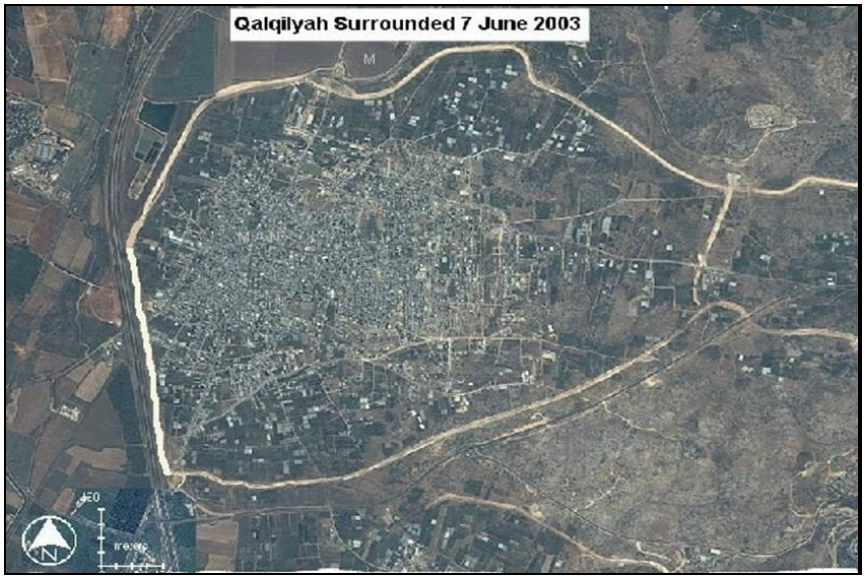

Figure (7): Aerial photo of Qalqilia City, 7th June 2003, Qalqilia Municipality

2.2 Population

According to the latest statistics, the population of Qalqilia City is 41,739 (PCBS, 2007). The population of the city for the year 2009 is estimated at 43,446 according to the PCBS with a population growth rate of 2.6% per year (PCBS, 2007).

As the population of the city increases it needs more and more services of water, wastewater, solid waste, health and other services. The following table summarizes the population, housing and establishment indicators for Qalqilia City and Qalqilia District. The population density is 10,103 person/km^2.

Table (1): Population, Housing, and Establishments in Qalqilia City (2007)

	No. of household units	No. of buildings	No. of establishments	Average size of household	No. of households	Total population
Qalqilia City	8,680	5,219	1,925	5.3	7,844	41,739
Qalqilia District	18,128	13,591	3,879	5.5	16,483	91,217

Source: PCBS, population, housing and establishment census 2007.

2.3 Climate

The climate of Qalqilia is Mediterranean with moderate summers and warm winters. The mean annual temperature for Qalqilia District is 22.3°C and the mean annual minimum temperature is 15.6°C. The mean temperature from June to August is 25°C. This value increases to an average of 26.2°C in August (RTSU, 2009).

In winter, the area is influenced by warm air from the sea. The average temperature from December to February is 11.8°C.

The rainy season in Qalqilia usually starts in late October and continues through May. Between December and February, almost 70% of the annual rainfall occurs, while 20% of the annual rainfall occurs in October and November. December and January are normally the wettest months in Qalqilia governorate. The amount of the mean annual rainfall in Qalqilia district varies from year to year and rain may fall with great intensity. During wet years the average annual rainfall of the city is 624.9mm (RTSU, 2009).

In Qalqilia District the wind direction mainly lies between the southwest and the northwest with mean annual wind speed of 3.4 km/hr. In winter, the district is influenced by the depressions passing from west to east over the Mediterranean. These depressions bring westerly rain bearing winds. The average wind speed from December to February is 4.1 km/hr (RTSU Qalqilia Municipality, 2009). In summer, the district is influenced by the sea breeze that comes from west in the morning. Towards noon, winds change their direction to southeast and later in the evening they turn to south and southwest. The average wind speed from June to August is 2.85 km/hr. In September and October, winds are more northerly with an average wind speed of 2.78 km/hr. In spring, the Khamaseen winds may blow over the area full of sand and dust. The mean daily wind speed from April to June is 3.2 km/hr (RTSU Qalqilia Municipality, 2009).

Humidity in Qalqilia District reaches high levels with an annual average of 69.6%. In winter, this value increases to an average of 75.9% in February while in May it reaches its lowest value of 62.4%. Summer months are humid with an average humidity of 70.3% from June to August (RTSU Qalqilia Municipality, 2009).

Rainfall, cloudiness, temperature and humidity in the West Bank (including the District of Qalqilia) are illustrated in Figures 8 and 9 (Atlas of Palestine, 2001).

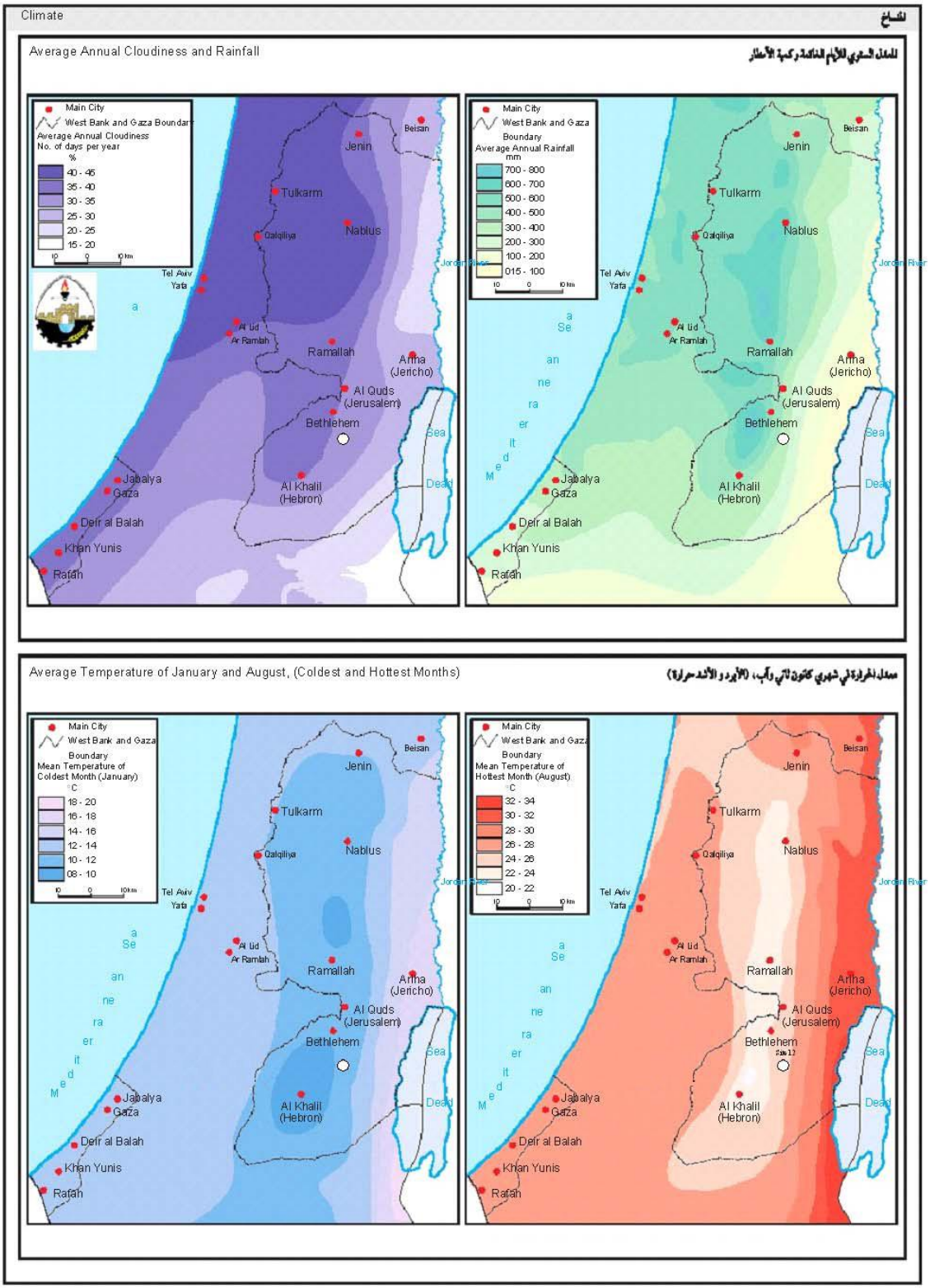

Figure (8): Climatic data (rainfall and cloudness) (Source: Atlas of Palestine, 2001)

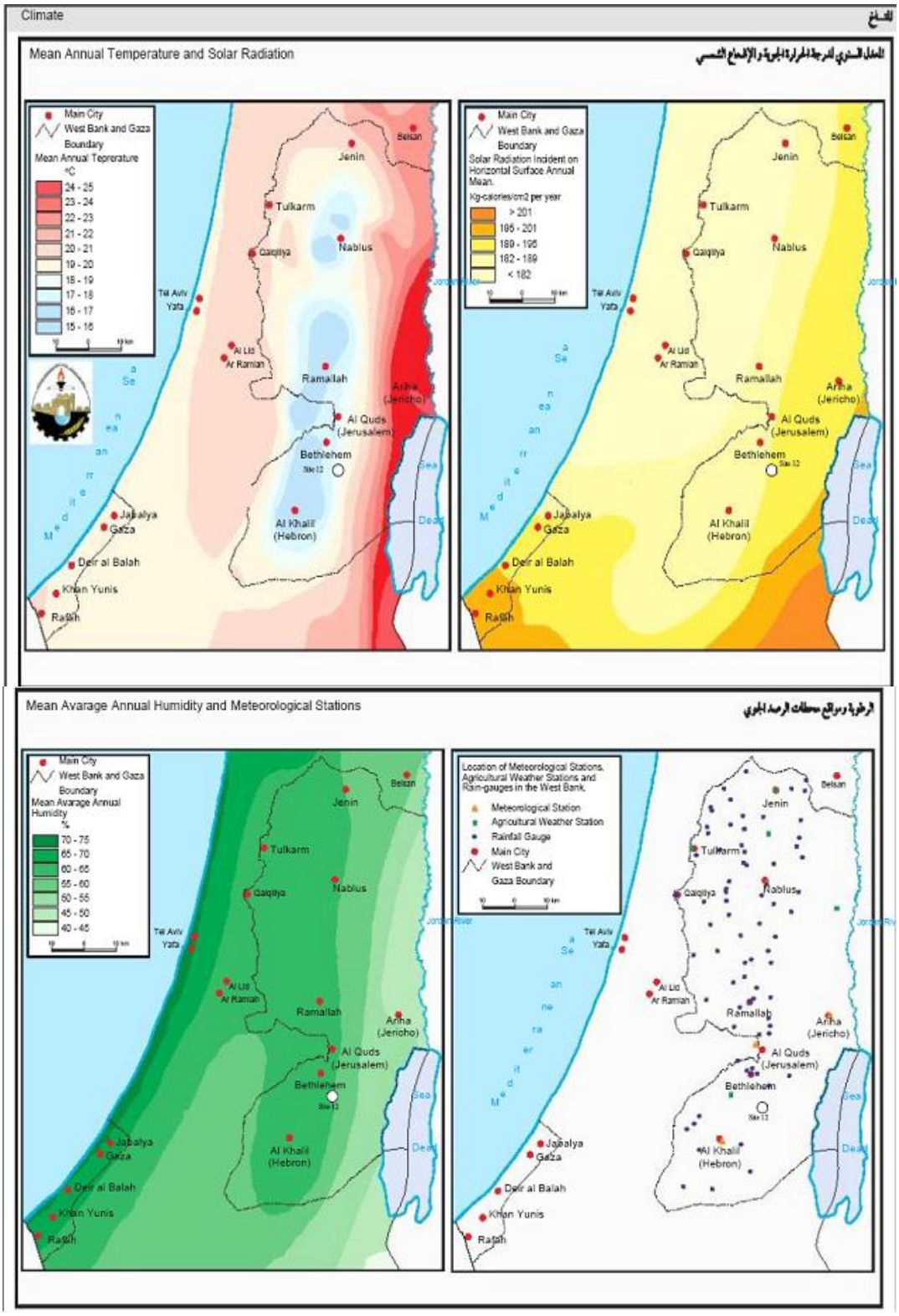

Figure (9): Climatic data (other parameters) (Source: Atlas of Palestine, 2001)

2.4 Soil

The Terra Rossa is the most common soil in Qalqilia District. It originates from the hard rocks of the Cretaceous series. The color is red to light brown. The parent materials are Dolomite and hard Limestone. Only in the valleys it is thick enough to have significant covering capacity, while in other areas rock outcrops and thin layers of soil prevail. Lime content varies between 0-10%, lime-free soils are occasionally slightly unsaturated. Organic matter content is 2-8%. The pH is in the range of 6.5-7.8 (Universal Group for engineering and consulting (U.G.), 2006)

2.5 Geology of Qalqilia City

Geologically the substrata of Qalqilia city are Cenomanian Touronian Series. The flat areas which skirt the west part of the city are overlain by Alluvial deposits. The whole area on which Qalqilia is located is made up of rocky dolomite outcrops. The elevation of the city rises from +40 m above mean sea level in the western parts to about +127 m above the mean sea level in the eastern parts of the city (U.G., 2006).

2.6 Economic and Social Situation

The Majority of Qalqilia population is farmers, skilled and unskilled laborers, and governmental employees. The agricultural and labor sectors have been completely paralyzed following the permanent siege of the city, the setting up of the separation wall around the city and the confiscation and isolation of the most fertile lands. (RTSU Qalqilia Municipality, 2009)

Qalqilia City is the metropolis of Qalqilia District, which comprises 31 villages and 3 other communities. These villages and communities depend on the infrastructure and other services, including educational and medical services within Qalqilia city (RTSU Qalqilia Municipality, 2009).

Qalqilia is surrounded on every side by Israel's separation barrier and checkpoints. The Israeli separation barrier is a system of 8 meter high concrete walls with cameras and sniper towers in some areas, and fencing with motion sensors, trenches, barbed wire pyramids and patrol roads, in other places (RTSU Qalqilia Municipality, 2009).

The Municipality Council supervises all infrastructure services in addition to contributions in health, education, culture, recreational and social services (RTSU Qalqilia Municipality, 2009).

Chapter Three
Literature Review

Chapter Three
Literature Review

3.1 Introduction

A literature review was done to review the concept of municipal SWM with particular respect to the cost analysis of municipal SWM alternatives. This was done to diagnose and understand the subject. The review revels few important research notes.

Great amount of researches and projects were done in this field. The studies vary widely from the economical evaluation of treatment technologies, comparison between economic visibility of treatment options, management plans, municipal solid waste full cost accounting workbook and economical evaluation of composting, recycling and reducing of MSW. The following sections summarize and describe these researches.

3.2 Evaluation of SW Treatment Technologies

The economic and environmental evaluation of waste treatment and disposal technologies for municipal solid waste were studied by Daskalopoulos et al. (1998). The main economic costs and the environmental impacts of the widely-accepted waste treatment and disposal methods were studied. Three basic alternatives for MSW disposal were discussed: direct dumping of unprocessed waste in sanitary landfills, processing of the waste before final disposal and processing of the waste to recover resources "material and/or energy" with subsequent disposal of the residues. The process, environmental impacts, operational factors,

examples of successful waste management schemes were presented and future trends were assessed. Land filling of the waste, waste incineration, composting and waste recycling options were discussed. Municipal Solid Waste Management was defined as the discipline associated with the control of generation, storage, collection, transfer, processing and disposal of MSW, in a way which is governed by the best principles of public health, economics, engineering, aesthetics, and other environmental considerations.

Miedema (1982) reviews the fundamental economic comparison of solid waste policy options and the sources of externalities associated with post-consumer waste were examined. A paradigm economy was constructed to compare the market and real income effects of disposal charges, recycling subsidies, user fees, and litter taxes with those of the status quo policy. The supply and demand equations of the general equilibrium system were derived and simulations were performed for each policy. Under certain assumptions, including zero transactions costs, it was concluded that real income can be maximized with a disposal charge policy, which is also the only innovative policy to assure no reduction of real income compared to the status quo, regardless of production technologies. It was concluded that five types of policy effects are of primary interest. These are the effects on real income, net waste (waste that must be collected and disposed), total waste generation, total recycling or resource recovery, and the recycling rate.

Renkow and Rubin (1998) investigated if municipal solid waste composting make economic sense. The article claims that there is little information on the costs of MSW composting and how those costs compare with the costs of alternative forms of waste disposal (especially traditional land disposal). The article reported the results of a survey of 19 MSW composting facilities around the United States. Results indicated that MSW composting generally costs around $50 per ton, and that very few facilities receive any revenues from the sale of compost to offset operating costs. Additional economic analysis indicates that, at present, MSW composting cannot be justified on financial grounds in most parts of the US, but may be competitive with land disposal where the cost of land filling is high (such as the north-east). Municipal solid waste composting technologies, surveys results, compost uses, costs of MSW composting, and comparison between the MSW composting and the land disposal were discussed in this paper.

3.3 MSWM Cost Analysis

In a report prepared by Golder Associates Inc. (2004) the cost analysis of the Archuleta County (Colorado, US) solid waste management system was studied. This study was conducted due to the inadequate funds being set aside for future capital expenditures at the County-owned and operated Archuleta County Landfill (ACL), such as that for equipment replacement, cell development and closure/post-closure financial assurance, as well as to gain a better understanding of the financial stability

of the Solid Waste Fund, the County requires an analysis of their solid waste disposal system from an engineering economics perspective.

The analysis is part of a strategic planning effort for the County and includes a report on the current system costs and an analysis of future solid waste disposal alternatives. The information obtained in the analysis was needed for establishing the County budget for the upcoming fiscal year, and for projecting future needs for disposal capacity and solid waste revenue. The analysis focuses on the tipping fees required to operate the system in a self-sustaining manner under the current conditions as well as under other viable options such as either partial or complete transfer of waste to other disposal facilities.

The scope of the project consisted of:

1. Current System: Providing a current system cost breakdown of the operations "as is," including landfill operating costs, transfer station operating costs, system administration, and hauling costs (for the County-operated transfer stations). The appropriate tipping fee was determined for the self-sustaining operation of current system (base tip fee), along with recommendations for appropriate additional tip fee increments to allow set aside of funds for future capital expenditures including equipment, staffing, and cell construction.

2. Transfer Option: A cost breakdown was prepared to determine whether a potential economic benefit would exist if the Archuleta County Landfill were utilized only for bulky wastes, such as construction and demolition

waste, and for the remaining municipal solid waste (residential and commercial) to be transferred to other landfills. Three landfills within a 100-mile radius were evaluated.

3. Based on the economics of Items 1 and 2 above, recommendations are made at the conclusion of the analysis for the best option and the associated tipping fee requirements for implementation of the recommended option.

Analysis of system revenues and expenditures from the year 2001 to the year 2004, personnel/staffing costs, and equipment operation and maintenance costs and other costs and benefits were also discussed in the report.

Florida Department of Environmental Protection has the municipal solid waste management full cost accounting workbook for local governments in Florida, 1997. The primary purpose of the workbook is to serve as a tool for local governments to use in identifying, collecting, tracking, and analyzing the costs incurred in operating their integrated solid waste management systems. Solid waste professionals can use the workbook to gather data to analyze the costs incurred to operate different segments of MSW programs and devise methods to increase the efficiency and cost effectiveness of those programs. Finally, the forms and check lists in the workbook, and the procedures it describes, can help local governments report to their communities, and to Department of Environmental Protection DEP, the full cost of MSW management

activities in a manner that helps simplify any further processing and analysis found necessary.

The workbook is available to all local governments in Florida to help them identify all the costs of their SWM programs. DEP believes that many local governments may not account for all the costs incurred in operating MSW systems and therefore may underestimate the amounts of corresponding streams of revenues that are required to keep those systems running. In such a circumstance, Full Cost Accounting data can be used to revise the budget for the MSW program or adjust user fees to reflect the full cost of the MSW management services provided by the local government.

An important document in this field is the policy brief Getting Waste Management Prices Right, by the Resource Recovery and Recycling Authority of Southwest Oakland County. The salient information from this paper for this analysis is the summary it provides of estimates for various external costs associated with landfill operations. The marginal cost of greenhouse gas pollution is $3.27 per ton for landfills without energy recovery and $2.22 per ton for landfills with energy recovery. The odor, visibility, and general appearance cost is between $3.05 and $4.39 per ton, the costs of waste transportation to landfills (congestion, air pollution, and the increased probability of road accidents is $0.51 per ton for urban landfills and $1.69 per ton for rural landfills. (Policy Brief: Getting Waste

Management Prices Right. Resource Recovery and Recycling Authority of Southwest Oakland County. January 2007).

Another reviewed paper was prepared by (Palmer et al., 1996). In this paper the authors studied the cost of reducing MSW. This paper explores public policies for reduction of municipal solid waste. A simple model of waste disposal was parameterized using supply and demand elasticities from the economics literature and 1990 prices and quantities of recyclable and recycled materials. Using this model, the waste reduction was calculated in response to three public policies:

1. Deposit/ refunds,
2. Advance disposal fees,
3. Recycling subsidies.

The results illustrate the effects of the three policies on source reduction and recycling of five recyclable materials that comprise 56% of municipal solid waste: aluminum, glass, paper, plastic, and steel. The calculated responses provide information about the cost of reducing municipal solid waste through various policies.

3.4 Cost Benefit Analysis

Denne et al., 2007 studied the cost benefit analysis of recycling for the Ministry of Environment of New Zealand. This study examines the costs and benefits of recycling to address the following questions:

1. What are the economic costs and benefits of diverting a number of waste streams from current disposal practices?

2. What is the net economic effect of given levels of recovery of each of these wastes?

3. How do the costs and benefits compare?

4. Are there opportunities for net economic benefits from increased levels of diversion of individual waste streams?

The study is not comprehensive of all waste streams but assesses the costs and benefits of recycling some of the more important materials by volume. These are: paper, plastics, glass, organic waste (kitchen waste and green waste), construction and demolition waste, tires and used oil.

In addition, the report does not consider the costs and benefits of all waste management options. Rather, it compares the costs and benefits of recycling, and particularly household curbside recycling, relative to landfill disposal. Other options include waste reduction measures that limit waste at source and alternative approaches to collection of materials for recycling, including through deposit refund schemes or bring systems. The benefits of recycling are estimated from:

1. Savings in landfill costs which are made up of the financial costs of landfill and externalities (environmental costs).

2. The saved costs of collection for disposal.

3. Other benefits, including 'direct consumer benefits' which are a measure of the extent of people's personal preferences to recycle rather than create waste. Direct consumer benefits are expressed as the difference between people's willingness to pay to recycle and the actual cost.

The benefit cost analysis of recycling programs for the Eugene Saint Vincent de Paul was studied by Jackson and Strauss (2007). This study aims to conduct a benefit-cost analysis of the recycling programs of the St.Vincent de Paul Organization. It begins by examining the costs of landfill use, including operating costs, external costs, and the issue of scarcity rent as it relates to landfills.

The benefits created from the recycling activities of St. Vincent de Paul are also examined. These benefits arise from the sale of recycled and reconditioned materials, as well as from the job opportunities the recycling program creates. The study attempts to quantify the benefits from the vocational service programs provided by St. Vincent de Paul. The study concluded that the external costs of having and using a landfill are higher than the tipping fee, which causes an inefficiently high amount of waste to be disposed at the landfill.

The study argued that the external costs of the landfill justify higher tipping fees (perhaps by imposing a tax on the landfill), a subsidy for alternative methods of waste disposal, or increased payments to SVDP for diverting waste from the landfill.

3.5 MSWM in the West Bank

The Environmental Quality Authority (EQA) prepared in 2007 an Environmental Management Plan (EMP) titled *Solid Waste Management System for Anabta and Surrounding Villages, Wadi Al Shaeer Joint Services Council*. This EMP has the purpose of protecting the environment and the quality of life of the population and is based on the objectives of the environmental strategy and law in general. It relates to the environmental mitigation actions that will be taken during and after the construction of a transfer station in Anabta to collect solid waste from surrounding areas and transfer these to the existing constructed landfill at Zahrat Al-Finjan.

The objectives of this EMP were listed as:

1. Place the proposed project in the context of the local and regional environment;

2. Adequately describe all components of the proposed project, so that the EQA can consider approval of a well-defined project;

3. Provide the basis of the proponent's environment management program, which shows that the environmental impacts resulting from the proposed project, including cumulative impact, can be acceptably managed; and

4. Provide a document that clearly sets out the reasons why the proposed project implementation and operation should be judged by the EQA to be environmentally acceptable.

Solid waste management practices in Nablus District were evaluated and analyzed by Abu Zahra (2006). This was done in three aspects:

1. Evaluation of the current practices in solid waste collection and disposal in the city, villages and camps.

2. Assessment of the satisfaction and awareness of the citizens with the level of services provided.

3. Determining the composition of the solid waste in both the city and the villages.

The existing system of SWM in Nablus City, Equipments, SWM staff, SWM fees, solid waste composition in Nablus District and SWM expenses and income were analyzed and discussed in the thesis.

Eid (2007) prepared a theses titled *Evaluation of solid waste management in Qalqilia District*. The study describes the problems, issues and challenges of MSWM faced by local authorities in Qalqilia District. Approaches of possible solutions that can be undertaken to improve MSW services were discussed.

The study consisted of a public survey, survey and discussions with local authorities staff involved in waste management, determination of

waste composition by segregation of 30 samples from 5 sites, and review of documents and field observation. The study provided information on MSW collection services availability and waste disposal practices in Qalqilia District. It was found that:

1. Little or no consideration of environmental impacts was considered in the selection of dumpsites.

2. Inspection and monitoring of the dumpsites was not consistent, 46.2% of local authorities dispose waste in open random dumps without any further treatment and 15.4% of local authorities dispose of their waste in open random dumps and then burn it.

3. 100% of local authorities employ workers in the MSW services without any training and they do not train them later to do their work. They obtain the experience from experiment and from their companions, so they are usually exposed to danger and hazards.

4. The collection workers and the vehicles are divided between small localities. Small numbers of waste containers is available in most localities.

5. MSW collection frequency in several villages is around or below two times per week.

6. The overall average MSW generation rate per capita for 26 localities in Qalqilia District is 1.46 kg per person per day.

7. The results obtained indicate that more than 83% of MSW could potentially be either recycled or composted.

8. It was noticed that MSWM budget ranges between (3% to 9%) of the total budget and about 42.3% of localities has a MSWM budget less than 3% of the total budget, 34.6% between 3% and 6% and 15.4% between 6% and 9%.

9. Results also show that 97.3% of the residents are willing to pay more for better services and 60.6% of residents are willing to separate wastes into organic and inorganic without money but 18.6% are willing with little money. 71.6% of residents are ready to transform organic wastes to natural fertilizers if they were trained to do so.

Chapter Four

Solid Waste Management System (SWMS) in Qalqilia City

Chapter Four

Solid Waste Management System (SWMS) in Qalqilia City

4.1 Introduction

One of the very important factors in keeping the environment clean and aesthetic is the efficient solid waste management especially in developing countries (Tin et al., 1995).

The proper disposal of Municipal Solid Waste (MSW) becomes more acute as the population of the cities becomes larger and larger (Tin et al., 1995). The improper disposal of the solid waste causes pollution and danger to the environment. In the absence of efficient collection of MSW, it will be dumped randomly in the open spaces, streets, valleys and by water bodies. The unsupervised process of dumping solid waste becomes a source of diseases, leachate from the decomposition which percolates into the soil and the water sources resulting in polluting water, soils, and air. In addition, the improper management of MSW causes harmful effects to the public health and environment (Lah, 2002).

According to Flintoff (1984), solid waste management involves activities associated with generation, storage, collection, transfer and transport, processing and disposal of solid waste which are environmentally compatible, adopting principles of economy, aesthetics, and energy and conservation. It encompasses planning, organization, administration, financial, legal and engineering aspects involving an interdisciplinary relationship.

Solid waste management in the West Bank has been a problem for the municipalities and village councils for the past decades. The PCBS estimated that 67% of the solid waste is collected. The collection is carried out randomly and the wastes are thrown on the ground outside the streets and around garbage containers (UNDP/PAPP, 2006).

4.2 SWMS in Qalqilia City

Qalqilia Municipality has the responsibility of MSW management system where it faces many difficulties in this regard. As the city population grows, the city generates increasing quantities of MSW. Most of the solid waste comes from domestic and commercial premises (RTSU, 2009).

The Health and Environment Department (HED) in Qalqilia Municipality has the responsibility of the solid waste management and disposal. Solid waste, vegetable market, slaughter place and food lab are managed by the HED (HED, 2009).

The existing collection and disposal system is not efficient and is resulting in an environmental pollution which may lead to health hazards in the near future. The majority of the MSW is collected by the municipality while part of it is not collected where people dispose of their waste improperly. The amount of MSW that is not collected by the municipality is less than 5% with little unofficial dumps around the city which produce intolerable odors and environmental hazards (RTSU and HED, 2009).

In a study conducted by Qalqilia Municipality in August 2007, Qalqilia City produces about 50 tons per day of MSW which is about 18 thousands ton per year. The study also found that the city produces about 40 tons per day of construction solid waste which is about 14 thousand tons per year. The individual average daily solid waste generation is 1.18 kg/d. (RTSU, 2007).

Note that the construction works solid waste amount is not the same in each month as it varies according to the construction activities in the city.

The construction SW is collected by a loader "bager" and a truck where it is used in both new roads construction in the city and backfilling operation in the Municipality solid waste landfill. The HED of Qalqilia Municipality manages the construction and building works collection. Fees are collected from the people for the removal of their construction wastes of building works waste which is estimated by the HED supervisors at the site (HED, 2009).

4.2.1 Equipments and labors used by HED for SWM

According to Qalqilia Municipality, 87 employers and workers are working in solid waste management and disposal system of the city. As summarized in Table 2, the head of the HED in addition to 11 drivers, 9 solid waste collection workers, 55 street cleaners, 4 foreman and 7

supervisors cooperates in the collection, transport and disposal of the solid waste in the city.

These numbers do not include the administrative work that is given to the SW sector in the Municipality from other departments such as the Administration Department, Accounting Department, Maintenance Workshop, and Mayor Office.

Table (2): SWM staff in Qalqilia Municipality.

	Item	Number of employees
1	Head of the department	1
2	Supervisors	7
3	Formen	4
4	SW collectors, (Compacting trucks staff)	9
5	Drivers	11
6	Street cleaner	55
	Total	**87**

Solid waste collection frequency is seven times per week. Collection of MSW is carried out daily during the year. The high collection frequency in the city is due to the high living standards and since the city is the center of the district (HED, 2009).

As summarized in Table 3, SW collection is done by using nine compactors, two tractors, one loader, and one truck in addition to a service car. The municipality has about 507 steel containers of one m^3, where these containers are distributed in the city and emptied by compacting trucks. It is estimated that one container serves 82 citizens.

Steel Containers sized of 4 m^3 are located in the vegetable market and other places in the city. These are removed and evacuated daily by the roll off or lifting truck. The Municipality uses compacting trucks that collect SW from the one m^3 containers and compact it 2-3 times denser. The municipality has nine compacting trucks where two of them are standby vehicles and after receiving the new compactors it is proposed to replace three of the old compactors.

A transporting truck is used for removing the solid waste of building operations which is filled by a loader in addition to two tractors to collect bulky items (HED, 2009).

Table (3): Inventory of solid waste management equipments and vehicles of Qalqilia City (HED, 2009).

	Item	Number
1	SW containers of 1 meter cube	507
2	SW containers of 4 meter cube	30
3	SW compactors	9
4	SW transporting truck	1
5	Tractor	2
6	Loader	1
7	Roll off truck	1
8	Lift truck	1
9	Mechanical street cleaning vehicle	1

Currently solid waste collection in Qalqilia City is carried out every day in the morning by the collection workers working with the compacting trucks. The compacting trucks collect the household solid waste from the containers distributed throughout the city. The collection workers move the solid waste cans and bags from the narrow streets to be on the compacting trucks rout to be disposed of (HED, 2009).

Street cleaners are grouped into teams and each team is headed by a foreman. The works are managed by the health department supervisors (HED, 2009).

Construction SW is collected by a loader "Bager" and a truck where it is used in both new roads construction in the city and backfilling operation in the Municipality solid waste landfill.

In the vegetable market at the centre of the city, the solid waste is collected in a 4 big containers (4 m^3 capacity). These containers in addition to the 26 other big containers that are distributed in many places in the city are evacuated daily by a roll off truck (HED, 2009).

HED supervisors are auditing the solid waste management actions in the city. A service car is used by the HED in the Municipality. The collected waste is transported to the existing landfill and the vehicles then are washed and cleaned (HED, 2009).

In July 2009 Qalqilia Municipality had received three new SW collection compactors (one of 3 m^3 and two of 5 m^3 compactors) in addition to a mechanical street cleaning vehicle. All were donated from the European Union and the total estimated cost of these vehicles is 480,000 US$. According to the HED and the Mechanical Department (MD) of Qalqilia Municipality the three new compactors will be used instead of three old compactors which are proposed to be sold due to the high maintenance cost (HED and MD, 2009).

Figures 10 and 11 are photos of the MSW collection vehicles of Qalqilia Municipality

Figure (10): SW collection equipments in Qalqilia Municipality

Figure (11): SW collection equipments in Qalqilia Municipality

4.2.2 The existing solid waste landfill of Qalqilia City

According to the HED, Qalqilia Municipality disposes of the MSW in a landfill that was constructed without any environmental precautions or health measures after the Israeli closures of the city in the beginning of 2002 and after the closure of Jayyouse Village solid waste dumpsite (HED, 2009).

The existing solid waste landfill is situated at the eastern part of the city with a total area of 25 dunums. 85% of this area is used for landfilling practices. The existing landfill is surrounded by agricultural areas and green houses. Figure 12 shows the existing landfill location.

Figure (12): The existing solid waste landfill location in Qalqilia City

The existing disposal system is not efficient and may result in environmental pollution which will lead to health hazards. Collection

vehicles dump their loads in the landfill while a loader cover them with soil in the absence of liner, gas and leachate collection, treatment and disposal system. Frequently, smokes and gases emitte to the air due to the burning of the solid waste. When fires start, the Municipality sends the fire fighters to deal with (HED, 2009).

The more serious problem is the possibility of polluting the groundwater which is the only source of drinking water in the city knowing that groundwater in Qalqilia City is located at fairly small depths always (between 29 and 116 m). Polluting the groundwater occurs when the leachate from the degradation of the MSW enters the aquifers (RTSU Qalqilia Municipality, 2009). Figure 13 shows the nearby agricultural areas around the existing SW landfill.

Figure (13): The agricultural areas and green houses around the existing landfill in Qalqilia City

The Municipal Council became aware of the environmental and health hazards of the existing landfill and the deteriorated environmental

situation there. It was decided to look for an alternative MSW disposal site (RTSU, 2009). Figure 14 presents photos for the current solid waste landfill in Qalqilia City.

Figure (14): The current solid waste landfill in Qalqilia City

4.2.3 Municipal solid waste composition in Qaqlqilia City

Municipal solid waste is classified according to its source or type to the following components:

1. Mixed household waste
2. Recyclables
3. Household hazardous waste
4. Commercial waste
5. Yard or Green waste
6. Litter and waste from community trash
7. Bulky items such as refrigerators, rugs, etc.

The mix household and part of the recyclables waste are generated in the houses. The commercial waste includes also some of the recyclables while bulky items are thrown by the people in the houses and the used material market in Qalqilia City especially for furniture parts.

The composition of MSW is the term that describes the distribution of each component of wastes by its percent weight or volume of the total. In a field study conducted in Qalqilia City landfill, the main constituents of MSW are organic wastes, plastic, paper, metal, glass, cardboard, inert, and others (Eid, 2007)

Table 4, figures 15 and 16 illustrate the MSW composition in Qalqilia City landfill.

Table (4): Average MSW composition in Qalqilia City landfill, (Eid, 2007)

Composition	Organic	Plastic	Paper	Metal	Glass	Cardboard	Inert	Others
% Weight	52	15	4	3	3	8	4	11
% Volume	27	35	10	2	2	13	2	9

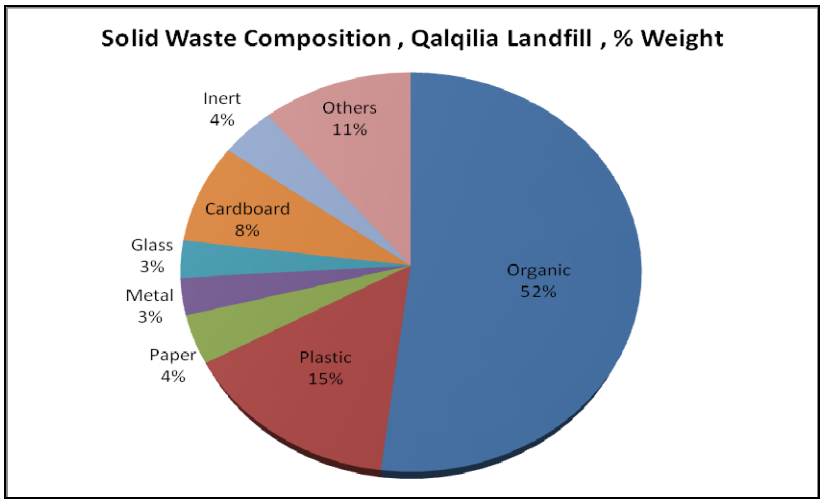

Figure (15): SW composition in Qalqilia landfill, % weight (Eid, 2007).

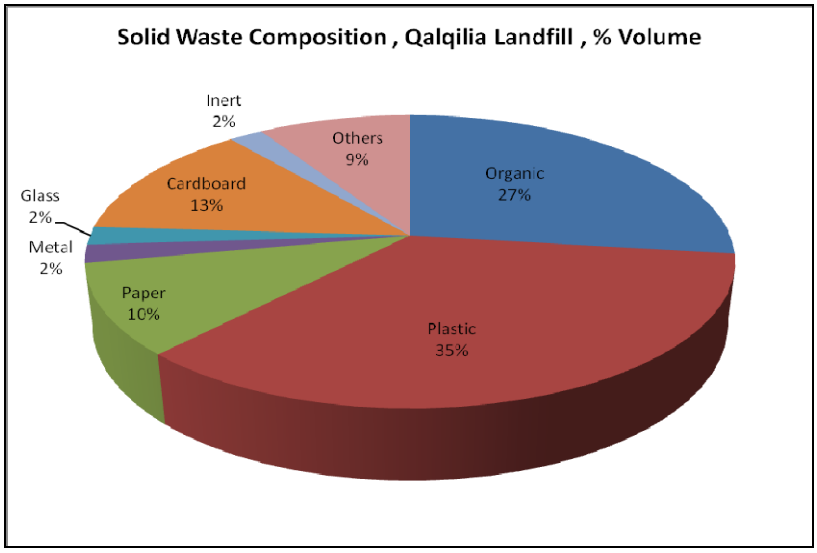

Figure (16): SW composition in Qalqilia landfill, % volume (Eid, 2007).

Solid waste generation during the next 30 years with a population growth rate of 2.6% and an increase in solid waste generation rate by 1% per year as it was assumed by DHV THE Netherlands – PHG Palestine, (2008) in their study "Environmental & social impact assessment report (ESIA) for Southern West Bank Solid Waste Management Project" is summarized in Table 5. Population in the year 2007 is based on the PCBS, Population, Housing and Establishment Census of 2007.

Table (5): Projected population and SW generation in Qalqilia City for the coming 30 years

Year	2007	2017	2027	2037
Qalqilia population	41,739	53,953	69,741	90,149
SW generation (ton)	49.39	70.52	100.70	143.78
SW generation / person (kg)	1.18	1.31	1.44	1.59

4.2.4 Medical solid waste in Qalqilia City

The medical solid waste in Qalqilia City includes waste from hospitals, clinics, medical centers, medical laboratories, dentists, optical centers, medical stores. According to a study conducted by HED in 2008, 0.93 ton of medical waste is collected during a period of 5 days. This means an average daily volume of 0.2 ton (HED, 2008).

The study also stated that no special treatment is available for the medical solid waste in the city which is estimated to be 79 ton per year after the construction of the New Hospital in the city.

4.2.5 Solid waste fee system in Qalqilia City

Solid waste fee system was modified in the year of 2008. The fees are collected yearly. The fee system includes different categories. As an example for the residential houses of less than 4 rooms the fees are 22 JD/Year. Table 6 shows the SW collection fees for selected categories in Qalqilia City (Accounting Department, Qalqilia Municipality, 2009).

Table (6): SW collection fee system in Qalqilia City (Qalqilia Municipality, 2009)

Item No.	Description	Fees (JD/Year)*
1	Residential < 4 Rooms	22
2	Hospitals and Health Centers	200
3	Clinics	60
4	Offices	50
5	University	150
6	School	100
7	Baby School	75
8	TV. Station	60
9	Commercial and industrial (Different categories)	From 40 to 250

***1 JD = 1.425 US $ (July 2009)**

Solid waste collection fees for the years of 2006, 2007 and 2008 are presented in Table 7.

Table (7): SW collection fees in Jordanian Dinar (JD), (Qalqilia Municipality 2009)

Item Description	2006 (JD)*	2007 (JD)	2008 (JD)
Household SW	85,010	85,908	165,413
Commercial SW	51,867	52,315	91,325
Total	**136,877**	**138,223**	**256,738**

***1 JD = 1.425 US $ (July 2009)**

Note that the big increase in SW collection fees in 2008 is due to the modification of SW collection fee system by the Municipal Council. This modification was made as the collected fees covers partially the SWM cost and the Municipality is obligated to cover the remaining cost from its budget.

In addition to the household and commercial fees the HED in Qalqilia Municipality collects fees for the removal of Construction waste, which is generated by the people while building their houses. The collected fees are determined on the site by the Department's supervisor according to the waste amount. As an example for the year 2008, about 4,725 $ were collected with an average of 394 $ /Month. For the year of 2009 the average collected construction waste fees for the first 8 months is 821 $/month (HED, 2009).

Chapter Five

Cost Analysis of Solid Waste Management

Chapter Five
Cost Analysis of Solid Waste Management

5.1 Introduction

Cost analysis is an important tool in decision making. The idea is to evaluate all the costs of a proposed policy or action, in order to determine the least cost option. The net benefits can also be determined by subtracting the total costs from the total benefits. The basic goal of this process is to determine which decision maximizes the possible benefits of a policy or action (Jackson and Strauss, 2007).

Conducting a cost analysis has many elements such as calculating the operating costs of all options. However, it also contains elements that are harder to quantify such as the environmental effects. These effects, which are not directly imposed on the operators, are considered external factors. External factors (that is, externalities) can either be negative or positive. When attempting to conduct a cost analysis externalities must be included, since someone in the community does eventually bear the external costs and benefits of them. The analysis also should consider the various external costs associated with each option. The negative externalities associated with landfills include environmental effects to the surrounding area. The environmental effects arise from the greenhouse gasses (such as methane) emitted from landfills when waste decomposes, the potential groundwater pollution through toxic seepage, and air pollution from the transportation of waste. The local externalities include decreased

property values in the areas surrounding landfills, increased traffic, and increased traffic accidents (Jackson and Strauss, 2007).

The required information to carry out cost analysis includes details on landfills and waste management, such as listing and quantifying the private and social costs of waste. Another important cost to consider is social cost of health risks caused by air and water pollution. Recycling costs and benefits, job creation and the resold of recyclables materials are also to be considered (Jackson and Strauss, 2007).

The development of an effective solid waste management system in Qalqilia City needs a benefit cost analysis study which is to be the road map for enhancing and improving the quality of MSW collection and disposal services and reducing the annual cost of SWM system.

5.2 Cost Estimate Consideration

For estimating the cost of MSW management system, the full cost accounting (FCA) procedure which is derived from the Municipal Solid Waste Management Full Cost Accounting Workbook for Local Governments in Florida 1997, is to be used. The FCA is a tool that helps to assess and report accurately and consistently the full costs of managing MSW. Because FCA offers a systematic approach for determining the full costs of MSW services, managers can identify accurately the cost of different MSW program options and contemplate adjustments to current

levels of service FCA data can be used to help establish rates and user fees that are sufficient to recover the full costs of the MSW services provided.

FCA is a systematic method of identifying, summing, and reporting the costs incurred in providing solid waste management services to communities. In addition to the obvious and direct costs of MSW management, FCA includes both "overhead" and "hidden" costs incurred to provide necessary support services for solid waste programs. Moreover, FCA considers the complete life cycle of MSW services from planning and administration (for example, permitting and construction of facilities) through proper closure and, if needed, long-term care of MSW facilities. In seeking to identify and include all direct and indirect costs associated with providing a particular service or program, FCA takes into account annual costs that are incurred during the operating life of a facility as a result of past and future outlays of funds. For example, the costs of capital assets may be depreciated over the expected useful life of those assets, while the future costs of closure and long-term care may be amortized evenly over the expected operating life of a MSW facility.

In implementing the FCA we focuse on all aspects of MSW management, identify all activities to be considered, clarify which costs are to be included, buildings, equipment, and properties used in MSW activities, identify human resources involved in the MSW management process, avoid double counting, include appropriate shares of indirect costs

for activities that support MSW management and provides detailed cost information in a simple, concise format (FCA, 1997).

The following activities, in general, are considered in estimating the total cost for solid waste management options:

1. SW collection activities
2. Transporting activities
3. Indirect operating cost
4. Landfill activities
5. Recycling activities
6. Transferring
7. Compost activities
8. Pre developed and construction
9. Closure and post closure

In addition to the above mentioned costs, the analysis also considered the various external costs associated with each option, such as groundwater pollution, transportation of waste and local property devaluation. Past studies have calculated various values for the external costs of landfills, these values are proposed to be used to calculate the external costs by using the most prevalent studies on landfills (Jackson and Strauss, 2007).

Three basic steps to calculate accurately the full cost of MSW services and programs are summarized in the following:

1. Identify all direct costs associated with providing MSW services
2. Identify all indirect costs associated with providing MSW services
3. Using financial records, and assign directly or allocate the costs of MSW management (identified in Steps 1 and 2 above) to the various solid waste programs (for example, collection, recycling, and disposal program areas).

The calculations include estimates for the items listed in the following sections.

5.2.1 Wages and benefits

Wages and related benefits include the following:

- Total annual wages
- Total annual benefits (insurance, holydays). Noting that these benefits are considered additional cost for the Municipality budget.
- Total annual post employment benefits

5.2.2 General operation, maintenance and insurance

Includes the costs of general operation and maintenance (O&M) for MSWM operations, such as vehicles maintenance, insurance and licensing.

5.2.3 Depreciation of capital outlays

A “capital outlay” is an outlay of cash made to acquire a resource that will be used in MSW operations for more than one year.

The established accounting technique of “depreciation” can be used to convert capital outlays into annual costs. Depreciation is a method of allocating the costs of capital outlays over the useful life of the resource, which is the period of time during which the resource is expected to provide services adequately and efficiently. A simple “straight-line” method of depreciation calculates depreciation costs by dividing the capital outlay minus any anticipated salvage value, by the useful life of the resource acquired (FCA, 1997).

For example, a collection truck that costs $160,000 with an anticipated salvage value of $10,000 and a useful life of 10 years would have an annual depreciation cost of one-tenth of its total adjusted capital cost, or $15,000 (($160,000 - $10,000) ÷10) = $15,000.

Under FCA, up-front costs can be depreciated evenly, on a straight-line basis, over the expected operating life of the facility, no matter how far in advance of actual operation of the facility they are incurred. For example, if total costs of predevelopment and construction of a landfill are $10 million, and the landfill is expected to last 20 years, the annual depreciation cost for that landfill would be one-twentieth of the total up-front cost, or $500,000 (FCA, 1997).

Buildings, vehicles, equipment, and other capital goods should be depreciated over their remaining useful lives.

However, land acquired for use as a landfill has a finite useful life (capacity) and therefore should be depreciated. The cost of depreciation for all capital outlays should be recognized annually until they are fully depreciated. No depreciation expense, however, should be recorded for assets that have remained in service after their estimated useful life has ended.

5.2.4 Amortization of future outlays

A "future outlay" is an expenditure of cash in the future that is obligated by current or prior activities. For example, the obligation to perform closure and long-term care is triggered when landfill operations begin. In addition, post employment employee benefits, such as payments for health care or retirement can be considered as a future outlay. One method of calculating the annual cost of amortization for a future outlay is expressed in the following equation:

(Current estimated cost of future outlay - amounts previously amortized)/(expected number of years until funds will be required), (FCA, 1997).

5.2.5 Indirect costs

Indirect costs represent the costs of essential services provided to the MSW program by other departments of the Municipality, as well as costs

incurred by other departments for general administration and executive oversight.

The method of allocating indirect costs requires that the Municipality first calculate the ratio of its MSW employees to its total employees. Second, the Municipality has to list the total budgets for each individual, group, or department that provides support services to the MSW program. The total budget for each individual, group, or department is then multiplied by the ratio of MSW employees to total employees. By following this methodology, the Municipality can estimate the total amount of indirect costs incurred by each individual, group, or department to provide support services to the MSW program. Subsequent allocations of indirect costs can be derived by calculating the percentage of MSW employees who are associated with each solid waste program area (FCA, 1997).

5.2.6 Benefits

It is important to consider all the proposed benefits associated with each MSWM option. Air and groundwater protection, reducing transportation of waste, reducing the local property devaluation, reducing health risks caused by air and water pollution, recycling benefits, job creation, resold of compost and recyclables materials, all of these benefits are to be measured and compared for each MSWM option.

5.2.7 Estimating the external costs of landfill

The various external costs associated with landfill operations are to be considered in the estimations. Some of the most widely recognized and largest external costs associated with landfills are air and groundwater pollution, transportation of waste, local property devaluation.

An important document in this field is the policy brief Getting Waste Management Prices Right, by the Resource Recovery and Recycling Authority of Southwest Oakland County. The salient information from this paper for this analysis is the summary it provides of estimates for various external costs associated with landfill operations. The marginal cost of greenhouse gas pollution is $3.27 per ton for landfills without energy recovery and $2.22 per ton for landfills with energy recovery. The odor, visibility, and general appearance cost is between $3.05 and $4.39 per ton, the costs of waste transportation to landfills (congestion, air pollution, and the increased probability of road accidents is $0.51 per ton for urban landfills and $1.69 per ton for rural landfills. (Policy Brief: Getting Waste Management Prices Right, Resource Recovery and Recycling Authority of Southwest Oakland County. January 2007).

Another relevant issue is scarcity rent, which is a function of the variable costs of operating plus a component of the cost of opening a new landfill and closing the previous one. In this way, the price of landfill disposal increases as the resource becomes increasingly scarce. The amount of scarcity rent added to the variable cost of operating the landfill will be

very low when the resource – that is, the landfill – is plentiful, but increasingly becomes a factor as the resource is reaches exhaustion (Jackson and Strauss, 2007).

In the absence of a related studies for finding the value of scarcity rent for the existing landfill in Qalqilia City it is very difficult to include this value in our estimations, noting that it is important to consider this issue in our solid waste management in the city.

5.3 Cost of SWM activities for Qalqilia City

In evaluating the cost of MSWM options for Qalqilia City, SW collection and disposal options are defined and the cost of these activities is evaluated.

5.3.1 SW collection and transporting activities

In this section, the costs of collecting and transporting MSW for Qalqilia City are estimated. In collecting and transporting the MSW for Qalqilia City, the following items were considered:

1. Labor wages (including the wages of the street cleaning groups)
2. O&M cost of SW collecting trucks (including fuel cost)
3. Collecting and transporting vehicles drivers wages
4. Operating cost

Table 8 summarizes the total annual cost of the SW collecting and transporting labors, employees, and drivers.

Table (8): SW collecting and transporting employees numbers and total annual cost (US $) (HED and Accounting Department of Qalqilia Municipality 2009)

	Item	Number of employees	Total annual cost ($)
1	Collecting vehicles drivers	11	59,859
2	SW collectors (compacting trucks staff)	9	42,750
3	Street cleaners, forman, supervisors	63	242,460
	Total	**83**	**345,069**

Table 9 summarizes the operating and maintenance cost (O&M) for MSW vehicles in addition to the cost of insurance and the related cost of Mechanical Department for MSW service for Qalqilia City. Note that the estimation is based on the share of MSWM from Mechanical Department works in the Municipality.

Table (9): O&M cost of SW collecting and transporting trucks, including fuel consumption, insurance cost and Mechanical Dep. works cost for MSW (Total annual US $)

	Item	Total annual cost ($)
1	Collecting and transporting vehicles O&M cost	22,586
2	Collecting and transporting vehicles fuel cost	136,324
3	Collecting and transporting vehicles insurance cost	11,293
4	Mechanical department employees wages according to MSW sector share of their works(1)	40,752
5	Mechanical workshop employees wages according to MSW sector share of their works(2)	11,022
	Total	**221,977**

(1): According to the Mechanical Department maintenance works share for MSW vehicles which is about 93% from the employees daily works and 31% of the head of the department daily work.

(2): Workshop works for SW vehicles and collection tanks, daily 4 hours which is 104 hours of the 156 working hours in the month which is about 67% from the employees daily works and 22% of the head of the department daily works.

HED is managing the collection and transporting of MSW in Qalqilia city. The cost items of the management of MSW include payments for water, electricity, paper, printing and supplies by the HED are summarized in Table 10.

Table (10): The cost of the management of MSW by the HED

	Item	Total annual cost ($)
1	Head of the department and employees wages	21,493
2	Communication cost	1,827
3	Water, electricity, paper, printing and supplies	810
	Total	**24,130**

5.3.2 Indirect operating costs

Indirect costs represent the costs of essential services provided to the MSW program by other departments of the Municipality, as well as costs incurred by other departments for general administration and executive oversight. These departments are the Administration Department including the Mayor office and the Municipality Council, the Accounting Department, Municipality warehouse and Computer Programming Unit.

According to HED, its workers and employees are 20% of the Municipality employees. According to RTSU of Qalqilia Municipality the

MSWM consumes 6% of the Mayor Office efforts. The full calculations and percentages are detailed in the annex.

The method of allocating indirect costs is based on the ratio of MSW employees to the total employees and multiplying the total budgets for each individual, group, or department that provides supporting services to the MSW program by this ratio. Table 11 summarizes the indirect operating costs of MSWM in Qaqlia Municipality.

Table (11): Summary of the indirect operating costs of MSWM for Qaqlia Municipality, (Accounting Department 2009)

	Item	Total annual cost ($)
1	Administration Department including Mayor office and Municipality Council	8,583
2	Accounting Department expenses	8,056
	Total	**16,639**

Note: for the detailed estimations see the appendix.

5.3.3 Cost of landfill activities

Qalqilia City suffers from the absence of a sanitary landfill. The existing landfill was constructed without any environmental consideration. Qalqilia Municipality is the owner of the site. The MSW collectors collect the MSW daily from the city and send it to the existing landfill. At the landfill, a special excavator spreads the SW and covers it with soil and construction waste. Qalqilia Municipality is responsible for guarding the site; two employees are working for this purpose one in the morning and one in the evening given that no fencing is available around the site (HED, 2009). Table 12 summarizes the different cost items of landfill activities.

Table (12): Cost of landfill activities

	Item	Total annual cost ($)
1	Earth works (backfilling of MSW with soil)	18,000
2	Site guarding	8,400
3	Land renting	3,000
4	Roads and general maintenance	2,700
	Total	**32,100**

5.3.4 Depreciation of capital outlays

Depreciation is the method of allocating the costs of capital outlays over the useful life of the resource, which is the period of time during which the resource is expected to provide services. The HED uses many vehicles and equipments which are used in MSW collection and disposal. These equipments and vehicles include the compactors, tanks, pins, collecting tools, excavator, truck, computers, furniture, containers and service cars. Table 13 summarizes the depreciation annual values.

Table (13): Depreciation annual values for MSW vehicles, equipments and tools

	Item	Total annual cost ($)
1	SW equipments and tools, SW collection bins, shovel, wheel barrow and brooms	10,490
2	Compactors, trucks, containers, Bager, Tractor with container, service car	126,589
3	Computers and furniture	256
	Total	**137,335**

Note: The details of depreciation calculations are given in the appendix

5.3.5 MSWM Benefits

Direct economic benefits from the solid waste management program (SWMP) consisted of revenues from non-fee and fee-based sources and the value of avoided landfill costs due to solid waste diversion. The revenues encompassed the earnings of the Municipality and the earnings of other parties including waste pickers (for example, from selling recyclables). Avoided landfill costs are estimated by multiplying the overall amount of waste diverted by the cost of the operation and maintenance of landfill per unit of waste (DHV Netherlands and PHG Palestine, 2008)

The benefits of SWMP in Qalqilia City includes annual fees collected by the Municipality in addition to the construction waste fees that collected in the site by the HED supervisors according to the waste amount. According to the Accounting Department in Qaqilia Municipality the total SW fees is 378,134 US $ in the year 2009. Noting that not all the fees are collected since not all the people in the city pay the fees. The municipality is obligated to cover the cost of SWMP from its budget (HED, 2009).

In Qalqilia City there is no recycling program. Recycling activities are carried out by waste pickers at small scales. They pick metals and sell it to local contractors it is worth to make an investigation or a study to quantify the volume of recycling operation in the city. (HED, 2009).

5.3.6 Transferring MSW cost

One of the options for the disposal of MSW in Qalqilia City is constructing a transfer station and transport MSW to Zahrat Al-Finjan Sanitary Landfill in Jenin District. When the solid waste disposal unit is remote from the collection area, a transfer station is to be built and used. In the transfer station, waste is collected from smaller collection vehicles to larger transfer vehicles such as trailers and tractors. Transfer stations can be quite simple or they can be complex facilities. The design of the facility is based on its intended use. The proposed cost of transferring the MSW includes:

1. The cost of constructing a transfer station (note that the total cost is depreciated over 20 years period assuming 20 years useful life)
2. The cost of the land of the transfer station
3. The cost of the operation and maintenance of the transfer station
4. The cost of transporting the MSW to Zahrat Al-Finjan Sanitary Landfill
5. The fees of Zahrat Al-Finjan Sanitary Landfill

The estimated cost of transferring the MSW to Zahrat Al-Finjan Sanitary Landfill is detailed in Tables 14 and 15, respectively. From the estimates it is found that the total annual cost of transferring the MSW is 326,505 US $. Noting that the depreciation period of the transfer station is

20 years, MSW generation is 50 ton/ day and Zahrat Al-Finjan Sanitary Landfill fee is 8.75 US$ / ton and the cost of transporting the MSW to ZFSL is 6.25 US$/ton.

Table (14): Transfer station construction cost

	Item	Total annual cost ($)
1	Contracting, excavation, and construction works (assuming 20 years service period)	529
2	Construction material cost (steel & concrete)	1,960
3	Land renting	625
4	External works (gate & site panel assuming 5 years service period)	198
5	Electrical works (assuming 5 years service period)	750
	Total	**4,062**

Table (15): Transfer station operation and maintenance cost in addition to transferring MSW to Zahrat Al-Finjan Sanitary Landfill in Jenin District

	Item	Total Annual Cost ($)
1	Site guarding (2 workers per day)	8,400
2	Site Staff (includes site manager and site worker)	10,200
4	Site services (electricity, water, communications and other)	1,500
5	Site general maintenance	1,500
6	Transferring MSW to Zahrat Al-Finjan Sanitary Landfill and landfill fees (assuming 50 ton/day MSW generation and 8.75$ / ton transferring and fees cost	270,000
7	The external costs of waste transportation to Zahrat Al-Finjan Sanitary Landfill (congestion, air pollution, and the increased probability of road accidents) is $1.69 per ton for rural landfills	30,843
	Total	**322,443**

The transfer station will employ a few staff members to manage and operate the station and to manage and operate the hauling trucks. Without a

waste separation line, the station will have about 4 staff members and therefore the investment has a positive impact on employment.

5.3.7 Costs of recycling activities in Qalqilia Municipality

Solid waste management program in Qalqilia Municipality does not include recycling activities. The generated MSW is collected and sent to the existing landfill to be disposed of without any processing other than compaction, spreading and covering by soil.

Some of the scavengers inter the existing landfill and collect part of the useful things, but the real value of these activities can be ignored. Cost and benefits of these activities are to be ignored until a proper recycling program is developed and adopted in the municipality. This option is to be discussed in the next chapter.

5.3.8 Closure and post closure cost for the existing SW landfill in Qalqilia City

When the existing solid waste landfill in Qalqilia City reaches its capacity, it is important to perform closure and post closure program to prevent the infiltration of rainwater into the waste body which will lead to the formation of leachate and may pollute the groundwater aquifers, as well as to avoid the spread of waste to the surrounding area. The final waste body has to be covered by a surface sealing system. This will comprise the following:

1. A “compensation layer”, comprising 50 cm of sandy – silty material, between the body of waste and the sealing layer. This is necessary as a foundation for the sealing layer, protecting it from the rough structured waste body, and as a space within which landfill gas can accumulate and be extracted (DHV Netherlands and PHG Palestine, 2008).

2. A “sealing layer”, which forms an impermeable barrier, that keeps landfill gas inside and rainwater out of the body of waste. A bentonite mat is usually used for the surface sealing layer, as appropriate clay is probably not available and asphalt has insufficient resistance against settlement of the waste body, Textured HDPE geo-membrane can be an alternative. Geo-textiles will be used as protection and drainage as required by the design (DHV Netherlands and PHG Palestine, 2008).

3. A “drainage layer”, above the sealing layer through which rainwater falling on to the surface of the landfill can flow off, into the surface drainage channels. The drainage layer will be made out of gravel material with a selected grain size and permeability (DHV Netherlands and PHG Palestine, 2008).

4. A “re cultivation layer” on which vegetation is grown to cover the structure and integrate it back into the natural surrounding environment.

About 22 thousands square meter is required to be covered and sealed in the existing municipal solid waste landfill. According to the HED of Qalqilia Municipality, the existing landfill is expected to reach its

capacity within two years so, the required closure and post closure cost is to be prepared within two years.

The cost of closure and post closure of the existing SW landfill in Qalqilia City is summarized in Table 16 noting that this cost is amortized by two years.

Table (16): Cost of closure and post closure of the existing SW landfill in Qalqilia City (DHV THE Netherlands – PHG Palestine, 2008)

	Item	Total Annual Cost ($)
1	Supplying and installing by welding Textured HDPE geo-membrane (1.5 mm) to cover 22 thousands meter squire.	165,000
2	Backfilling works under and over the HDPE layer	66,000
3	Monitoring and testing works for the nearby water wells and other testing (proposed to be performed for 5 years)	5,000
	Total	**236,000**

5.3.9 Local property devaluation

Due to the presence of the existing SW landfill, the surrounding agricultural lands lost part of its selling value. According to Qalqilia Municipality the affected areas are estimated to be about 98,000 m^2. This area is affected directly but the area that is affected indirectly is more than that. Also it is important to know that the devaluation of the local property in the landfill surrounding areas is to be more and more as the selling value of the lands in Qalqilia city becoming higher and higher due to the limited available lands in the city. If the owners of the surrounding lands are to be compensated the compensation amounts is proposed to be the yearly benefit of the land's value. Noting that the value of the land surrounding

the existing landfill is 30 $/m^2$, the proposed compensation is to be (98,000*30*0.05= 147,000 $)

5.3.10 Estimating the external costs

The various external costs associated with the existing landfill operations in Qalqilia City are to be considered in the estimations. Some of the most widely recognized and largest external costs associated with landfills are air and groundwater pollution, transportation of waste, local property devaluation, odor and visibility. The literature values are to be used for the estimations. Table 17 summarizes the externalities cost.

Table (17): The various external costs associated with the existing landfill operations

	Item	Total Annual Cost ($)
1	The marginal cost of air pollution (that is, greenhouse gas emissions) is $3.27 per ton for landfills without energy recovery.(average daily MSW generation is 50 tons)	59,678
2	The range of cost estimates for landfill externalities is $3.05 to $4.39 per ton, the average of which ($3.72) is used.	67,890
3	The costs of waste transportation to landfills (congestion, air pollution, and the increased probability of road accidents) is $0.51 per ton for urban landfills	9,308
	Total	**136,876**

Source of externalities cost: Resource Recovery and Recycling Authority of Southwest Oakland County., (2007) Policy Brief: Getting Waste Management Prices Right.

Chapter Six

MSWM Options for Qalqilia City

Chapter Six
MSWM Options for Qalqilia City

6.1 Introduction

After estimating the different cost consideration for municipal solid waste management for Qalqilia Municipality, this chapter is to discuss and evaluate the cost of the different solid waste management options in the city.

After the discussion and evaluation of SWM options recommendation and conclusions are to be derived.

6.2 Cost analysis for MSW management options in Qalqilia City

The potential MSW management options for Qalqilia City which are to be discussed and evaluated are:

1. Maintaining the existing situations (The do-nothing option). In this situation, the Municipality collects the municipal and construction solid wastes, then all of the collected waste is sent to the existing landfill to be disposed there.

2. Constructing a transfer station and transport the MSW to Zahrit Al-Finjan Sanitary Landfill in Jenin District which is the only sanitary landfill in the north of the West Bank.

3. Constructing a sanitary landfill for Qalqilia City operated by the Municipality.

4. Making partial recycling to separate recyclable materials and partial compost generation then transfer the remaining part of the solid waste to Zahrat Al-Finjan Sanitary Landfill.

In this study options 1,2 and 4 will be discussed in detailed while option 3 is conflicting with EQA policy to confirm 3 main sanitary landfills in West Bank where ZASL is for North of West Bank, in addition to the highest capital cost and the lack of the required land in Qalqilia City.

6.2.1 Option 1: Maintaining the existing situations (The do-nothing option)

This option includes the cost of collecting and transporting MSW, the operating and maintenance cost of the collecting and transporting trucks, management cost, indirect operating cost, the landfill activities cost, the depreciation of capital outlays, the closure and post closure cost and the local property devaluation. These costs are summarized in Table 18.

Table (18): Maintaining the existing situation "the do nothing option" cost

	Item	Total annual cost ($)
1	The cost of collecting and transporting MSW	345,069
2	The operating and maintenance cost of the collecting and transporting trucks	221,977
3	Management of MSW by the HED cost	24,130
4	The indirect operating cost	16,639
5	The landfill activities cost	32,100
6	The depreciation of capital outlays	137,335
7	The closure and post closure cost (for the coming two years)	236,000
8	The local property devaluation	147,000
9	Various external environmental costs associated with the existing landfill operations	136,875
	Total cost ($)	**1,297,125**

From the Table and as the average MSW generation in Qalqilia City is 50 tons per day, the cost per ton is (**1,297,125**/(365*50)= 71.1$). If we ignore the local property devaluation value, the environmental externalities, and the closure and post closure cost, the average cost of MSW per ton is to be (777,125/ (365*50) = 42.6$).

This option has the least job opportunities creation, high groundwater pollution vulnerability, high air pollution vulnerability, no recycling or limited recycling and compost selling benefits, the highest local property devaluation, and the high probability of causing injuries and health risks. Figure 17 shows the agricultural lands close to the existing landfill in addition to the waste pickers in the site.

Figure (17): The agricultural lands near the existing landfill and waste pickers in the site

6.2.2 Option 2: Constructing a transfer station and transport the MSW to Zahrat Al-Finjan Sanitary Landfill in Jenin District

This option implies the cost of collecting and transporting MSW, the operating and maintenance cost of the collecting and transporting trucks to the transfer station site, cost of the management of MSW by the HED,

indirect operating cost, the depreciation of capital outlays, the cost of the construction of transfer station, the operation and maintenance cost of the transfer station and the cost of transferring the MSW to Zahrat Al-Finjan Sanitary Landfill. The cost values are summarized in Table 19.

Table (19): The different cost estimates of constructing a transfer station and transferring the MSW option

	Item	Total annual cost ($)
1	The cost of collecting and transporting the MSW	345,069
2	The operating and maintenance cost of the collecting and transporting trucks	221,977
3	Management of MSW by the HED cost	24,130
4	The indirect operating cost	16,639
5	The depreciation of capital outlays	137,335
6	Construction of transfer station cost	4,062
7	Operating and maintenance of transfer station	21,600
8	Transferring the MSW to Zahrat Al Finjan Sanitary Landfill and landfill fees	270,000
9	The external costs of waste transportation to Zahrat Al-Finjan Sanitary Landfill (congestion, air pollution, and the increased probability of road accidents) is $1.69 per ton for rural landfills	30,843
	Total	**1,071,654**

From the table and as the average MSW generation in Qalqilia city is 50 tons per day, the cost per ton is (**1,071,654**/(365*50)= 58.7$). If we ignore the environmental externalities cost the cost per ton is proposed to be 57$.

Note that in this option the closure and post closure cost is not required, and the presence of the Transfer Station (TS) in the area does not cause local property devaluation. In addition to that this option has more job opportunities creation than the first option, low possibility of

groundwater pollution, less air pollution, no recycling or limited recycling and compost selling benefits, increase travel distance which increase the fuel consumption and increase the vehicle emissions.

6.2.3 Option 3: Construction of a sanitary landfill for Qalqilia City

The construction of a sanitary landfill for Qalqilia City has many constraints. The political situation which prevents Qalqilia Municipality from taking the required licensing, the required suitable land is not available specially after the construction of the Separation Wall, the high construction and operating cost of the sanitary landfill in addition to the recommendation of the Environmental Quality Authority (EQA) in the West Bank to make Zahrat Al-Finjan Sanitary Landfill the central landfill in the northern part of the West Bank. As an example, the construction cost of Zahrat Al-Finjan Sanitary Landfill is $ 14 million.

6.2.4 Option 4: Making partial recycling for recyclable materials and compost and transport the remaining SW to Zahrat Al-Finjan Sanitary Landfill

This option includes the preparation of a special unit for recycling program. The benefit of this option is the reducing of the amount of MSW that is to be disposed in the landfill or transferred to the sanitary landfill in addition to the benefits from selling the recyclable material and compost.

Partial separation, mechanical or manual separation is to be performed. The organic compounds in the MSW is 52%, plastic 15%,

paper 4%, Metals 3%, Glass 3% and cardboard 8% (Eid, 2007) If we could separate the organic compounds for compost and selling the recyclable material, then this will reduce the MSW management cost. As an example Figure 18 shows the recycling of plastic at Zahrat Al-Finjan Sanitary Landfill. The resulted shredded plastic material is then sold to the plastic factories to be recycled to new products.

Assume that 50% of the plastic, metal, cardboard and organic compounds to be recycled and separated, and transfer the remaining amount of MSW to Zahrat Al-Finjan Sanitary Landfill. This is supposed to reduce the transferred MSW by 39%. The cost estimates of this option are summarized in Table 20.

Table (20): Partial recycling for recyclable material and compost cost

	Item	Total annual cost ($)
1	The cost of collecting and transporting MSW	345,069
2	The operating and maintenance cost of the collecting and transporting trucks	221,977
3	Management of MSW by the HED cost	24,130
4	The indirect operating cost	16,639
5	The depreciation of capital outlays	137,335
6	Construction of transfer station cost	4,062
7	Operating and maintenance of transfer station	21,600
8	Transferring the MSW to Zahrat Al Finjan Sanitary landfill	164,700
9	The external costs of waste transportation to Zahrat Al-Finjan Sanitary landfill (congestion, air pollution, and the increased probability of road accidents) is $1.69 per ton for rural landfills	18,814
	Total	**954,326**

Figure (18): Plastic recycling in Zahrat Al-Finjan Sanitary Landfill

Note that if we can separate all the generated MSW in Qalqilia City and assuming that 100% of the organic compounds are used in the composting process, 100% of plastic, metal, cardboard compounds recycling and assuming that the recycling and compost program covers its cost with no revenues, then this will reduce the transferred SW by 78%, which means that the cost of this option will be reduced to 836,997 $.

From Table 20 and as the average MSW generation in Qalqilia City is 50 tons per day the cost per ton is (954,326/(365*50)= 52.3$) and if the full separation is considered, then this cost will become (836,997/(365*50) = 45.9$).

In this option the closure and post closure cost is not required, and the presence of the TS in the area does not cause local property devaluation. In addition to that, this option has most job opportunities creation than the other options as many of these opportunities is to be available for recycling and compost programs. No groundwater pollution is

expected with less air pollution. This option has greater recycling and compost selling benefits since it reduces the amount of SW to be transferred and the travel distance will be reduced. This will reduce vehicle emissions and fuel consumption.

6.3 Results and discussion

After the evaluation of MSW options for Qalqilia City, it is noted that the first option which is maintaining the existing situations (the do-nothing option), has the highest cost which is 71.1$/ton, in addition to the environmental impacts on the groundwater and air pollution. If we ignore the local property devaluation, closure and post closure cost and the environmental externalities the cost is 42.6$/ton.

This option also causes the most effect on the local property devaluation. In the absence of the enough areas for agricultural and housing purposes, this option is considered detrimental economically and environmentally.

The second option which implies the construction of a transfer station and transport the MSW to Zahrat Al-Finjan Sanitary Landfill in Jenin District seems to be more economical than the first option. The cost of MSWM is 58.7$/ton in this option. Environmentally this option seems to be more friendly to the environment as the vulnerability of the groundwater and air pollution is less than that of the first option. For the job creation and local property devaluation this option is more reliable but this option increases the travel distance of the vehicles and fuel consumption.

The third option which implies the construction of a sanitary solid waste landfill in Qalqilia City is not possible for the city due to the limited available lands, the complicated political situation and the high construction and operation cost. As an example, according to Zahrat Al-Finjan Sanitary Landfill manager it was very important for them to receive the generated MSW from the northern governorates Nablus, Tulkarm, Qalqilia in addition to Jenin District to cover the operation and maintenance cost of the landfill. In addition to that, the EQA has the attitude to promote the construction of three sanitary landfills in the West Bank, one in the north which is Zahrat Al-Finjan Sanitary Landfill, the other one is in Ramallah district and third is for the southern governorates in Bethlahm District.

The fourth option which is performing partial recycling for recyclables material and compost and transferring the remaining solid waste to Zahrat Al-Finjan Sanitary Landfill in Jenin District seems to be the most economical and environmental friendly from the other options. The cost of MSWM can range from 45.9$/ton to 52.3$/ton. This cost is according to the amount of municipal solid waste to be separated and recycled. This option provides more jobs and reduces the vulnerability of groundwater and air pollution. This option has also a positive impact as it reduces the travel distance and fuel consumption by reducing the amount of MSW to be land filled.

A comparison was made and summarized in Table 21 between municipal solid waste management options for Qalqilia City. The individual average daily MSW generation is 1.15 kg/d, the average household according to PCPS 5.5 person/house that mean the family in the city generated (365*1.15*5.5/1000 = 2.3 ton/y. the cost of associated of each family solid waste generation per year summarized in Table 21 based on each option.

Table (21): SW management options for Qalqilia City cost summary

MSW management option	Cost $/ton	Cost / year for each family $
Maintaining the existing situations "do nothing option"	71.1	163.5
Constructing a transfer station transport MSW	58.7	135
Partial recycling for recyclables and compost	From 45.9 to 52.3	105.6 to 120.3

Chapter Seven

Conclusions and Recommendations

Chapter Seven
Conclusions and Recommendations

7.1 Conclusions

The following are the key conclusions:

1. Four options of MSW disposal systems were discussed for Qalqilia City and these are:

   a. Maintaining the existing situation (The do-nothing option). In this option, the Municipality collects the municipal and construction solid wastes and all the collected waste is sent to the existing landfill to be disposed of there.

   b. Constructing a transfer station and transport the MSW to Zahrat Al-Finjan Sanitary Landfill in Jenin District which is the only sanitary landfill in the north of the West Bank.

   c. Constructing a sanitary landfill for Qalqilia City operated by the Municipality.

   d. Making partial recycling to separate the recyclable materials and partial compost generation and then transfer the remaining part of the solid waste to Zahrat Al-Finjan Sanitary Landfill.

2. Solid waste disposal options for Qalqilia City were evaluated based on cost analysis and it was found that three of the four options are the most suitable disposal options and these are options 1, 2, and 4.

3. The first option which is maintaining the existing situations (The do-nothing option), has the largest cost which is 71.1$/ton, in addition to the environmental impacts on the groundwater and air pollution. This option also causes the most effect on the local property devaluation. In the absence of the enough areas for agricultural and housing purposes this option is considered detrimental economically and environmentally. If we ignore the local property devaluation, the environmental externalities and the cost of closure and post closure of the existing landfill the cost drops to 42.6 $/ton.

4. The second option; constructing a transfer station and transport the MSW to Zahrat Al-Finjan Sanitary Landfill, seems to be more economic than the first option where the cost of MSWM is 58.7 $/ton in this option. Environmentally this option seems to be friendlier to the environment as the vulnerability of the groundwater and air pollution is less than that of the first option. For the job creation, and local property devaluation this option is more reliable but this option increase the travel distance of the vehicles and fuel consumption. If we ignore the cost of environmental externalities the cost is to be 57 $/ton.

5. Making partial recycling for recyclables material and compost and transferring the remaining solid waste to Zahrat Al-Finjan Sanitary Landfill seems to be the most economical and environmental friendly from the other options. The cost of MSWM can be from 45.9$/ton to 52.3$/ton. This cost is according to the amount of municipal solid

waste to be separated and recycled. This option provides more jobs and reduces the vulnerability of ground water and air pollution. This option reduces the travel distance and fuel consumption by reducing the amount of MSW to be transported and land filled.

7.2 Recommendations

1. Qalqilia Municipality is encouraged to have a specific project for the proper closure and post closure of the existing solid waste landfill. This project will eliminate the local property devaluation at the landfill area and protect the groundwater. About 22 thousands meter square of land is to be available for the municipality to be used for other purposes after the proper closure of the existing solid waste landfill.

2. It is recommended that Qalqilia Municipality starts to have pilot programs for solid waste separation and recycling in addition to the generation of compost especially that the city is located in an agricultural area. This will reduce the cost of solid waste management by reducing the amount of land filled waste and improves the environmental conditions in the city.

3. Qalqilia Municipality is encouraged to study SWM options carefully, choosing the most economical and environmental option which will decrease annual expenses for SWMS and provide additional funds to construct vital projects in the City.

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Appendices

Appendix (1): MSWM cost /Benefit Spread Sheet

Benefit Cost Analysis of Solid Waste Management for the City of Qalqilia			
Date / year	**2008 / 2009**		
Estimated SW (Ton) / Day	**50**		
Cost Consideration:		**Per / Month**	**Per / Year**
Adminstration Cost (US $) "Adminstration Dep."		**715**	**8,583**
Accounting Cost (NIS) "Accounting Dep."		**671**	**8,056**
Adminstration Cost ($) HED.		**1,791**	**21,493**
Solid Waste Employees Wages ($) " Health And Environmental Dep."		**28,756**	**345,069**
Fuel Consumption for SW Collection Vehicles		**11,360**	**136,324**
Average Maintenance Cost ($)		**6,197**	**74,360**
Vehicles Insurance Cost ($)		**941**	**11,293**
Equipment Depreciation $)		**11,445**	**137,335**
Landfill Cost ($)		**2,419**	**32,100**
Closure and Post Closure Cost		**19,667**	**236,000**
Comunication, Water, Printing, Electricity ($)		**220**	**2,637**
Environmental external cost		**11,406**	**136,875**
Total Cost ($)		**95,588**	**1,150,125**
MSW Incom (Fees) ($)		**31,023**	**372,270**
Building Waste Fees ($)		**553**	**6,640**
Average Cost ($) / Ton		**63.02**	
Solid Waste Incom (Fees) / Ton		**20.76**	
Qalqilia Paying / Ton of MSW from Municipaliuty Budjet		**42.26**	**771,215**
Qalqilia Paying / Ton of SW from Municipaliuty Budjet (Ignoring Closure Cost)		**29.33**	**535,215**

MSW Management Options for Qalqilia City:		
Option One: " Do nothingg option" or the existing situation		**Total Annual Cost ($)**
Cost of collecting and transporting MSW		**345069**
Operating and maintenance cost of collecting trucks including fuel and insurance cost		**221977**
Cost of management of MSW by the HED		**24130**
Indirect operating cost		**16639**
The landfill activities cost		**32100**
Depreciation of capital outlays		**137335**
Closure and post closure cost		**236,000**
Environmental external costs		**136,875**
The local property devaluation		**147,000**
Average cost per year		**1297125**
Average cost per ton of MSW		**71.1**
Munisipal Solid waste income per year (Fees)		**378910**
SWT income per ton	**20.8**	**20.8**
Qalqilia Paying / Ton of MSW from Municipaliuty Budjet	**50.3**	**50.3**
Qalqilia Paying / Ton of MSW from Municipaliuty Budjet (ignoring closure cost and local property devaluation and environmental external costs)	**21.8**	**21.8**
Qalqilia Paying for MSWM from its Budjet	**918,215**	
Qalqilia Paying for MSWM from its Budjet excluding environmental effects, and closure cost	**398,340**	

MSW Management Options for Qalqilia City:		
Option Two: Constructing atransfer station and transporting MSW to Zahrat Al Finjan sanitary landfill		**Total Annual Cost ($)**
Cost of collecting and transporting MSW		**345069**
Operating and maintenance cost of collecting trucks including fuel and insurance cost		**221977**
Cost of management of MSW by the HED		**24130**
Indirect operating cost		**16639**
Depreciation of capital outlays		**137335**
Construction a transfer station cost (dpreciated per 20 years)		**4062**
Operating and maintenance of transfer station		**21,600**
Environmental cost of transporting SW (external cost)		**30,843**
Transporting MSW to Zahrat Al Finjan Landfill		**270,000**
Average cost per year		**1071654**
Average cost per ton of MSW		**58.7**
Munisipal Solid waste income per year (Fees)		**378910**
MSW benefits from closing the existing landfill (environmental external effects)		**127568**
SWT income per ton	**27.8**	**27.8**
Qalqilia Paying / Ton of MSW from Municipaliuty Budjet	**31.0**	**31.0**
Qalqilia Paying for MSWM from its Budjet	**565,177**	
Qalqilia Paying for MSWM from its Budjet excluding environmental effects of transporting MSW	**29.3**	

MSW Management Options for Qalqilia City:		
Option Four: Making partial recycling, compost and transporting the remaining SW to Zahrat Al Finjan sanitary landfill		**Total Annual Cost ($)**
Cost of collecting and transporting MSW		**345069**
Operating and maintenance cost of collecting trucks including fuel and insurance cost		**221977**
Cost of management of MSW by the HED		**24130**
Indirect operating cost		**16639**
Depreciation of capital outlays		**137335**
Construction a transfer station cost (dpreciated per 20 years)		**4062**
Operating and maintenance of transfer station		**21,600**
% of recycling and compost process for (plastic, metal, cardboard and organic compounds)	**50%**	
Transporting MSW to Zahrat Al Finjan Landfill		**164,700**
Environmental cost of transporting SW		**18,814**
Average cost per year		**954326**
Average cost per ton of MSW		**52.3**
Munisipal Solid waste income per year (Fees)		**378910**
MSW benefits from closing the existing landfill (environmental external effects)		**127568**
SWT income per ton	**27.8**	**27.8**
Qalqilia Paying / Ton of MSW from Municipaliuty Budjet	**24.5**	**24.5**
Qalqilia Paying for MSWM from its Budjet	**447,849**	

MSW Compounds	% by weight	% of processing	Remaining part (%)
organic	52	50%	26
plastic	15	50%	7.5
cardboard	8	50%	4
metal	3	50%	1.5
		total	39

Appendix (2): Fuel Consumption for SW Collection Vehicles in Qalqilia City

		Oct-08		Nov-08		Dec-08		Jan-09		Feb-09		Total (5 Months)		Ave- Monthly Consumption	
Vehicle Description	Vehicle I.D.	Fuel (L)	Cost (NIS)	Fuel (L)	Cost (NIS)	Fuel (L)	Cost (NIS)	Fuel (L)	Cost (NIS)	Fuel (L)	Cost (NIS)	Fuel (L)	Cost (NIS)	Fuel (L)	Cost (NIS)
نفايات ايفيكو	**A1**	483	2777	394	1910	**983**	**4522**	403	1612	777	3263	3040	14084	608	2817
نفايات سكانيا	**A2**	388	2231	799	3874	**757**	**3482**	694	2776	864	3629	3502	15992	700	3198
نفايات سكانيا	**A3**	610	3507	877	4252	**908**	**4177**	1067	4268	807	3389	4269	19593	854	3919
نفايات فولفو	**A4**	0		400	1940	**170**	**782**	0	0	343	1441	913	4163	183	833
نفايات فولفو	**A5**	370	2127	855	4145	**1020**	**4692**	830	3320	444	1865	3519	16149	704	3230
نفايات نيسان	**A6**	0		125	606	**135**	**621**	0	0	0	0	260	1227	52	245
رافعة حاويات	**A8**	440	2528	768	3726	**724**	**3330**	630	2520	502	2108	3064	14213	613	2843
قلاب احتياط	**B1**	0		140	679	**0**	**0**	148	592	88	370	376	1641	75	328
قلاب سكانيا الصحة	**B2**	0		218	1057	**586**	**2696**	95	380	140	588	1039	4721	208	944
جرافة كاتربللر	**C1**	1668	9593	2447	11870	**2433**	**11192**	2761	11044	2209	9278	11519	52977	2304	10595
تركاتور فورد	**D1**	86	494	186	900	**707**	**3252**	179	716	144	605	1301	5967	260	1193
تراكتور ماسي فيرجسون	**D2**	117	672	292	1415	**142**	**653**	215	860	238	1000	1004	4600	201	920
انترناشونال كباش 1992	**L2**	0		178	862	**182**	**837**	227	908	233	979	820	3586	164	717
متسوبيشي 1999	**M4**	349	2007	416	2019	**407**	**1872**	374	1496	313	1315	1859	8709	372	1742
MSW Compactor (5m3)	Volvo/A10													600	2850
MSW Compactor (5m3)	Volvo/A11													600	2850
MSW Compactor (3m3)	Volvo/A12													600	2850
Street Cleaner Vehicle (3m3)	Volvo/A13													900	4200
											Total	**36483**	**167620**	**9997**	**45441**
											Yearly			**119960.2**	**545297**
														US $	**136324**

US $ =	**4**	**NIS**

Appendix (3): MSW Vehicles Maintenance, Mechanical Department, Mechanical Workshop

US $ =	4	NIS												
Vehicle Description	Vehicle I.D.	Normal Main. Cost (NIS) 2007	Long Term Main. Year 2007	Period	For 2007	Total Main. Cost 2007 (NIS)	Normal Main. Cost (NIS) 2008	Long Term Main. Year 2008	Period	For 2008	Total Main. Cost 2008 (NIS)	Average Main. Cost (NIS)	Insurance Cost (NIS)
تقايات ايفيكو	A1	8090				**8090**	11040	8890.00	3 years	2963	**14003**	**11047**	**3250**
تقايات سكانيا	A2	6375				**6375**	6062				**6062**	**6219**	**3250**
تقايات سكانيا	A3	1348				**1348**	8353				**8353**	**4851**	**3250**
تقايات فولفو	A4	4876				**4876**	6225				**6225**	**5551**	**3250**
تقايات فولفو	A5	8830				**8830**	2260				**2260**	**5545**	**3250**
تقايات تيسان	A6	9448	31000.00	5 years	6200	**15648**	1110	6200.00	4 years	6200.00	**7310**	**11479**	**3250**
رافعة حاويات	A8	2830	7000.00	5 years	1400	**4230**	4516	1400.00	4 years	1400.00	**5916**	**5073**	**3250**
قلاب احتياط	B1	3025				**3025**	4000	21878.00	5 years	4375.6	**8376**	**5700**	**3250**
قلاب سكانيا الصحة	B2	4418				**4418**	12286				**12286**	**8352**	**3250**
جرافة كاتربللر	C1	24459				**24459**	4812	9100.00	4 years	2275	**7087**	**15773**	**1600**
تركاتور فورد	D1	1941				**1941**	2986				**2986**	**2464**	**2200**
راكتور ماسي فيرجسون	D2	2911				**2911**	2170				**2170**	**2541**	**1700**
نترناشونال كياش 1992	L2	2150	12000.00	10 years	1200	**3350**		1200.00	9 years	1200.00	**1200**	**2275**	**3250**
متسوبيشي 1999	M4	4333				**4333**	2622				**2622**	**3478**	**2650**
					Total	**93834**					**86856**	**90345**	**45172**
											US $ =	**22586**	**11293**

Maintenance Hours Per Month for SW Vehicles:

Vehicle Description	Vehicle I.D.	Maintenance Hours / Month
نفايات ايفيكو	**A1**	16
نفايات سكانيا	**A2**	16
نفايات سكانيا	**A3**	16
نفايات فولفو	**A4**	16
نفايات فولفو	**A5**	16
نفايات نيسان	**A6**	16
رافعة حاويات	**A8**	16
قلاب احتياط	**B1**	5
قلاب سكانيا الصحة	**B2**	5
جرافة كاتربللر	**C1**	3
تركاتور فورد	**D1**	5
تراكتور ماسي فيرجسون	**D2**	5
انترناشونال كباش 1992	**L2**	7
متسوبيشي 1999	**M4**	3
	Total	**145**
Total Working Hours For Main. Unit		**156**
% of Mechanical Dep. Works for SW Vehicles		**93**

Mechanical Department Employees Wages and % of The Wages to the SW Sector:

Employee	Description	Monthly Wage (NIS)	% for SW Sector	Cost (NIS)	Notes
Employee No. 1	Head of Dep.	2161	31%	670	(Mechanical department consists of three units, Maint. Unit takes 33% of the Head works, 93 % of main. Works for SW sector, the overall ratio is 33*93=31 %)
Employee No. 2	Engineer	3329	93%	3096	According to Main. Works % for SW vehicles.
Employee No. 3	Proffesional	2077	93%	1932	According to Main. Works % for SW vehicles.
Employee No. 4	Proffesional	2787	93%	2592	According to Main. Works % for SW vehicles.
Employee No. 5	Proffesional	1612	93%	1499	According to Main. Works % for SW vehicles.
Employee No. 6	Proffesional	1260	93%	1172	According to Main. Works % for SW vehicles.
Employee No. 7	Proffesional	1581	93%	1470	According to Main. Works % for SW vehicles.
Employee No. 8	Proffesional	1240	93%	1153	According to Main. Works % for SW vehicles.
	Total monthly wages for SW sector			**13584**	
	Yearly wages for SW sector			**163007**	US $ = **40752**

Mechanical Workshop unit Employees Wages and % of The Wages to The SW Sector

Employee	Description	Monthly Wage (NIS)	% for SW Sector	Cost (NIS)	Notes
Employee No. 1	Head of Dep.	2161	22%	475	(Mechanical department consists of three units, Workshop. Unit takes 33% of the Head works,67 % of workshop. Works for SW sector, the overall ratio is 33%*67%=22 %)
Employee No. 2	Proffesional	1922	67%	1288	According to workshop. Works % for SW sector.
Employee No. 3	Proffesional	1620	67%	1085	According to workshop. Works % for SW sector.
Employee No. 4	Proffesional	1232	67%	825	According to workshop. Works % for SW sector.
	Total monthly wages for SW sector			**3674**	
	Yearly wages for SW sector			**44088**	**US $ = 11022**

Note: workshop works for SW vehicles and collection tanks, daily 4 hours which is 104 hours of the 156 working hours in the month which is about 67%

Total (US $)	**74360**	**yearly**

Appendix (4) Adminstration, Accounting and Health and Environment Cost

US $ =	4	NIS										
Adminstration Cost (NIS) "Adminstration Dep."												
Employee	Position / Department	Wage Monthly (NIS)	% For SW Sector	Monthly Cost (NIS)	Yearly Cost (NIS)	Notes						
Mayor	Mayor	8000	6%	480	5760	This share is according to the Health " Environmental' department share from other departments in the Municipality						
Municipality Council	Member	7000	6%	420	5040	This share is according to the Health " Environmental' department share from other departments in the Municipality						
Mayor Secretary	Mayor Secretary	2463	6%	148	1773	This share is according to the Health " Environmental' department share from other departments in the Municipality						
Employee No.1	Administration Dep.	2463	20%	492.6	5911.2	Health Department workers and employees are 20% of the Municipality employees						
Employee No.2	Administration Dep.	2326	20%	465.2	5582.4	Health Department workers and employees are 20% of the Municipality employees						
Employee No.3	Administration Dep.	2277	20%	455.4	5464.8	Health Department workers and employees are 20% of the Municipality employees						
Employee No.5	Central	2000	20%	400	4800	This share is according to the Health " Environmental' department share from other departments in the Municipality						
Employee No.6	Mun. Stores Manager	2600	6%	156	1872	This share is according to the Health " Environmental' department share from other departments in the Municipality						
Employee No.7	Computer Programmer	2700	6%	162	1944	This share is according to the Health " Environmental' department share from other departments in the Municipality						
			Total	**2860.98**	**34331.76**	**US $ =**	**8583**					
			US $	715	8583							

Accounting Cost (NIS) "Accounting Dep."

Employee	Position / Department	Wage Monthly (NIS)	% For SW Sector	Monthly Cost (NIS)	Yearly Cost (NIS)	Notes
Employee No.1	Accountant	2112	20%	422.4	5068.8	Health Department workers and employees are 20% of the Municipality employees
Employee No.2	Accounting Dep.	2414	25%	603.5	7242	SW share from the daily work.
Employee No.3	Teler	2507	50%	1253.5	15042	SW share from the daily work.
Employee No.4	Teler	1230	33%	405.9	4870.8	SW share from the daily work.
			Total	**2685.3**	**32223.6**	**US $ = 8056**
			US $	671	8056	

Adminstration Cost (NIS) "Health / Environmental Dep."

Employee	Position / Department	Wage Monthly (NIS)	% For SW Sector	Monthly Cost (NIS)	Yearly Cost (NIS)	Notes
Employee No.1	Head of Dep.	3778	33%	1246.74	14960.88	SW share from the daily work.
Employee No.2	Supervisor	2488	100%	2488	29856	SW share from the daily work.
Employee No.3	Supervisor	2021	60%	1212.6	14551.2	SW share from the daily work.
Employee No.4	Supervisor	2217	100%	2217	26604	SW share from the daily work.
Employee No.5	Supervisor	0	0%	0	0	
			Total	**7164.34**	**85972.08**	**US $ = 21493**
			US $	1791	21493	

Solid Waste Employees Wages (NIS) "Health / Environmental Department":

Employee	Position / Department	Wage Monthly (NIS)	% For SW Sector	Monthly Cost (NIS)	Yearly Cost (NIS)	Notes
Employee No.1	Driver	1670	100%	1670	20040	
Employee No.2	Driver	1790	100%	1790	21480	
Employee No.3	Driver	1850	100%	1850	22200	
Employee No.4	Driver	1610	100%	1610	19320	
Employee No.5	Driver	1670	100%	1670	20040	
Employee No.6	Driver	2150	100%	2150	25800	
Employee No.7	Driver	1740	100%	1740	20880	
Employee No.8	Driver	1530	100%	1530	18360	
Employee No.9	Driver	2503	100%	2503	30036	
Employee No.10	Driver	1710	100%	1710	20520	
Employee No.11	Driver	1730	100%	1730	20760	**59859**
Employee No.12	SW Collection	1790	100%	1790	21480	
Employee No.13	SW Collection	1580	100%	1580	18960	
Employee No.14	SW Collection	1790	100%	1790	21480	
Employee No.15	SW Collection	1580	100%	1580	18960	
Employee No.16	SW Collection	1550	100%	1550	18600	
Employee No.17	SW Collection	1400	100%	1400	16800	
Employee No.18	SW Collection	1460	100%	1460	17520	
Employee No.19	SW Collection	1490	100%	1490	17880	
Employee No.20	SW Collection	1610	100%	1610	19320	**42750**
Employee No.21	Street Cleaner	1520	100%	1520	18240	
Employee No.22	Street Cleaner	1460	100%	1460	17520	
Employee No.23	Street Cleaner	1550	100%	1550	18600	
Employee No.24	Street Cleaner	1400	100%	1400	16800	
Employee No.25	Street Cleaner	1490	100%	1490	17880	

Employee No.26	Street Cleaner	1370	100%	1370	16440	
Employee No.27	Street Cleaner	1400	100%	1400	16800	
Employee No.28	Street Cleaner	1370	100%	1370	16440	
Employee No.29	Street Cleaner	1370	100%	1370	16440	
Employee No.30	Street Cleaner	1340	100%	1340	16080	
Employee No.31	Street Cleaner	1400	100%	1400	16800	
Employee No.32	Street Cleaner	1340	100%	1340	16080	
Employee No.33	Street Cleaner	1340	100%	1340	16080	
Employee No.34	Street Cleaner	1280	100%	1280	15360	
Employee No.35	Street Cleaner	1280	100%	1280	15360	
Employee No.36	Street Cleaner	1250	100%	1250	15000	
Employee No.37	Street Cleaner	1370	100%	1370	16440	
Employee No.38	Street Cleaner	1250	100%	1250	15000	
Employee No.39	Street Cleaner	1310	100%	1310	15720	
Employee No.40	Street Cleaner	1340	100%	1340	16080	
Employee No.41	Street Cleaner	1250	100%	1250	15000	
Employee No.42	Street Cleaner	1250	100%	1250	15000	
Employee No.43	Street Cleaner	1310	100%	1310	15720	
Employee No.44	Street Cleaner	1250	100%	1250	15000	
Employee No.45	Street Cleaner	1280	100%	1280	15360	
Employee No.46	Street Cleaner	1220	100%	1220	14640	
Employee No.47	Street Cleaner	1250	100%	1250	15000	
Employee No.48	Street Cleaner	1340	100%	1340	16080	
Employee No.49	Street Cleaner	1250	100%	1250	15000	
Employee No.50	Street Cleaner	1160	100%	1160	13920	
Employee No.51	Street Cleaner	1190	100%	1190	14280	
Employee No.52	Street Cleaner	1160	100%	1160	13920	
Employee No.53	Street Cleaner	1250	100%	1250	15000	

Employee No.54	Street Cleaner	1160	100%	1160	13920	
Employee No.55	Street Cleaner	1160	100%	1160	13920	
Employee No.56	Street Cleaner	1220	100%	1220	14640	
Employee No.57	Street Cleaner	1190	100%	1190	14280	
Employee No.58	Street Cleaner	1130	100%	1130	13560	
Employee No.59	Street Cleaner	1190	100%	1190	14280	
Employee No.60	Street Cleaner	1220	100%	1220	14640	
Employee No.61	Street Cleaner	1130	100%	1130	13560	
Employee No.62	Street Cleaner	1130	100%	1130	13560	
Employee No.63	Street Cleaner	1130	100%	1130	13560	
Employee No.64	Street Cleaner	1130	100%	1130	13560	
Employee No.65	Street Cleaner	1190	100%	1190	14280	
Employee No.66	Street Cleaner	1130	100%	1130	13560	
Employee No.67	Street Cleaner	1220	100%	1220	14640	
Employee No.68	Street Cleaner	1190	100%	1190	14280	
Employee No.69	Street Cleaner	1130	100%	1130	13560	
Employee No.70	Street Cleaner	1130	100%	1130	13560	
Employee No.71	Street Cleaner	1130	100%	1130	13560	
Employee No.72	Street Cleaner	1220	100%	1220	14640	
Employee No.73	Street Cleaner	1220	100%	1220	14640	
Employee No.74	Street Cleaner	1130	100%	1130	13560	
Employee No.75	Street Cleaner	1160	100%	1160	13920	
Employee No.76	Group Co. ST. Cl.	1550	100%	1550	18600	
Employee No.77	Group Co. ST. Cl.	1610	100%	1610	19320	
Employee No.78	Group Co. ST. Cl.	1400	100%	1400	16800	
Employee No.79	Group Co. ST. Cl.	1490	100%	1490	17880	
Employee No.80	Health Supervisor	1550	100%	1550	18600	
Employee No.81	Health Supervisor	1370	0%	0	0	

Employee No.82	Health Supervisor	1370	100%	1370	16440	
Employee No.83	Supervisor	1250	0%	0	0	
Employee No.84	Health Supervisor	1310	100%	1310	15720	
Employee No.85	Market Supervisor	1310	100%	1310	15720	**242460**
			Total	**115023**	**1380276**	**345069**
			US $	**28756**	**345069**	

Total Wages NIS / Mon.	**127734**
Total Wages NIS / Year.	**1532803**
Total Wages US $ / Mon.	**31933**
Total Wages US $ / Year.	**383201**

Appendix (5): Existing Landfill Cost

US $ =	**4**	**NIS**	
MSW Generation	**50**	**Ton**	
Landfill Cost:			
Item Description	Average Monthly Cost (NIS)	Yearly Cost (NIS)	Yearly Cost ($)
Earth Works	6000	72000	**18000**
Site Security	2800	33600	**8400**
Land Renting	375	12000	**3000**
Road and General Maintenance	500	10800	**2700**
Total	**9675**	**128400**	**32100**
Total (US $)	**2419**	**32100**	

Closure and Post Closure Cost:

Item Description	**Amount**	**Unit Cost ($)**	**Total Cost ($)**	**Total annual Cost ($)**	**Ammortization Period (Years)**
Supplying and installing by welding Textured HDPE geo-membrane (1.5 mm) to cover 22 thousands meter squire.	**22,000**	**15**	**330,000**	**165,000**	**2**
Backfilling works under and over the HDPE layer for the total area	**22,000**	**6**	**132,000**	**66,000**	
Monitoring and testing works for the nearby water wells and other testing (proposed to be performed for 5 years)	**L.S**	**10,000**	**10,000**	**5,000**	
Total			**472,000**	**236,000**	

Local property devaluation:

Item Description	m2	Unit Cost ($)	Total Cost ($)
Affected Area around the landfill	98,000	30	147,000
Total			**147,000**

Environmental external costs for the landfill:

Item Description	Amount	Unit Cost ($)	Total Cost ($)
The marginal cost of air pollution (that is, greenhouse gas emissions) is $3.27 per ton for landfills without energy recovery.	18,250	3.27	59,678
Range of cost estimates for landfill disamenities is $3.05 to $4.39 per ton, average ($3.72) is used	18,250	3.72	67,890
Costs of waste transportation to landfills (congestion, air pollution, and the increased probability of road accidents) is $0.51 per ton for urban landfills	18,250	0.51	9,308
Total			**136,875**

Appendix (6): Comunication cost and Payments for Utilities

US $ = 4 NIS

Comunication Cost For " Health and Environment Department"

Item Description	Monthly (NIS)	Yearly (NIS)	Notes
Telephone	153	1836	Based on average monthly cost
Mobile Phone	456	5472	"0.25*160+0.6*160+160+160" based on average monthly"
Total	**609**	**7308**	
		1827	**US $**

Payments for Utilities " Health and Environment Department"

Item Description	Monthly (NIS)	Yearly (NIS)	Notes
Electricity & Water	120	1440	Based on average monthly cost
Paper, Printing ,Supplies	150	1800	Based on average monthly cost
Total	**270**	**3240**	
		810	**US $**

Total Cost (US $)	**2637**

Appendix (7): Municipal Solid Waste Fees

Solid Waste Fees in Qalqilia Municipality

Item Description	No. of customers	2006 ($)	2007 ($)	2008 ($)	US $ is	4	NIS
Household Sw	7299	123264.5	124566.6	239848.85			
Commercial Sw	1100	75207.15	75856.75	132421.25			
Total	**8399**	**198472**	**200423**	**372270**			

Removal of Building Works Waste Collected Fees

Month	**Fees (NIS)**	**Fees ($)**	**US $ =**	**4**	**NIS**
Nov-07	1940	485			
Dec-07	1580	395			
Month	**Fees (NIS)**	**Fees ($)**			
Jan-08	560	140			
Feb-08	550	138			
Mar-08	800	200			
Apr-08	1400	350			
May-08	1090	273			
Jun-08	1350	338			
Jul-08	1830	458			
Aug-08	2673	668			
Sep-08	1255	314			
Oct-08	2892	723			
Nov-08	2715	679			
Dec-08	1785	446			
Total	**18900**	**4725**			
Average	**1575**	**394**			
Month	**Fees (NIS)**	**Fees ($)**			
Jan-09	2800	700			
Feb-09	2120	530			
Mar-09	3205	801			
Apr-09	4640	1160			
May-09	2855	714			
Jun-09	4720	1180			
Jul-09	3170	793			
Aug-09	2760	690			
		821			
Average	**2213**	**553**			

Appendix (8): Trandfer Station Cost

Solid Waste Generation (Ton / Month)	50		
US $ =	4	NIS	

Transfer Station Construction Cost:

Item Description	Total Cost (NIS)	Yearly Cost (NIS)	Yearly Cost ($)
Contracting, excavation and construction works cost	*42329*	2116	529
Construction material cost (steel & concrete)	*156778*	7839	1960
Land Renting	*2500*	2500	625
External works (Gate and site panel)	*3960*	792	198
Electrical works	*15000*	3000	750
Total	**220,567**	**16,247**	**4,062**
Total (US $)	*55,142*	4,062	

Transfer Station Operating Cost:

Item Description	Monthly Cost (NIS)	Yearly Cost (NIS)	Yearly Cost ($)
Site security	*2800*	33600	8400
Site stuff	*3400*	40800	10200
services: electricity, comunication, water	*500*	6000	1500
General maintenace	*500*	6000	1500
Transferring MSW to Zahrat Al Finjan Landfill and Zahrat Al Finjan Sanitary Landfill Fees	*90000*	1080000	270000
The costs of waste transportation to Zahrat Al Finjan Sanitary landfill (congestion, air pollution, and the increased probability of road accidents) is $1.69 per ton for rural landfills	*10,281*	123370	30843
Total	***107,481***	**1,289,770**	**322,443**
Total (US $)	*26,870*	322,443	
Total annual cost of transfer station option:	326,504		
Transferring Cost Per Ton of MSW(US$)	18.1		

Appendix (9): Depreciation Cost

US $ =	**4**	**NIS**

Solid Waste Collection / Equipment And Tools Cost:

Item Description	Used Units	Unit Cost (NIS)	Total Cost (NIS)	Total Cost ($)
Broom	273	18.5	5050.5	1263
Shovel	10	35	350	88
Wheel Barrow	12	130	1560	390
SW collection Bins	50	700	35000	8750
computers and furniture			1024	256
Total			**42984.5**	10746
		Total (US $)	**10746**	

Costs of Depreciation of Capital Outlays:

Asset Group	Asset Supgroup	Vehicle Load (Ton)	Asset Type / I.D.	Unit	Year of Valuation	Year of acquisition	Year of manufacturing	Age of Asset (Year)	Normal Useful Life (Year)	Useful Life (Year)	Remain Useful Life (Year)	Replacement Unit Cost ($)	Replacement Cost "Current Cost" ($)	Depresiation yearly ($)
Compactor	*Afeco*	7.5	A1 4*2	1	2009	1999	1999	10	10	15	5	84,790	84,790	5653
	Scania	11.5	A2 4*2	1	2009	1990	1990	19	10	24	5	115,370	115,370	4807
	Scania	11.5	A3 4*2	1	2009	1990	1990	19	10	24	5	115,370	115,370	4807
	Volvo	7.7	A4	1	2009	1990	1986	23	10	28	5	139,000	139,000	4964
	Volvo	7.9	A5	1	2009	1990	1991	18	10	23	5	139,000	139,000	6043
	Nisan	6.5	A6 4*2	1	2009	1998	1998	11	10	16	5	42,000	42,000	2625
	Rino	9.2	A7 4*2	1	2009	2000	1983	26	10	31	5	20,000	20,000	645
Containers Loader	*Volvo*	6.5	A8 4*2	1	2009	2000	1993	16	5	21	5	62,000	62,000	2952
Truck	*Scania*	11.5	B1 4*2	1	2009	2001	1990	19	10	24	5	60,000	60,000	2500
	Scania	11.5	B2 4*2	1	2009	2001	1990	19	10	24	5	60,000	60,000	2500
Bager	*Caterpillar*		C1 4*4	1	2009	2003	2003	6	10	10	4	210,000	210,000	21000
Tractor with container	*Ford*		D1	1	2009	1988	1985	24	10	29	5	16,250	16,250	560
	Frgson		D2	1	2009	1996	1996	13	10	18	5	16,250	16,250	903
	Ford		Tractor container	1	2009	1997	1997	12	10	17	5	3,750	3,750	221
	Frgson		Tractor container	1	2009	1997	1997	12	10	17	5	3,750	3,750	221
Containers			container 1100 Litre, Steel	100	2009	2005	2005	4	5	5	1	175	17,500	3500
			container 1100 Litre, Steel	50	2009	2007	2007	2	5	5	3	175	8,750	1750
			container 1100 Litre, Steel	250	2009	2000	2000	9	5	14	5	175	43,750	3125
			SW containers	23	2009	2003	2003	6	5	11	5	1,500	34,500	3136

			4m3											
			container , plastic	10	2009	2002	2002	7	5	12	5	245	2,450	204
			SW containers 4m3	10	2009	2008	2008	1	5	5	4	2,225	22,250	4450
			container 1100 Litre, Steel	10	2009	2008	2008	1	5	5	4	245	2,450	490
Roll off truck	*Internatio nal*	4	4*2 L2	1	2009	2000	1992	17	10	22	5	94,500	94,500	4295
Service Car	*Mitsupish i*		M4 4*4	1	2009	1999	1999	10	10	15	5	38,850	38,850	2590
Furniture				10	2009	2006	2006	3	10	10	7	150	1,500	50
Computers				5	2009	2007	2007	2	6	6	4	750	3,750	206
Total														**84198**
New equipments:														
MSW Compactor (5m3)	Volvo	15 ton	A10	1	2009	2009	2009	1	10	10	10	95,000	95000	**9500**
MSW Compactor (5m3)	Volvo	15 ton	A11	1	2009	2009	2009	1	10	10	10	95,000	95000	**9500**
MSW Compactor (3m3)	Volvo	12 ton	A12	1	2009	2009	2009	1	10	10	10	81,000	81000	**8100**
Street Cleaner Vehicle (3m3)	Volvo	15 ton	A13	1	2009	2009	2009	1	10	10	10	209,000	209000	**20900**
														48000
Total (US $)	**137335**													

جامعة النجاح الوطنية
كلية الدراسات العليا

دراسة تحليل التكاليف لإدارة النفايات الصلبة لمدينة قلقيلية

إعداد
إبراهيم محمد نمر هندي

إشراف
د. محمد نهاد المصري
د. حافظ قدري شاهين

قدمت هذه الاطروحة استكمالا لمتطلبات نيل درجة الماجستير في هندسة المياه والبيئة بكليـــة الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين
2010م

دراسة تحليل التكاليف لإدارة النفايات الصلبة لمدينة قلقيلية

أعداد

إبراهيم محمد نمر هندي

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الملخص

تعتبر إدارة النفايات الصلبة من أهم القضايا المتعلقة بعمل البلديات في فلسطين خصوصا بعد المشاكل والآثار البيئية الكبيرة التي تسببت بها مكبات النفايات العشوائية المنتشرة في فلسطين. كذلك تلعب دراسات التكلفة دورا مهما في تقييم طرق التخلص من النفايات الصلبة وتفضيل طريقة على أخرى.

هذه الدراسة تهدف إلى تحديد التكاليف لخيارات إدارة النفايات الصلبة في مدينة قلقيلية و تقييم ادراة النفايات الصلبة الحالية وتحديد الخيار الأقل كلفة لادراة النفايات الصلبة في المدينة.

هناك اربعة خيارات لإدارة النفايات الصلبة تمت دراستها لمدينة قلقيلية:

1. البقاء على الوضع الحالي
2. إنشاء محطة ترحيل للنفايات الصلبة ونقل النفايات الصلبة في المدينة الى مكب زهرة الفنجان في منطقة جنين
3. إنشاء مكب صحي للنفايات الصلبة والتخلص من نفايات المدينة فيه
4. عمل فصل جزئي للنفايات الصلبة وإعادة استخدام المواد التي يمكن تدويرها ومن ثم ترحيل الجزء المتبقي الى مكب زهرة الفنجان في منطقة جنين.

بعد دراسة التكاليف للخيارات المتاحة تبين أن الخيار الأول يكلف (71.1 دولار للطن الواحد) وفي حال إهمال التكاليف المتعلقة بالآثار البيئية تنخفض هذه التكلفة لتصل إلى (42.6 دولار للطن الواحد)، أما الخيار الثاني فقد تبين انه يكلف (58.7 دولار للطن الواحد) تنخفض هذه التكلفة الى (57 دولار للطن الواحد) في حال إهمال الآثار البيئية.

أما الخيار الرابع باستخدام آلية التدوير وترحيل الجزء المتبقي إلى مكب زهرة الفنجان فقد تباينت التكلفة بحسب نسبة الفصل للنفايات الصلبة وتراوحت التكلفة من (45.9 دولار للطن الواحد إلى 52.3 دولار للطن الواحد) علما بان هذا الخيار يعتبر الأكثر صداقة للبيئة. كذلك تبين بان التكلفة ستكون اكبر بكثير لخيار إنشاء مكب صحي للتخلص من النفايات الصلبة وتعارض ذلك مع سياسة سلطة جودة البيئة في فلسطين حول انشاء مكبات مركزية للتخلص من النفايات الصلبة في الضفة الغربية بالإضافة إلى الصعوبات البيئية الأخرى.

أوصت الدراسة بأن تقوم بلدية قلقيلية بعمل مشروع خاص لإغلاق مكب النفايات الحالي لما في ذلك من فوائد بيئية ومادية كبيرة. أوصت الدراسة كذلك أن تبدأ بلدية قلقيلية بعمل مشروع تجريبي لفصل النفايات الصلبة للتقليل من كميات النفايات الصلبة المرحلة او المطمورة وكذلك حماية البيئة مع ضرورة أن تختار البلدية الخيار الأمثل للتخلص من النفايات الصلبة في المدينة لما في ذلك من تقليل الإنفاق السنوي لتغطية التكاليف الإضافية لإدارة النفايات الصلبة في المدينة مما سيوفر الميزانيات الضرورية لإنشاء المشاريع الحيوية الأخرى في المدينة