TOWARDS AN ENVIRONMENTALLY SOUND SUSTAINABLE SOLID WASTE DISPOSAL STRATEGY: THE GAZA STRIP CASE

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Submitted in Partial Fulfillment of the Requirements of the Degree of Doctor of Philosophy, April 2004

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOS

LIST OF BOXES

ABBREVIATIONS

Agenda 21	The Action Plan from the Earth Summit from 1992
BPEO	Best Practicable Environmental Option
BS	British Standards
CATWOE	Soft System Thinking mnemonic (Customers, Actors, Transformation process, Weltanschauung, Owners and Environment constraints.
CM	Conceptual Model
DoE	Department of Environment
DoHE	Department of Health Education
DSS	Decision Support System
DG's	Director Generals
DSR	Driving Force State Response
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EU	European Union
ERM	Environmental Resource Management
GDP	Gross Domestic Product
GNP	Gross National Product
GM	Gaza Municipality
GTZ	German Technical Cooperation
HAS	Human Activity Systems
HCW	Health Care waste
ISWM	Integrated Solid Waste Management
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
MEnA	Ministry of Environmental Affairs
MoH	Ministry of Health
MoLG	Ministry of Local Government
MoPIC	Ministry of Planning and International Cooperation
NIMBY	Not in My Back Yard
NIABY	Not in any Back Yard
NIMTO	Not in My Term of Office
NGO's	Non Governmental Organizations
OECD	Organization for Economic and Cooperation Development

O&M	Operation and Management
PNA	Palestinian National Authority
PCBS	Palestinian Central Bureau of Statistics
PEF	Palestinian Environmental Friends (NGO)
PAHO	Pan American Health Organization
PSR	Pressure States Response
PLC	Palestinian legislative Council
PDP	Palestinian Development Plan
PARC	Palestinian Agriculture Relief Committee (NGO)
PMMP	Palestinian Municipal management project
SE	System Engineering
SSM	Soft System Methodology
SWMC	Solid Waste management Council
SWMEO	Solid waste management Experts office
SWM	Solid Waste management
FCM	Federation of Canadian Municipalities
UNRWA	United Nations Relief and Works Agency
UNEP	United Nations Environmental Program
UK	United Kingdom
UNCSD	United Nations Commission on Sustainable Development
USEPA	United States Environmental Protection Agency
UNSCO	United Nations Special Coordinator in the Occupied Territories
3 R's	Reuse, Reduce and Recycle
RP	Rich Picture
RD	Root Definition
WCED	World Commission on Environment and Development
WHO	World Health Organization

ACKNOWLEDGEMENTS

First and foremost, I'm most grateful to my supervisor, Mr. Andy Hamilton, lecturer at the School of Construction and Property Management at the University of Salford for his professional and tireless efforts in providing me with an overall guidance, direction and friendly support. Without this help, this work could not have been achieved. His commitment in giving me time in going thorough this manuscript and in making constructive criticisms helped shape this thesis is highly appreciated. He has been my great source of encouragement and motivation. I also would like to thank my academic advisor Mr. Steve Curewell for his criticism and support. Also I would like to thank my local advisor Dr. Samir Afifi, lecturer at the Islamic university for his support and encouragement and to Dr. Khairy Al-Jamal for his technical and invaluable support.

Special thanks and deep gratitude to my colleague Mr. M. Shubbair, from the Ministry of Environmental Affairs in Gaza for his continuous support during this research. Also special thanks to Dr. Muhammad Al-Agha and the other colleagues and friends from Islamic university and colleagues from the Ministry of Planning and International Cooperation. I would like to convey special thanks to the contributions and cooperation given by the Municipality of Gaza, Solid Waste Management Council, Municipality of Rafah and local environmental NGO's specially the Palestinian Environmental Friends (PEF) during the case studies and interviews.

I'm grateful to all members of the School of Construction and Property Management at the University of Salford and to Dr. Andrew Cotton and Dr. Mansour Ali from Loughborough University and other colleagues and friends from the UK.

Finally, I wish to thank my family, as well as my wife, sons and daughters, for their understanding in such difficult situation during the Intifada. Sometimes so far from home and when near, always involved in this research. In spite these costs the work was grateful pleasure.

DECLARATION

I declare that the research contained in this thesis was solely carried out by me. It has not been previously submitted to this or any other Institution for the award of a degree of any other qualification.

ABSTRACT

Solid waste management has been recognized as one of the most immediate and serious problems confronting the Palestinian institutions especially those responsible for service delivery, policy and strategy formulation.

The complexity and historical context of integrated and sustainable waste management with special focus on the disposal options of municipal solid waste is studied within the context of sustainable development. This is the core of the research, which seeks to make a contribution to the understanding and assessing of waste management process including relations and mandates of institutions involved in solid waste management decision-making process which forms the basis for the development of an environmentally sound sustainable disposal strategy of municipal solid waste for the Gaza Strip.

The work is based on case studies derived from four holistic case studies in the Gaza Strip. Soft system methodologies are used to illuminate the qualitative concerns. It is applied to the solid waste management in order to analyse and assess the solid waste existing situation and recommends some actions in order to improve the disposal situation. The quantitative information from practice is placed alongside the qualitative data to give further insight into the issues being studied. Solid waste indicators and scoring system as triangulation with the soft system approach were selected to represent and evaluate disposal alternatives of the four case studies. An evaluation of the four disposal options as percentages was the outcome of the evaluation of disposal matrix.

It was discovered that an overlaps between Palestinian institutions involved in solid waste decision-making. Clear mandates, responsibilities, legislation is not efficiently functioning. Its concluded that soft system methodology supported with case studies methodologies, have proved to be a suitable approach for structuring, expressing, modeling the available information and as a result solving the problem of waste management.

Comprehensive solid waste management legislation must be formulated so that effective sustainable solid waste management programs can be laid out. National waste management strategy considering landfilling, composting, 3R's, and incineration as an integrated sustainable disposal option was recommended to be adopted by the Palestinian National Authority.

CHAPTER
1

PART I: INTRODUCTORY PART

CHAPTER ONE: INTRODUCTION

PART I: INTRODUCTORY PART

CHAPTER 1: INTRODUCTION

1.1 Background for the Study

Waste disposal and processing is very important in waste management practice in the Gaza Strip. The Gaza Strip suffers from a lack of convenient sites for sanitary landfills, and so any means of reducing waste quantities is to be welcomed. This thesis is an analysis and a discussion of the current trend and issues on solid waste management in the Gaza Strip. Its aims are focused on the aspect of identifying the policy and strategy framework for a sustainable disposal of solid waste management.

The research is limited to the solid waste or municipal waste, which classified as controlled waste according to the UK EPA 1990. Toxic waste, which is another component of waste, which needs different laws and management system, is only briefly mentioned to relate it to the management of the solid waste.

As a result of the Palestinian-Israeli Peace Agreement (Oslo II), where the Palestinian National Authority (PNA) took over the Gaza Strip and West Bank in 1994, a considerable investment from the donor community has been directed to improve municipal services and particularly SWM. However, Palestinian institutions do not have the capability and capacity to manage such investment.

This research was carried out between the period April 2000 and August 2003 when the Palestinian uprising (Intifada) had started and is still ongoing. Within this period, there were significant changes in the quality of municipal services being provided by Palestinian municipalities and village councils including waste management. For example, most of the time municipal trucks were not allowed to dump their loads at the official landfills, which resulted in accumulation of heaps of waste around housing areas. On site data for the research was collected through questionnaire, interviews, case studies and active participation in solid waste coordination meetings in addition to the literature review from scientific journals, proceedings and consultants.

1.1.1 Aims and Objectives of the Research

The main aim is to investigate the existing practice of municipal solid waste (MSW) handling in the Gaza Strip in terms of collection, storage, transportation, recycling and critically focus on disposal options and alternatives. Also evaluating existing conditions and progress made in reduction at source, reuse and recycle (3R's) as waste minimization scheme beside other options and suggest an environmentally sound sustainable and integrated disposal strategy of the MSW in the study area of the Gaza Strip. Soft System Methodology (SSM) and its applications will be applied to the SWM. It is aimed at analyzing and assessing the disposal alternatives of SWM in the Gaza Strip using SSM.

1.2 General Objectives

The general objectives of the study are to:

- Understand SWM strategies and policies through SSM applications.
- Identify existing strategies and policies of waste disposal,
- Characterize the prerequisites, parameters or elements that contribute to the formulation of a framework for an environmentally sustainable sound disposal strategy of MSW,
- Distinguish sustainable integrated disposal alternative through selection of technologies and the design of system of SWM,
- To show that SSM can be used for the analysis of case studies representing disposal options.

SSM can be seen as an approach, which took the "trial and error" principle. Unlike other system analysis methods which guide the user through a structured process from problem definition to solution implementation. SSM is a set of guidelines that help the analyst in performing the analysis while allowing considerable scope of personnel interpretations. SSM is a methodology that aims at bring about improvement in areas with social concerns by activating in the people involved in the situation learning cycle, which is ideally never ending. SSM is critically discussed in chapter 5 and 6.

1.2.1 Specific Objectives of the Study

- To understand and analyze the SWM existing situation with special focus on the disposal options,
- To assess influential aspects affecting disposal options,
- To identify issues and problems to efficient disposal of MSW,
- To evaluate sustainable waste management strategy as an integrated SWM suiting the Gaza Strip case.

1.3 Conceptual Framework

Solid waste disposal in the Gaza Strip is linked to unavailability of convenient sites for sanitary landfills, and so any means of reducing waste quantities is to be welcomed. The most common disposal practice in the Gaza Strip is dumping at landfill sites located around the city. One reason for this is the lack of landfill space in the cities.

The conceptual framework has dealt with three aspects, which may lead to the understanding of the SWM problem, Figure 1.1.

- Firstly, disposal strategy of MSW is not available. There is a need to understand the SWM existing situation with special focus on the disposal option.
- Secondly, problems associated with the sustainability and integrated disposal options. The integration of the influential aspects: Technical, environmental, financial, socio-economic, policy/political and institutional to determines the sustainability of the SWM system. These aspects are instrumental in both the assessment and the planning of sustainable waste management disposal strategy.

Thirdly, institutional problems associated with SWM service delivery. This problem is due to the unavailability of clear determination of rules and jurisdiction and establishment of legal and regulatory framework. Figure 1.1 illustrates the framework, which highlight the main influential aspects affecting the whole process especially the disposal of solid waste. The influential aspects include political, institutional, social, financial, economical and technical aspects. Each one of these aspects will be elaborated later in chapter four.

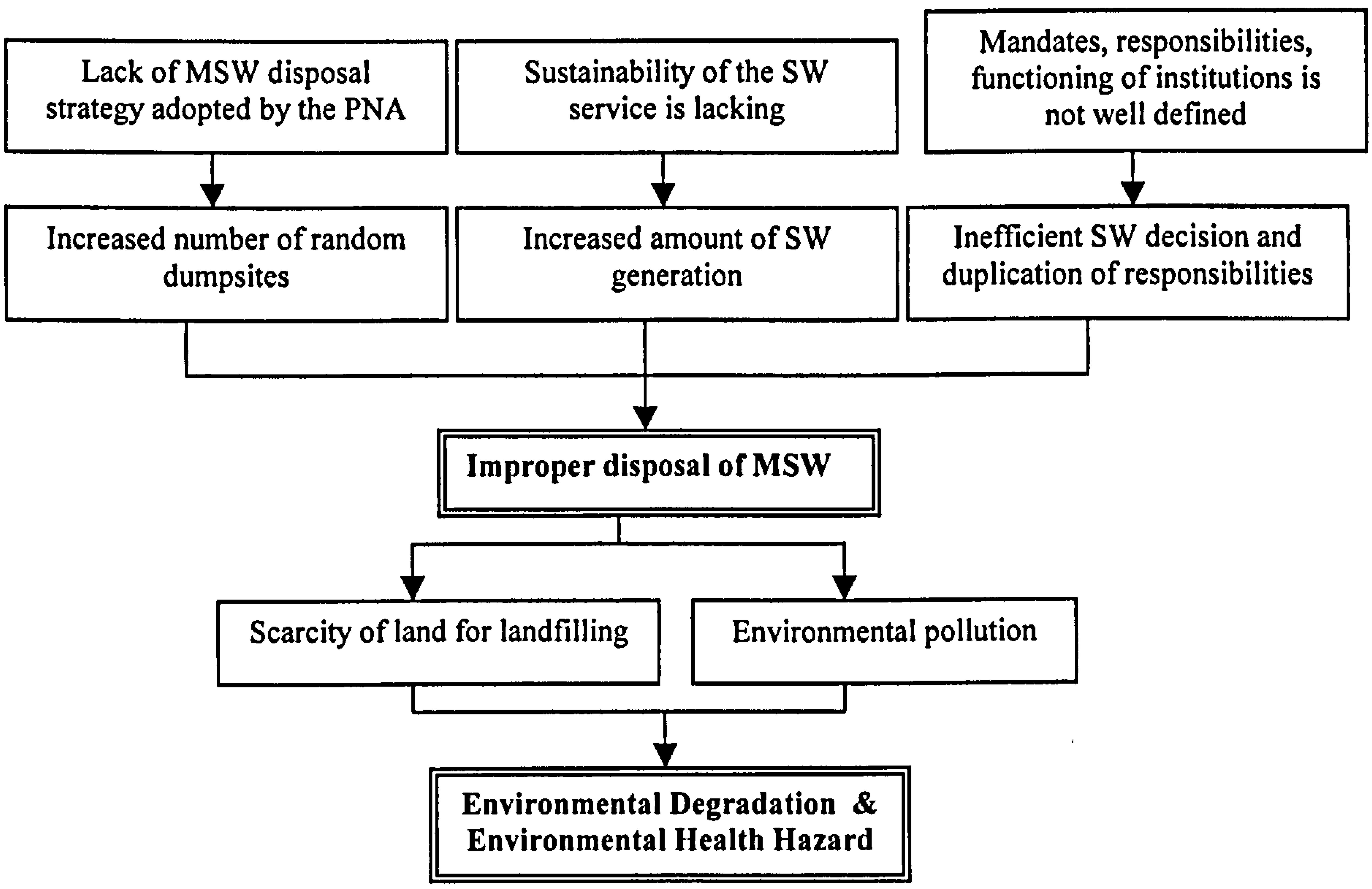

Figure 1-1: Simplified Illustration of the Conceptual Framework of the Research

1.3.1 Research Methodology

The direction of this study is designed according to the steps set out below, Figure 1-2 shows the guidelines used to achieve the dissertation aims and objectives, reviewing and analyzing background information obtained from:

- Literature review representing various disciplines, including environmental science, health engineering, and business management: journals, periodicals, handbooks, manuals, conference and proceedings articles.

- Current publications and reports from waste disposal authorities like municipalities, village councils, SWMC, UNRWA, NGO's and reports from international consultants,
- Questionnaire surveys.
- Soft System Methodology (SSM).

Task	Actions
Select topics and subject of research, identify case study and study sites	Literature reviews
Identify main characteristics and types of waste, process, disposal strategies, policies and activities	Identify existing documented and published record and establish their importance, identify trend in sustainable waste management
Review, analyze and assess published documentation and records with case studies representing disposal options including analysis of disposal alternatives using SSM	Analysis of disposal alternatives of SWM using SSM – 7 stages, Root Definition (RD), Rich Picture (RP), CATOWE elements
Identify possible alternatives to improve waste disposal policies and strategies and formulate integrated sustainable suggestions	Application of case studies by selection criteria of SW indicators by Integrated SWM aspects and selection technologies leading to evaluation of disposal matrix
Recommend and establish SSM applicability and disposal evaluation of alternatives with reference to case studies	Discuss outputs with concerned parties

Figure 1-2: Direction of the study

1.3.2 Research Design

Immediately after the research and review of the literature, the researcher made a thorough investigation and analysis of the disposal alternatives of municipal solid waste from the published reports and waste management plans obtained from various neighboring countries in the Middle East. Important variables and influential aspects that identified the kind of waste disposal system were analyzed. In the research, SSM was applied to analyze and elaborate the disposal situation in the Gaza Strip through the various stages of the SSM. In addition, four case studies representing disposal options from the Gaza Strip were selected in order to highlight the issue of waste disposal problems as illustrated in Figure 1-3.

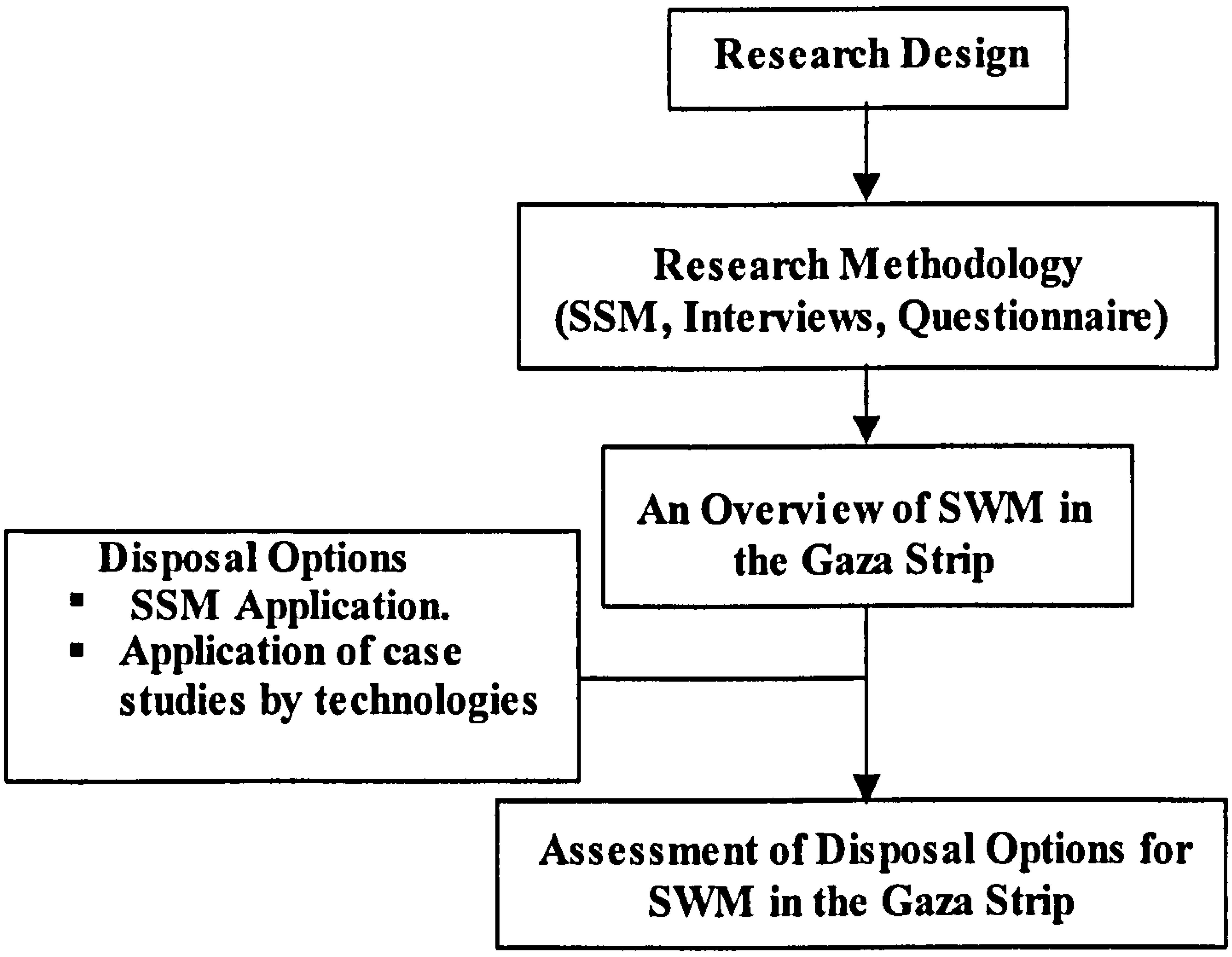

Figure 1-3: Illustrated steps of the Research Design

1.3.3 Limitation of the study

- **Socio economic and political constraints:** Due to the socio economic and political problems prevailing in the Gaza Strip associated to the ongoing Intifada and the frequent siege, curfew and closures, the researcher has faced many problems moving between cities and villages throughout Gaza while data gathering.

- **Time constraints:** The problem of timing for interviews was of great concern during the survey in the Gaza Strip. Each interview conducted lasted an average of two hours excluding the time used by the researcher to browse the departmental documents and meeting other personnel in the their department.

- **Lack of data:** It is often claimed that the lack of data on waste composition and quantities is a major factor, which has inhibited the development of disposal strategy of MSW in the Gaza Strip. The problems were in relation to the availability of data from Gaza, bureaucratic of making decisions. Difficulties have arisen while making appointments for arrangement for the self-assisted questionnaire session with the right authorized officer or person who is given the responsibility on matters related to the management of waste.

- **Quantitative analysis of solid waste indicators:** The indicators developed for this research were more for illustration of how such indicators could be of value in this area, and, as such, they are not fully validated indicators. A full sensitivity analysis has not been carried out for the indicators developed, although the application of sensitivity analysis is discussed in Chapter Seven.

1.3.4 Motivation for Research

Waste generation and waste reduction reflect many complex economic and social factors. Disposal of waste in the Gaza Strip poses problems that increase proportionally with population density especially after the PNA took over the Gaza Strip and West Bank in 1994. The Gaza Strip suffers from a lack of convenient sites for sanitary landfills, and so any means of reducing waste quantities is to be welcomed (El-Hawi, 1997).

The authors position as director of Infrastructure Department at MoPIC of the PNA with access to policy papers and other documents that some of the public doesn't have access to, these papers of the PNA being used for policy formulation. This position has helped in facilitating the process of choosing the research methodology. In addition, the author has a good access to data concerning implementation of SWM projects in the Gaza Strip through various solid waste projects funded by donor countries. Therefore, case studies, questionnaire and SSM as a research methodology to assess and understand the SWM problem situation were adopted and used by the author trying to develop a disposal strategy for the MSW suiting the Gaza Strip case.

1.3.5 Needs and significance of the Study

- **No previous documents on the subject:** the twenty-seven years of lack of attention to the infrastructure management which accompanied the Israeli occupation has resulted in little documentation and publishing on the solid waste sector. In this time there has been little investment in the various environmental sectors, particularly solid waste. Some of the existing infrastructure deteriorated while the population and their needs rapidly increased. This has lead to environmental degradation in almost every aspect.

- **Planning, policy and strategy for the SWM are not available:** The presence of the Israeli occupation and shortage of strong central environmental management contributed towards the indifference and lack of awareness of the needs and means of achieving acceptable environmental standards. All this lead to a situation that a significant part of the population of the Gaza Strip have become accustomed to living with environmental standards that are well below human dignity. The Palestinian National Authority (PNA) doesn't have specific strategy to deal for solid waste. Informal coordination between the external aided projects exists through Sector Working Group (SWG), which coordinated through the United Nations. However, Planning takes place by individual ministries and not on a national level.

- **Scarcity of land for landfilling:** Currently with no waste minimization strategy through reduce, reuse, recycle (3R's) and composting is considered by local authority. Due to the scarcity of area of land for public services specially landfills in addition, the Israeli settlements were built on a third of the area of the Gaza Strip, it became impossible securing land for landfilling facilities. So, developing disposal strategy for MSW considering local conditions is a vital and national request by the PNA.

- **SWM existing situation is not precisely and concisely analyzed:** Very little is published to analyze the situation of solid waste in the Gaza Strip, where the environmental situation is in a disastrous state and is deteriorating further. The situation has reached a stage that is threatening to health and is well below acceptable standards (MEnA, 1999). Therefore, developing a solid waste disposal strategy for the Gazà Strip in an effective way has become an absolute priority.

Study results will help in assessing the existing waste disposal practices and thereby suggest ways to improve the efficiency of the SWM in the Gaza Strip. Also, it will suggest ways to enhance the involvement of the public in SWM decision-making.

1.4 Research Structure/Outline

The research will cover some key issues of waste management in the Gaza Strip. It will analyse the system of solid waste problems including solid waste generation, handling system, storage, processing, transportation and special focus on the disposal options and alternatives and the impacts on the institutional, socio-economic, political, legal and financial related issues. In order to better present the investigation carried out the thesis is divided in five main parts as shown in Figure 1-4. The thesis is structured as follows:

Part I, the introductory part, is composed of ***Chapter One*** which described the background of the research, followed by research goals and objectives, conceptual framework which also include research methodology, research design, limitation, needs and significance of the study. In addition, hypothesis of the research and organization of the research.

Part II, the Contextual part; composed of four chapters. ***Chapter Two*** presents review of literature, which is relevant to the study objective. Especially, efforts were made to describe the historical development in waste management including integrated and sustainable waste management. Moreover, discussions also covered briefly solid waste management situation in the Gaza Strip. Principal of waste management policy and strategy is also discussed. ***Chapter Three,*** highlights the issues of waste processing with special focus on the disposal options. ***Chapter Four,*** this chapter is focused on methods of waste collection and disposal. It discusses the main process, highlighting the four disposal options.

Part III, methodological Part; ***Chapter Five,*** discusses the methodology of the research includes research design, analytical approach of the study and data gathering techniques, survey design, data analysis tools and data processing and analysis.

Part IV, the empirical part, presents the empirical work and consists of two chapters; ***Chapter Six,*** which assesses and analyzes the disposal alternatives of SWM in the Gaza Strip using soft system methodology (SSM). The SW disposal problem is highlighted through the application of SSM approach. ***Chapter Seven;*** in this chapter, special focus on SWM and associated disposal alternatives including: institutional arrangements, technical, political and legal aspects. It gives a general description, discusses criteria for the selection and other significant issues concerning case studies. SSM was applied for each case study. The collection, transportation and final disposal of MSW and the data in the Gaza case studies are also discussed. These are subsequently applied to the four case studies of this chapter. Selection and developing of solid waste indicators is included.

Finally, Part V, the concluding one, composed of two chapters. ***Chapter Eight*** addresses and summarizes the findings of the research. ***Chapter Nine*** presents some alternative approach and recommends some policy measures (based on the findings) to overcome the disposal problems of the MSW in the Gaza Strip.

Structure of the Thesis - Table of Contents

I: Introduction Part

Chapter 1 Introduction

- Background for the study
- Goals and Objectives of the Research
- Conceptual Framework
- Limitation of the study
- Hypothesis of the Research
- Over view of the thesis

II: The Contextual Part – SWM Existing Situation

Chapter 2: An overview of the environmental Situation in the Gaza Strip

- Introduction
- Demographic information
- Status of important environmental themes
- History of the environmental management
- SWM Existing Situation
- Trends of Development & Waste Management in Gaza

Chapter 3: Issues in Waste Management

- Introduction
- Historical development in Waste Management
- SWM Present Situation
- Integrated and Sustainable Waste Management
- Principle of Waste management Strategy

Chapter 4: Methods of Waste Collection and Disposal Options

- Introduction
- Existing situation of MSW disposal Option
- Sources, Quantities, Characteristics
- Storage and Collection
- Disposal Methods and Options
- The Main Influential Aspects Affecting Disposal Strategy in Gaza Strip

III: Methodological Part

Chapter 5: Research Methodology

- Introduction
- Research Design
- The Qualitative, Quantities and Triangulation Methodologies Approach
- Soft System Methodology SSM
- Preparing Data Collection

IV: The Empirical Part – Disposal Options: The Gaza Strip Case

Chapter 6: Analysis of Disposal Alternatives of Solid Waste Using SSM

- Introduction
- Application of SSM to SWM
- Rich Picture, Root Definition and CATWOE
- SSM-Seven Stages
- Conclusion

Chapter 7: The Palestinian Experience of MSW Disposal Options Through Case Studies

- Introduction
- Case Study One: Solid Waste Management Council "SWMC" – Sanitary Landfilling
- Case Study Two: Palestinian Environmental Friend "PEF" – Composting
- Case Study Three: Gaza Municipality, Reduce, Reuse, Recycle – 3R's
- Case Study Four: Shifa Hospital – Incineration

V: The Concluding Part

Chapter 8: Discussion and Summary

Chapter 9: Conclusion and recommendation

Figure 1-4: Structure of the Thesis

CHAPTER

2

PART II: THE CONTEXTUAL PART – SWM EXISTING SITUATION

CHAPTER TWO: AN OVERVIEW OF THE ENVIRONMENTAL SITUATION IN THE GAZA STRIP

PART II: THE CONTEXTUAL PART – SWM EXISTING SITUATION

CHAPTER 2: AN OVERVIEW OF THE ENVIRONMENTAL SITUATION IN THE GAZA STRIP

2.1 Introduction

This chapter describes the current environmental problems. These are: land use issues and infrastructure; population related issues, including water use, solid waste generation and wastewater and sanitation; and the industrial sectors. The environment in the West Bank and Gaza suffers from considerable strains. A shortage and pollution of resources coupled with very high population growth, few job opportunities and long years of negligence have created many environmental hazards. Shortage of water and deterioration of water quality constitute a limiting factor in the demographic and economic development of the West Bank and Gaza. Israeli security and closure problems caused interruption of economic and municipal activities and aggravated the present pollution that proliferates in every city, town or village in the West Bank and Gaza. According to the Environmental Strategy developed by the Ministry of Environmental Affairs (MEnA, 1999), the environmental problems in Gaza and the West Bank are mostly caused by the following factors:

- The demographic momentum as demonstrated by the very high birth rate, low age of the population and high dependency rate. The very high birth rate coupled with shortage of resources significantly contributes to the environmental problems. The very constrained space of the Gaza Strip and the rapid population growth has turned this strip into one of the world's most congested areas. This coupled with shortage of resources leads to environmental damage that affects public health and overloads the limited sanitation services.

- Thirty years of lack of attention, deteriorating infrastructure and negligence, which accompanied the Israeli occupation of the West Bank and Gaza. Over the period 1967-1994, there has been inadequate, even little, investment in the various environmental sectors, particularly water, wastewater sanitation and solid waste. During that period some of the existing infrastructure deteriorated while the population and their needs rapidly increased. This lead to environmental degradation in almost every aspect.

- The presence of the Israeli occupation and shortage of strong central environmental management contributed towards the indifference and lack of awareness of the needs and means of achieving acceptable environmental standards. Municipal services were not only inadequate but are deteriorating as well, with no planning or serious investments. All this has lead to a situation in which a significant part of the population of the West Bank and Gaza, particularly inside the refugee camps, has become accustomed to living with environmental standards that are well below human dignity.

- Over the last many years, the West Bank and Gaza have become the dumping ground for various second hand and obsolete small Israeli factories, appliances expired food and materials. Most of these were inefficient and environmentally unsound. This only contributed towards the deterioration of the environment in the West Bank and Gaza. The problem is accentuated by the presence of Israeli settlements - usually located on top of the hills - which discharge their waste downstream to the wadis and agricultural fields in the West Bank. This, with improper wastewater reuse practices by Palestinian farmers, resulted in the unacceptable health risks, presence of insects, mosquitoes and flies that spread disease and are a grave nuisance, particularly in the agricultural areas in the Jordan Valley.

In short, the environmental situation in the West Bank and Gaza is in a disastrous state and is deteriorating further. The situation has reached a stage that is threatening to health and is well below acceptable standards. Therefore, dealing with the environment in the West Bank and Gaza in an effective way, has become an absolute priority.

2.2 Study Area Profile

The area is presently called Gaza Governorates and was formerly part of the sub-district of Palestine, during the British Mandate Period. It was one of the 18 sub-districts and it included three towns, Gaza, Khan Yunis and Rafah, and 54 villages. The Gaza Strip has an area of only 365 km^2. The population in 2002 was 1.2 million, 36% of the total population in Palestine (MoH, 2002). From 1948 to 1991,the total population tripled from 260,000 to 785,000 people (DURP/MoPIC, 1998) which makes this area one of the most densely populated areas in the world (2,150 persons/km^2 in 1991). Gaza Governorates first came into existence 50 years ago in 1948, after the first Arab-Israeli war. Geographically, Gaza Governorates is part of the Palestinian coastal plain in South West Palestine, where it forms a long narrow rectangle. Its area is approximately 45 km^2, its width 5.7 kilometers in the North section and attaining a maximum of 12 km at the South end (Figure 2-1).

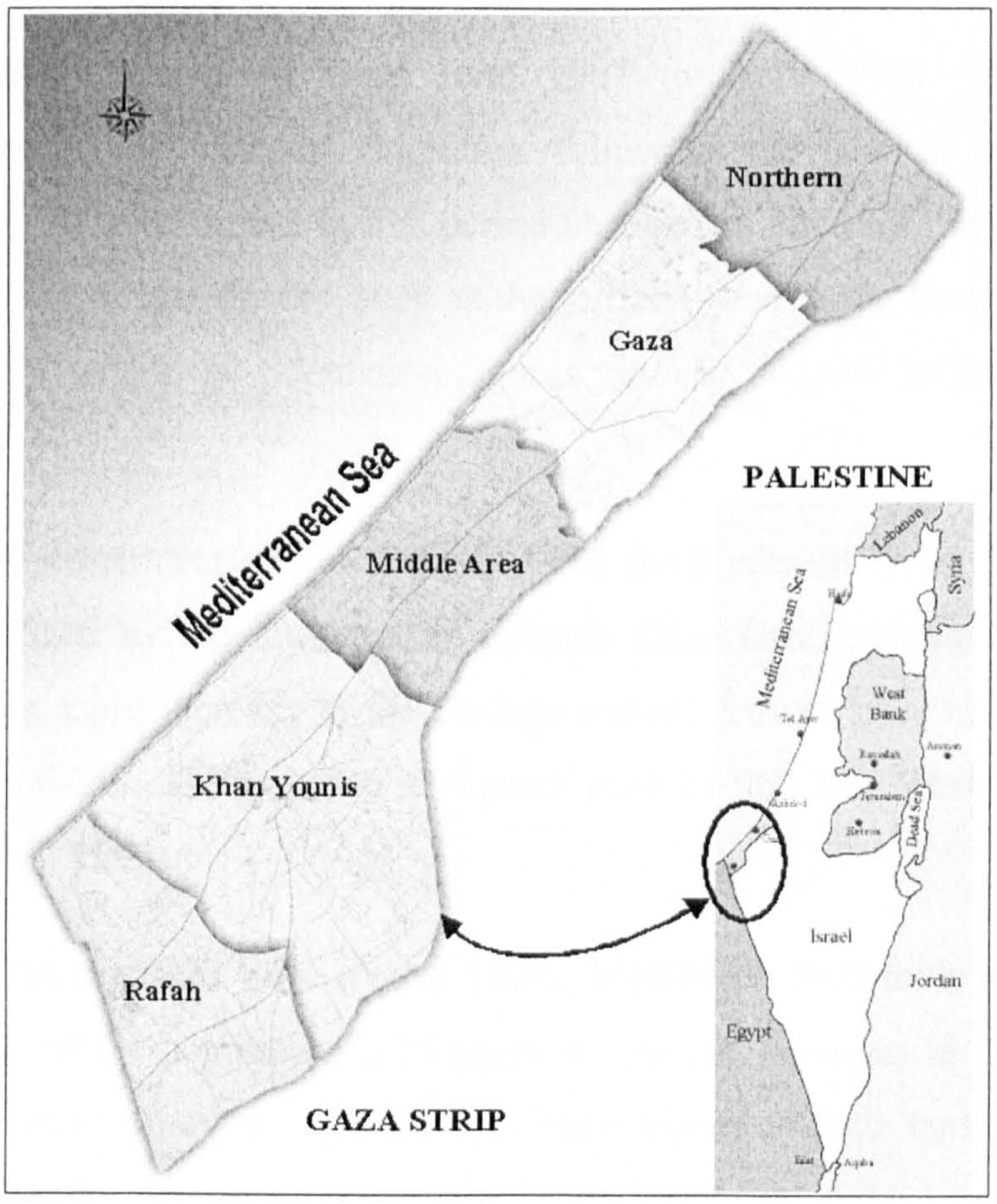

Figure 2-1: The Five Governorates of the Gaza Strip

(Source: MoPIC, 2001)

2.2.1 Demographic information

The broad population characteristics of Gaza Governorates are strongly influenced by political development, which have played a significant role in the growth and population distribution of the Governorates. A new pattern of settlement evolved with the formation of the eight refugee camps in Gaza Governorates after the Israeli-Arab war in 1948 (UNRWA, 1993).

As a result of the unique political situation of Gaza Governorates there have been three administrative periods from 1948-1998. Thus the evolution of modern Gaza can be divided into three periods:

1. The Egyptian period from 1948 to June 1967: This period is characterised by movement of the Palestinian refugees towards Gaza. Before the 1948 war, Gaza Governorates were estimated to have a population of only 800,000 indigenous inhabitants.

2. The Israeli occupation from June 1967 to April 1994. This period is characterised by external migration following the war of June 1967. In addition, the growth rate in this period changed in different decades according to changing circumstances, such as the Intifada Revolution from 1987 to 1994. From 1967-1994 the population figures reached 842,600 inhabitants (PCBS, 1998).

3. The Palestinian period from April 1994 until present time. This period is characterized by the immigration towards Gaza Governorates. In this period there was a big increase in the average annual growth rate, which reached to between 6-7%. The population figures rose to 963,300 inhabitants in 1996 (UNRWA, 1993).

Today, Gaza Governorates have a very young population in comparison with other countries – 51% of the population is 14 years or younger. As many as 21% of Gazans are 4 years of age or younger. Moreover, it has a higher average number of children per adult household members than in the West Bank and East Jerusalem (PCBS, 1998).

The socio-economic and cultural background of the Gaza sub-district of Palestine was a distinctive rural society. The primary rural nucleus was the extended family, living together in a close knit collection of houses, the families related by tradition, economic activities and socio-religious links. All such villages of the Gaza sub-district outside the present borders were eradicated after the emergence of Israel in May 1948, which caused the exodus of the Palestinian inhabitants. The distribution of the urban and rural population was changed due to political circumstances. The relative decline of the rural population was mainly due to the movement of the refugees towards different urban areas (MoPIC, 1997).

2.2.2 Population

The total area of the West Bank and Gaza is around 6185 square kilometers (km^2). According to (MoH, 2002) the West Bank and Gaza Strip are inhabited with a population around 3.2 million, of which 1.6 (50:5%) are males and 1.6 (49:5%) are females. In the Gaza Strip, the population size is estimated at 1.2 million (36.3%) of total population in Palestine, of which 603,615 (50.4%) are males and 592,976 (49.6%) females. The Palestinian population growth is one of the highest in the world, over 2.5-5.5% annually within 10 years. The population growth in the West Bank is less than in Gaza. Most of the Palestinian communities in the West Bank are rural areas, which are widely scattered into 422 small towns and villages. The population density in the West Bank is almost 330.9 persons per km^2. The Gaza Strip has a density of over 2804.4 persons per km^2. Actual population density is much higher than this, due to Israel's expropriation of land, rendering large areas inaccessible to the Palestinian who are the owners of the land.

Palestinian refugees registered by the United Nations Relief and Works Agency (UNRWA) accounted for 335,696 in the West Bank of which one-quarter of these actually live in refugee camps. However, the registered refugees in Gaza Strip are 381,659 of which 75% do live in camps (PCBS, 1998).

The population of Palestine is very young. Almost half are under the age of 15 years, and only 3.5% are above 65 years old. The dependency ratio (those under 15 and over 60 years, who depend on the working population) is over 100%, which is also very high by any standard. This also contributes to the further aggravation of the environmental situation (PCBS, 1998).

2.2.3 Population Distribution

Distribution of population over the Palestinian land has been provided by the PCBS. The trend of urbanization is demonstrated by the 54% of the population who live in urban areas. The other half is distributed between rural areas (about 30% of population) and refugee camps (about 16%). In the Gaza Strip 63.6% of the population live in urban areas, 5.3% in rural areas while 31.1% live in refugee camps. The census also shows that at the end of 1997 there were nearly 406,896 households in the West Bank and Gaza Strip. Subsequently, an average household size of about 6.4 persons is concluded (PCBS, 1998). Table 2.1 summarizes the size of the existing population and the projected population for the year 2010.

Table 2.1: Overview of existing population (1997) & projected population (2010)

Area	Population in 1998* (in million)	Population in 2010** (in million)
Gaza	1.02	1.6
East Jerusalem	0.33	0.50
West Bank	1.54	2.33
Total	**2.89**	**4.43**

* Source: PCBS Survey, 1997
** Estimates are based on PCBS Growth Rate Projection

This trend is expected to continue until the year 2015 as shown in Figure 2-2

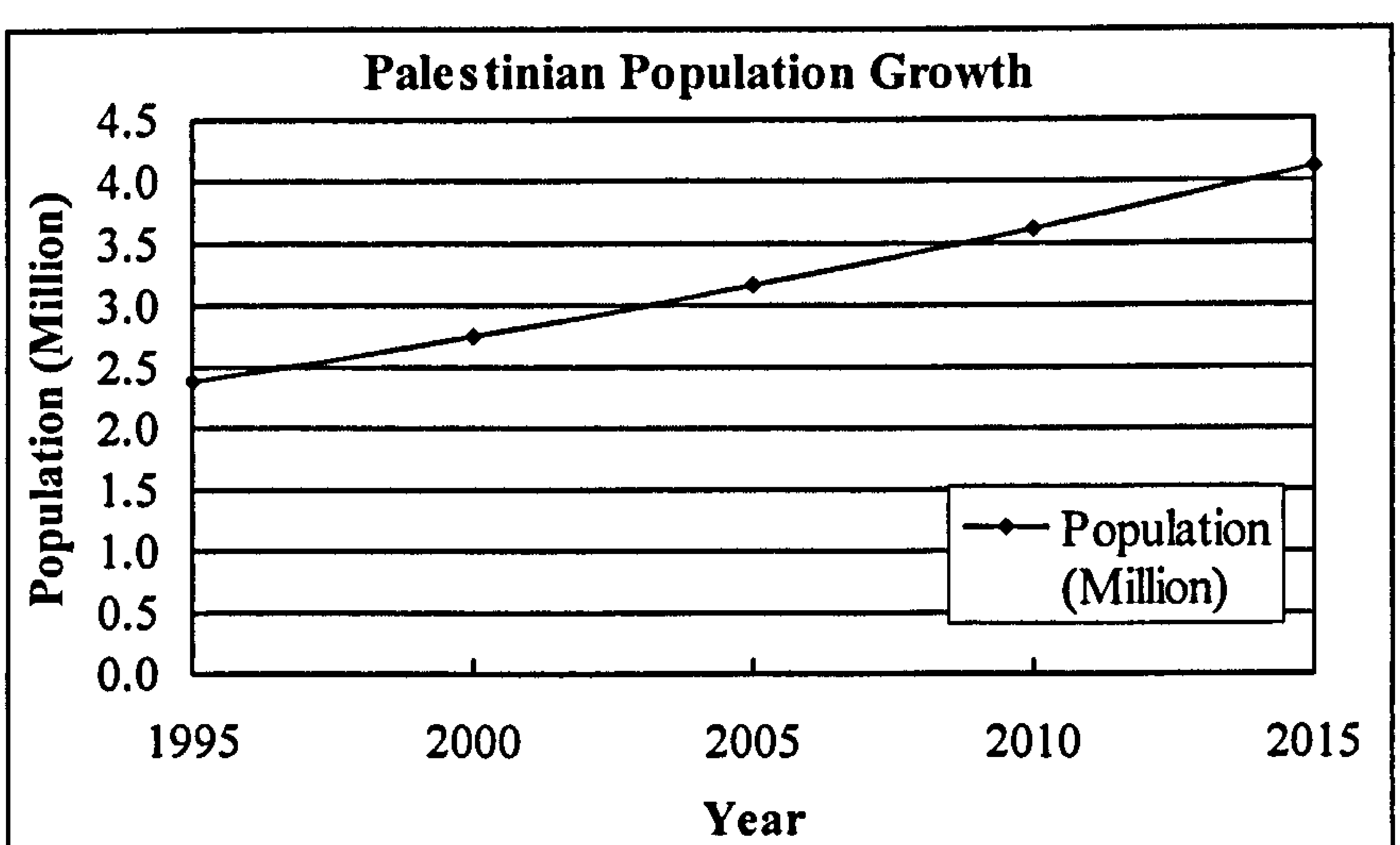

Figure 2-2: Palestinian Population Growth

Source: PCBS Survey, 1998

In Gaza many of the environmental problems are caused by the small size of the area (365 km^2) combined with the high population density. Probably the greatest problem is the shortage of good quality water – the salinity of the groundwater is high in some areas and in other parts of the Gaza Strip there is a high nitrate content (MoH, 2002).

2.3 History of Environmental Management

Part of the Gaza Strip is still under the Israeli military occupation. Environmental management, as all other aspects of life, is run by the civil administration through an environmental department, which was established in July 1993 and made operational in November 1994 under the Ministry of Health. Most of the department was transferred to the PNA through the transfer of authorities as part of the Ministry of Health (MEnA, 1999).

After the transfer of authorities in Jericho and the Gaza Strip, the Environmental Planning Directorate (EPD) was established within the Ministry of Planning and International Cooperation to deal with the issues of environmental management at the national level. The EPD was functional mostly in the Gaza Strip with limited representation in the West Bank. The researcher used to serve as director of the Solid Waste Department for the EPD (MEnA, 1999).

A number of other ministries have created environmental departments to deal with related issues, including the Ministry of Agriculture where an environmental department was created in the Gaza Strip. The Ministry of Local Government has its own environmental department to support the municipalities in dealing with environmental issues within built up areas (MEnA, 1999).

Most of the environmental services in the refugee camps in Palestine have been provided by UNRWA. Such services are connected to the municipal services outside the camps, i.e. solid waste collection, waste water, pest control and so on. Municipalities in Palestine hold complete responsibility over environmental services within the town, i.e. solid waste collection, waste water, pest control and so on. Village councils share the same responsibility within villages (UNRWA, 1993).

Until today, environmental activities and practices in the West Bank were mostly regulated by legislation which existed before 1967, mainly Jordanian legislation. The most important is the Jordanian Law of Public Health No. 43 for year 1966, as well as the Planning and Zoning Law (No. 79, for year 1966). Since the Israeli occupation in 1967, some new activities were regulated through new ad hoc instructions and regulations that were issued by the Israeli Civil Administration. Because of this haphazard approach, environmental responsibilities were distributed among too many official departments and institutions.

There was a lack of proper coordination and effective monitoring and management. Correspondingly, the Department of Environmental Health, which normally reports to the Ministry of Health, became responsible for licensing activities, ensuring quality of food and drinks, and monitoring quality of water and urban cleanliness. While, at the same time, the important role of overcoming pollution hazards in cities and towns rested with the municipalities. The scattering of environmental activities among many players with no proper legislation and the absence of a single coordinating institution contributed strongly to the present environmental degradation in Palestine.

On the 10th of December 1996, the Palestinian Environment Authority (PEnA) was established by a PNA Presidential Decree to be in charge of all environmental issues in Palestine. It was established with full legal status and its own budget. Until today there has been no law enacted to govern the duties and responsibilities for the PEnA. However, it is expected that the PEnA will be the umbrella for the environmental sector coordination, and will monitor and propose legislation and regulations for this sector. It will also be responsible for planning and will be involved in proposing projects for the sector.

At the end of 1997 a merger was worked out between the PEnA and the Environmental Planning Department (EPD), which was part of the Ministry of Planning and International Cooperation. So far, the PEnA have reached agreements and memorandum of understanding with a number of ministries on the transfer of responsibilities on environmental issues to the PEnA. These ministries include the Ministry of Planning and International Cooperation (MoPIC), the Ministry of Health (MoH), and the Ministry of Agriculture. In August 1998, the President of the PNA was appointed State Minister for the Environment. Furthermore, the President issued a decree that gave the Minister of State authorization over the PEnA. Few months ago, the PEnA was merged with the Ministry of Environmental Affairs (MEnA), which was established in August 1998 by a decree from the president of the PNA.

Palestine suffers from a large number of serious environmental problems: the available water resources have been greatly depleted; in many areas, especially in Gaza, the ground-water quality has deteriorate and natural resources have been over-explored; areas with soil pollution and erosion are expanding; dust emissions and air pollution are high; the Gaza shoreline and the marine environment have been heavily polluted; nature and biodiversity are under heavy stress; the landscape and visual environment are distorted and the rich cultural heritage is threatened by mismanagement.

These problems are big and in many cases interrelated. They are caused by a complex system of developments, not in the least by the political problems with the Israeli occupation and settlements. Currently the Palestinian Authority only has control over about 3% of the West Bank and around 60% of Gaza. It is obvious that this forms a major constraint for implementation on any environmental planning. Still, it is widely felt by the Palestinians that an integrated environmental strategy must be developed, covering the whole of the Palestine and based on a structured analysis of the problems and their causes. This strategy will formulate and prioritize the measures that are needed to tackle the big environmental problems in the coming years.

2.4 Public Health and Environmental Sanitation

Public health is one of the major reasons or justifications for improved solid waste services. The Infants Mortality Rate (IMR) is one of the main parameters for assessing the general public health condition in a population, and it is generally believed to reflect the sanitary conditions in the community. The Ministry of Health and UNRWA publish annual figures for registered infant deaths and births. The IMR has been declining rapidly over the last 20 to 25 years as a result of improved health services. However, the conditions in the Gaza Strip are worse than in the West Bank and lag far behind those in the industrialized countries.

UNRWA reports in 1996 from the Beach Camp indicate that the infection rate of ascaris (helminthes) in 4-5 year old children was 85%, and about 25% of all stools examined were positive for Gardia cysts (protozoa). In September and October 1991 Rafah Camp experienced several outbreaks of typhoid per week. These figures give an indication that the infection rate of parasitic diseases is high. The prevalent high rate of incidents of diarrheal diseases and the prevalence of enteric pathogens underline the risks of outbreaks of communal diseases.

Almost all households have a piped water supply. Groundwater is the only source of supply. The aquifer is 30-100m deep at the coastline and tapers off towards the border with Israel. The groundwater movement is from east to west, but hardly any water comes from the Israeli side. This means that the water supply capacity is limited to being recharged by rainfall on the Gaza Strip.

A field survey carried out by Camp Dresser & Mckee with UNRWA in 1996 showed that 95% of the people in the communities put improvement of the water supply and roads as the highest priority, 88% on improved sewerage and 84% on improved solid waste services. Improvements in schools, public buildings, health facilities, etc. were considered less important.

In spite of a severe housing shortage, the very high population density and severe over-crowding – 2.5 people per room in the Gaza towns, villages and camps; $10m^2$ per person in Beach Camp – the housing standard is surprisingly good. Some 98-99% of the houses are connected to electricity and a piped water supply, while only 34% are connected to sewerage in the Gaza towns and villages, and 57% use septic tanks or latrines. The remaining 9-10% are without sanitary facilities.

The water quality, however, does not meet World Health Organization (WHO) standards as the concentrations of chlorides and nitrates are too high. The groundwater is seriously polluted as a consequence of the inadequate management of liquid and solid wastes. The concentration of nitrates in the groundwater increased in the populated areas and may reach 400mg/l, which is almost 10 times the WHO recommended limit.

The sewerage systems are often incomplete and treatment plants lacking. In Khan Yunis for example, raw sewage flows into the streets in large parts of the town. The sewage is mixing with refuse, and this makes proper refuse collection almost impossible. This situation represents a serious health risk.

While the municipalities provide refuse containers for public use, less than 50% of the waste generated is actually collected. The reasons for this may be many. The more obvious are a lack of containers in some areas that the containers are spaced too far apart so that the residents resort to dumping at more convenient places, or that the containers are too few or too small and therefore keep overflowing. It is noticed that the residents keep their homes and courtyards very clean, but are much less conscious about public areas. The refuse is very often thrown in the street or at the nearest convenient place. Most public areas, vacant plots and other open areas are littered with garbage.

The environmental conditions in the Gaza Strip are so serious that they are verging on an environmental crisis and constitute a constraint to economic development in Gaza. The most important environmental aspect in connection with landfills in the Gaza Strip is possible water pollution caused by leachate from the decomposing waste and run-off from the fills. It may be seen from Figure 4.1 that the official sites are located within an area where the chloride content is still low. As shown in Figure 1 in chapter 4 for ground water quality regarding chlorides and nitrates content. Increasing salinity rates within the groundwater must be expected within 10 to 12 years based on the present extraction rate. The static groundwater level is already at or slightly below sea level. This means that there is a groundwater depression in this area. This issue has to be dealt with carefully during the feasibility study.

The amount of leachate that is produced in a landfill depends on the amount and intensity of rainfall, evaporation and run-off from the landfill itself. The mean annual rainfall on an open surface in this area is 350mm. In more humid areas the leachate production will be about 35-55% of the annual rainfall. It is expected that the leachate production from landfills in Gaza will be less than 35% of the rainfall.

Coad, (1997) argues that leachate in Gaza will have to travel 40-60m through soil before it reaches the groundwater. It is well known that bacteria and organic material are removed from water when passing through soil, and only mineralized chemicals may pass through. The soil consists of sand, silty sand and clay, which are known to have good cat ion exchange capacity, which means that most of the heavy metals will be removed in the soil, but chloride and nitrate may go through the soil.

In the latest workshop conducted by the Ministry of Health in 1998, some recommendations emerged:

- **Protection of public health.** Critical flaws in current solid waste management practices that cause public health problems needed to be eliminated.
- **Biological and infectious waste.** A separate collection and disposal system of biological and infectious waste is needed.
- **Hazardous and toxic waste.** Separate collection and disposal of hazardous and toxic waste is needed.

2.5 Natural Resources in the Palestinian Environment

2.5.1 Water Resources

Ground water is so far the largest source of water for the Palestinian people, both in the West Bank and Gaza. Other minor sources are springs, surface water occurrences and collected rainwater. Palestinians have also water rights in the surface water of the River Jordan but they are denied access to this resource. Depletion of the (fresh) ground-water resources is already a severe problem in Gaza and parts of the West Bank. In view of the envisaged demographic and economic developments, water demands in Palestine are expected to grow further, aggravating the problem of depletion of ground water as the major water source. Already the water availability for the Palestinians has been decreased to the low average of 25-30m^3 per day per capita. For comparison: the average Israeli per capita water availability is 90-100m^3 per day (PWA, 1995). The water use in the domestic sector in 1995 and the projected water demand for 2010 are presented in Table 2.2. It shows that the expected growth from 1995 until 2010 in domestic water demand will be about 100% for Gaza and some 250% for the West Bank. This increase is due to the expected growth in population as well as the envisaged increase in the per capita consumption.

Table 2.2: Overview of domestic water use and projected future demand

Source: PWA, 1995

Area	Existing water use (1995) (in MCM/year)	Expected water demand in 2010 (in MCM/year)
Gaza	47	100
West Bank	46	187

2.5.2 Wastewater Management

Currently about 70-80% of the domestic wastewater that is produced in Gaza is discharged into the environment without treatment, either directly at the source, after collection from cesspits or through the output of the sewer system. The largest part of the wastewater flows into the sea; a minor part infiltrates into the soil and contaminates the soil and ground water. Moreover, the discharge causes public health risks through direct exposure as well as through reuse of untreated wastewater on irrigated lands.

There are a few treatment facilities in Gaza, but none is working properly and thus they discharge almost untreated effluent. Similarly with storm water which occasionally causes floods during the winter period, and often mixes with sewage during periods of intense rainfall, causing pollutant torrents to flow through densely populated areas. The untreated effluent from Gaza city flows directly to Wadi Gaza, where it eventually forms a lake of raw sewage discharging into the surf zone of the Mediterranean.

The disposal of the septage from the cesspits by vacuum tankers represents a considerable volume of domestic wastewater. Ideally this volume should be disposed off in a purpose-built treatment plant or a disposal area designed specifically to deal with liquid waste. In practice the septage is dumped in the nearest open Wadis, in agricultural drainage channels or on open fields.

2.5.3 Air Pollution

In Gaza the high density of traffic and the generally old age of the cars are the main causes of the air pollution problem. In addition, the industrial coastal zone in Israel occasionally causes air pollution in Gaza, especially from the coal-fired power stations of Ashdod and Ashkelon, and the Ashdod refinery. However, the winds in Gaza blow mainly from the West, and therefore this air pollution only occasionally affects the Gaza Strip. (MEnA, 1999).

Main sources of air pollution and noise nuisance

The main sources of air pollution can be summarized as:

- Industrial air emissions near urban centers and residential areas;
- Dense traffic and old cars in the urban centers;
- Dust and particulate matter from stone quarries in the West bank; and
- Solid waste burning at open dumpsites, especially in the West Bank.
- Wastewater treatment plants.

2.5.4 Land Use in Gaza

The scarcity of land is the largest constraint with regard to the environmental management of the Gaza Strip. Urban and horticultural expansion is concentrated in the western coastal zones of Gaza. The expansion of buildings and other urban dwellings is estimated to be 1000-1500 dunums a year (1 Dunum equal $1000m^2$).

Agricultural expansion in the Gaza strip, however, seems to have reached its limits. Recently a large part of the remaining dunes and nature areas have been leveled and excavated for the purposes of intensive horticulture. Further intensification of agriculture is expected to continue, although there is a tendency to take unproductive citrus orchards out of production. As a result of the large agricultural expansion, the irrigation water resources are heavily overexploited.

Meanwhile, large agricultural areas in the eastern part of Gaza are abandoned as a result of soil Stalinization, water scarcity and marketing problems for products like citrus fruit. Although the land lies fallow, no new types of land use have been found. Relocating industrial activities might be an option for further development of these eastern areas.

Planning instruments, regulations and laws are at present not sufficiently developed. Sectoral developments take place without sufficient consideration of the conflicts of interest that may arise with other sectors. An integrated approach in this matter is urgently needed. The Regional Development Plans and the Emergency Natural Resources Protection Plan, developed by MoPIC, can provide important instruments to regulate the land use, provided that the plans will obtain a mandatory status.

2.5.5 Solid Waste Management

When the Palestinian Authority took control of the Gaza Strip and Jericho in 1994 there were many weaknesses in the solid waste management system that was inherited from the Israeli Civil Administration, partly because of the Palestinian uprising or intifada. During the time of Israeli occupation the mayors had not changed – so that some were over eighty years old before they were replaced by the Palestinian administration – taxes were not being paid as a protest, and waste containers were burned and damaged as a gesture of protest.

The deteriorating economical conditions faced by many Palestinians as a result of border closures by the Israelis motivated the international community to look for ways of alleviating the suffering by means of job creation schemes. Such schemes have included mass street sweeping programmes in Gaza to collect the fine sand, which quickly accumulates, on the roads.

Solid waste management continues to be seen as an important issue. There is particular concern in the Gaza Strip about the area of land that will be required for landfill disposal of waste, and whether sanitary landfilling is a sustainable option for Gaza. This is explained further in the landfilling case study in chapter seven. In the West Bank there is insufficient storage and collection equipment and there are no sanitary landfills. The uncertainty over the political future of many West Bank communities makes the situation much more difficult, and in many towns and villages waste is burned in the streets – often in overfilled containers – or dumped beside roads just outside the built-up area.

The situation with respect to generation and collection of solid waste in Gaza is comparable to that in the West Bank, although in Gaza collection services cover a larger percentage of the population. With respect to solid waste disposal, however, considerable progress has been made in the Gaza Strip. Many small, uncontrolled dumpsites have been closed – that is, they are no longer being used – and there are currently two controlled landfills in operation - Gaza City and Deir El-Balah. At the most northern and southern parts of the Strip there are still problems with solid waste disposal; however a sanitary landfill is being constructed east of Rafah in the south. Part of the site near Gaza City was lined to make it suitable for the disposal of hazardous waste and it is operating at present.

A survey conducted by MoPIC in 1997 of the top 20 municipalities on the West Bank and Gaza Strip indicates that their solid waste budgets include only collection costs and not the disposal costs of solid waste.

2.6 Current Situation of SWM in the Gaza Strip

Although very few field tests have been carried out on solid waste contents in the Gaza Strip, it can be generalized that among domestic premises, shops, offices, hotels, institutions and factories, household waste accounts for more than 70% of the total in cities like Gaza, Khan Younis and Rafah. This percentage is less than 50% in the northern agricultural cities like Beit Lahia, Jabalia and Beit Hanoun (EPD/MoPIC 1998).

2.6.1 Quantities and Characteristics

The quantities of waste collected in towns, villages and camps are usually estimated based on the number of people served, the equipment in operation, the loads transported to the landfills, and the professional judgments of experts.

Estimates of solid waste production per capita per day are different:

- UNRWA estimates 2 liters of solid waste are generated per capita per day.
- The findings of the GTZ Project Adviser at the Middle Area are 0.7-0.8kg per person per day.
- In a recent study for PECDAR and the EU it was found that 75% of waste is organic kitchen waste. Waste density was also estimated as 250-600kg/m^3.

Generally typical waste composition in the Gaza Strip could be as follows:

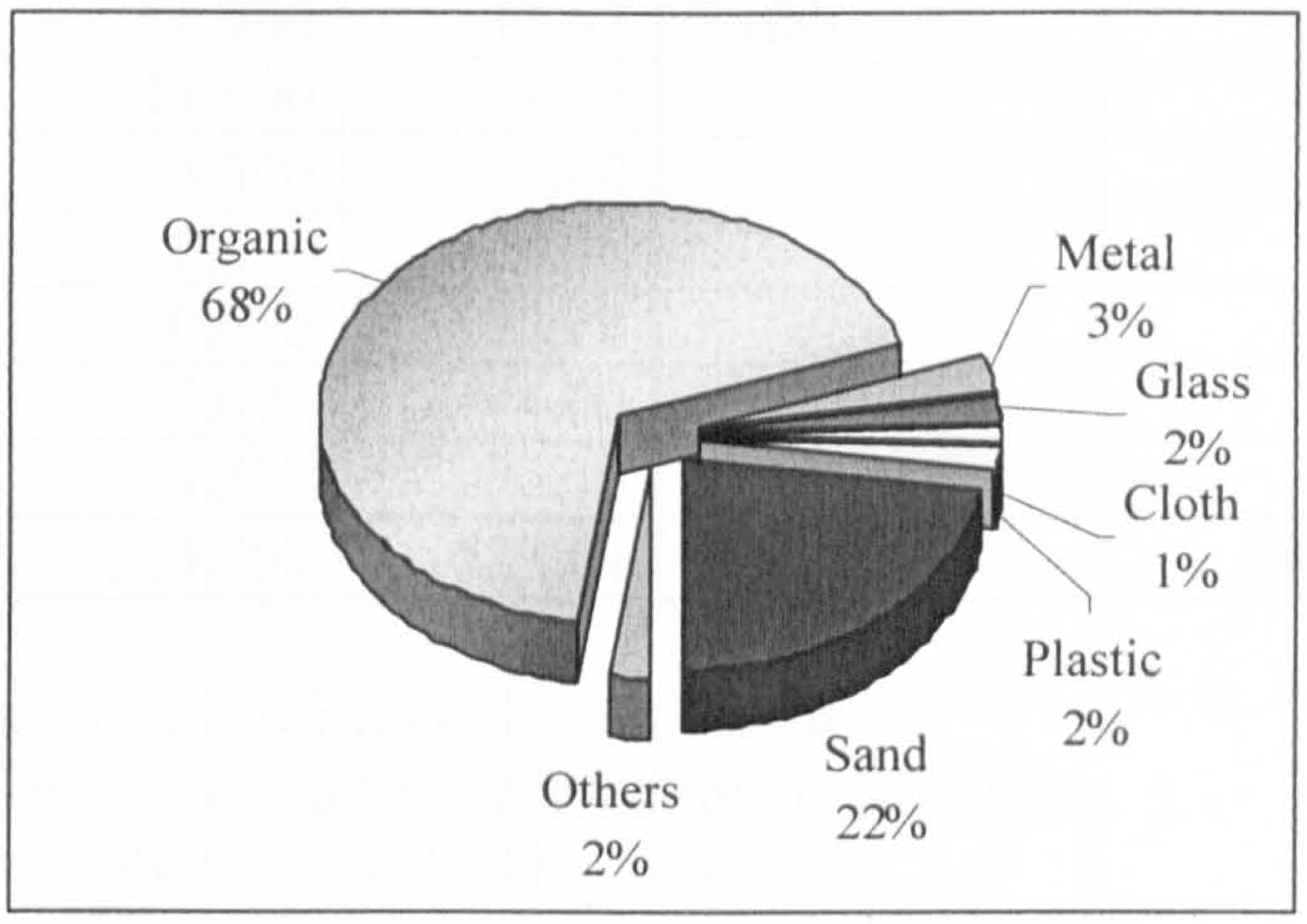

Figure 2-3: The solid waste characteristics in the Gaza Strip

(UNRWA, 2000)

Further estimates from different parties conclude that less than half of the waste generated in the households is actually collected and disposed of at the official landfills. The remaining waste is littering the roads, open spaces, beaches, wadis, and temporary and unofficial dumps. The general appearance of the area supports this estimate. This is considered a rather poor performance. No system will collect 100% of the waste generated, but 70-90% overall collection efficiency in an urban area ought to be attainable. The prevalent collection system in the municipalities is the so-called communal system, where people bring their waste to municipal containers, mostly $0.8m^3$ capacities, which are placed along the streets or in other public areas. The containers are emptied into trucks with lifting cranes. The quantities of waste generated in Gaza Strip based on the above-mentioned assumptions are shown in Table 2.3.

Table 2.3: Quantities of Wastes Generated in the Gaza Strip

(Source: UNRWA, 1995)

Towns & Villages	Population (1995)	Refuse Ton/day	UNRWA Camps	Population (1995)	Refuse Ton/day
Jabalia	33,300	26.64	Jabalia Camp	60,400	42.28
Beit Hanoun	15,000	12.00	Beach	50,400	35.28
Beit Lahia	21,100	16.88	Bureij	22,200	15.54
Gaza	278,900	278.9	Nusirate	42,300	29.61
D/Balah	35,200	28.16	Maghazi	17,200	12.04
Zawaida	8,100	6.48	D/Balah	12,100	8.47
Qarara	11,100	8.88	Khan Younis	42,300	29.61

Towns & Villages	Population (1995)	Refuse Ton/day	UNRWA Camps	Population (1995)	Refuse Ton/day
Bani Suhaila	16,900	13.52	Rafah	55,400	38.78
Abasan Kabira	11,600	9.28			
Abasan Sagh.	5,500	4.40			
Khuza'a	6,200	4.96			
Khan Younis	90,600	72.78			
Al Bayouq	5,000	4.00			
Rafah	45,200	36.16			
Total	**583,700**	**523.04**		**302,300**	**211.61**

Notes:
1. Refuse generation rate is 0.7 kg/c/d in all camps
2. Refuse generation rate is 0.8 kg/c/d in all towns & villages
3. Refuse generation rate is 1.0 kg/c/d in Gaza town
4. Refuse density at containers is assumed as 0.35-0.40kg/litre.

2.6.2 Hazardous Waste

There is currently no definition to specify which waste is considered hazardous. Many industrial and commercial sources are small: such as dry-cleaning businesses, discarding organic solvents; photographic laboratories, discarding used processing chemicals; garages, waste lubricating oil; woodworking and metal fabrication shops, paints, cleaning chemicals; and tanneries, heavy metals. Much of this waste is liquid, but it can be classed as solid waste if it is transported in tanks or containers and it may be deposited on solid waste disposal sites.

In the absence of legislation requiring hazardous waste producers to notify the authorities about their waste, it is necessary for the authorities to look for the producers. There is a database of industries prepared by the Palestinian Chamber of Commerce, and the Development Resources Center in Gaza has done some investigations of the industries in Gaza. The Environmental Planning Directorate has started a programme of visiting industries to undertake a preliminary environmental survey, looking for potential environmental hazards associated with each factory. There is, as yet, no inventory of sources of dangerous waste.

Some work has been done by the EPD in conjunction with the Ministry of Health, to collect information about current practices relating to the management of waste generated in hospitals and other healthcare facilities. It appears that hospitals have no comprehensive system for segregating hazardous biological and chemical waste from other general waste, and that many dangerous types of waste are deposited in communal containers where children and animals have access to them. Children like playing with syringes and some have been injured by them, and such injuries are able to transmit infections, which could be fatal. Hospital administrations seemed to regard management of infectious wastes as of little importance.

Coad, 1997 argues that donors have provided several incinerators for hospital wastes, but most are very simple and not equipped with pollution control facilities. The incinerator at Shifa hospital in Gaza City caused many complaints because of the smoke and smell it emitted, and it was ordered to cease operation (more detail on this is explained in the incineration case study in chapter seven). A small incinerator in Jericho was operated incorrectly at first perhaps because of language difficulties between the commissioning engineer and the operator. It was claimed that the incinerator that was installed in a large hospital complex in Khan Yunis did not meet European standards. At one time it was announced by the Ministry of Health that no further incinerators should be installed because of the air pollution problems associated with them. Some influential people seem to have the idea that an incinerator solves the problem of hospital waste management, not realizing that segregation and safe management of hazardous wastes is a question of changing the culture of a hospital, involving staff at all levels, and is more a question of training, motivation and supervision than of the installation of an incinerator (Coad, 1997).

2.7 Institutional Arrangement of SWM in The Gaza Strip

During the Israeli occupation there was no Palestinian structure at governmental level to take the lead in environmental issues or to formulate legislation and guidelines. Only since the Oslo-I Agreement was signed have the Palestinians been entitled to establish a regulating body.

The Palestinians gained limited autonomy, first over the Gaza Strip and Jericho in 1994, and then over other parts of the West Bank during 1996. When formed, the Palestinian National Authority (PNA) and the municipalities had little experience in administering services like solid waste management. The relatively low performance level of SWM services is strongly related to this lack of experience and lack of strategies or policies.

The PNA, the Ministry of Local Government (MoLG) and the Ministry of Environmental Affairs (MEnA's) goal and corporate strategy focuses on the use of waste as a resource in economic development, and they intend to maximize the reuse of waste materials. To the extent that this is possible such a strategy will both increase the life expectancy of the landfills by reducing the amount of waste that needs to be buried, as well as creating additional sources of revenue through the sale of recycled materials and compost. The main functions, responsibilities and tasks for Palestinian institutions involved in SWM are elaborated in Table 2.4.

Table 2.4: Palestinian Institutions Involved in SWM

Source: Gaza Governorate, (2002)

Institution	Roles, mandate and Responsibilities
Ministries • MoLG • MEnA • MoPIC • MoH	▪ Identify and prioritize needs for the municipalities ▪ Prepare project proposals and aid coordination with donors on behalf of municipalities ▪ Coordination and facilitations between municipalities village councils, UNRWA, NGO's and private sector. ▪ Strategies, polices and regulation/enforcement for SWM.
Municipalities	▪ SW data collection, technical reports and needs assessment. ▪ Daily supervision, monitoring and enforcing of SWM. ▪ Responding to the public claims on SWM issues.
UNRWA	▪ Provide SW services to the refugee camps. ▪ Prepare SWM proposals to be funded from donors in cooperation with MoPIC through Palestinian Development Plan PDP. ▪ Exchange equipments with municipalities and village councils. ▪ Cooperation with municipalities in disposal facilities.
SWMC	▪ Provide municipalities and village councils in the middle area with collection and disposal of SW. ▪ Raising environmental awareness to the public in the middle area ▪ Fundraising of SWM projects in cooperation with the PNA and UNRWA.
NGO's	▪ Awareness campaigns and other educational materials. ▪ Implement SW projects on a community and pilot scale.
Private Sector	▪ Carry out SW operations in the emergency cases. ▪ Provide SW collection and landfill operation to municipalities in case of donor funded projects.

2.8 Trends of Development and Waste Management in Gaza

Coad, (1997) argues that Gaza is covered with many unofficial and/or uncontrolled dump sites that are currently used for disposal of solid wastes. These are very unsatisfactory from many environmental and aesthetic stand points, causing air and water pollution, contaminating soil and spoiling their surroundings. According to the field survey by the researcher, dumpsites spread over kilometers of the coastal zone. Gaza has scant economic resources and so it is doubly appropriate to examine the potential for the reuse or recycling of construction or municipal waste. Lack of environmental laws and regulations related to solid waste activities have negatively affected the management of solid waste.

According to the UNRWA/CDM report in 1993 on Strategic Actions for the Development of the Environmental Health Sector in the Gaza Strip, the increase in population during the last 40 years has been substantial. Overpopulation has created adverse living conditions, directly or indirectly influencing the quality of health and social well-being of the population. In some situations, human and animal life is directly threatened and requires an immediate response. For example, dumpsites are spots where children play or try to find materials to play with. The other adverse developments such as unsustainable use of scarce resources like land, water and semi natural landscapes may inhibit economic and social development of the area in the medium term. During this time the refugee population tripled from 170,000 to 510,000 people with an estimated 280,000 (55%) living in the more densely populated refugee camps. Taking the 1995 population as 886,000 people and the Gaza strip as 365km^2 in area, the population density is then 2,427 persons/km^2 as explained in Table 2.5.

Table 2.5: Population Trends for the Gaza Strip

Source: UNRWA, 1993

Year	Refugees		Residents	Settlers	Total
	In Camps	Outside Camps			
1990	280,000	230,000	275,000	3,000	788,000
1995	335,000	250,000	285,000	10,000	880,000
2000	398,000	297,000	300,000	20,000	1,015,000
2005	472,000	354,000	315,000	34,000	1,175,000
2010	560,000	420,000	330,000	50,000	1,360,000

It can be seen that refugees living in camps represent a high growth rate at 4.5 percent per year (based on UNRWA statistics), while outside the camps the annual growth rate is projected at just under 4.5 percent per year. Recent hospital statistics indicate a current birth rate approaching 6 percent. Even with the projected rates used above, the total population for the Gaza Strip is expected to exceed 1,000,000 people by the year 2000 and 1,360,000 by the year 2010. This is an increase of 72 percent from the 1990 population, taking into consideration the political changes and the possible outcomes of the Declaration of Principals between the PLO and Israel. Palestinian returnees are expected to contribute to make population growth rates as high as 6.8% for the period 1995-2000 and 3.5% for the period 2000-2010, and as a result solid waste generation is expected to be significantly increased (UNRWA, 1993).

2.9 Summary

In this chapter, the current environmental problems like land use, infrastructure, population, water, wastewater and environmental sanitation in the Gaza strip have been discussed. The demographic momentum with the very high birth rate associated with the shortage of resources have significantly contributes to the environmental and public health problems. The 30 years of Israeli occupation where no attention is being paid to the real investment in environmental sanitation sector. During this period, the Gaza Strip has become a dumping site for the Israeli second hand and obsolete small factories. The wastewater discharged from the Israeli settlements to the Palestinian farms was the main cause of unacceptable health risk, aesthetic problems, presence of insects, mosquitoes and flies and spread disease. Water quality does not meet World

Health Organization standard as the concentration of chlorides and nitrates are too high. It is polluted as a consequence of the inadequate management of liquid and solid waste since 20-30 of the Palestinian cities has access to sewage networks. Sitting of landfills in the Gaza Strip is one of the most ever problems facing local authorities due to the lack of convenient sites available for landfilling and the Israeli conditions that the Palestinian National Authority has to follow. Recently, solid waste management has become one of the sectors, which got some funding from donors mainly in landfill construction, equipments, containers, and institutional building as explained in chapter seven. In the Gaza Strip, solid waste budget includes only collection costs and not the disposal one. Solid waste characteristics is mainly organic, around 70% of the waste generated is organic waste although composting is being considered on a national level as explained in chapter seven in case study two.

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CHAPTER
3

CHAPTER THREE:

ISSUES IN WASTE MANAGEMENT

CHAPTER 3: ISSUES IN WASTE MANAGEMENT

3.1 Introduction

This chapter is focused on key issues in waste management, which form the general backbone of support for this research. It contains four sections. **Section one** considers the historical development in waste management. **Section two** discusses the solid waste management (SWM) situation in developing countries including the Gaza Strip. **Section three** discusses integrated solid waste management (ISWM), it's definition, analysis, understanding and principles, focusing on the waste management hierarchy and as a part of strategic planning. **Section four** discusses the definition of sustainability including the key principles of sustainability, sustainable development indicators, waste and sustainable development, the society and public participation and finally the development of sustainable waste management. Part of this chapter is focused on the present practices from the PNA institutions, UNRWA and municipalities in the Gaza Strip that require policies and strategies on sustainable waste management with a special focus on the disposal practices of MSW.

3.2 Historical Development in Waste Management

Virtually everything we do creates waste. People in the early years disposed of their waste in holes dug behind their houses or on their farmland. This practice may help reduce waste and improve the quality of the crops but as populations increased and towns were established, waste disposal became a concern for all.

Dumping in ready dug holes may sound reasonable in the countryside but not in towns. Historically, according to Haris and Bickerstaffe (1990), people in the towns tended to dump their waste on to streets and "street dumping" became common practice throughout the world. To try to curb this ill-practice of household and street dumping, the authorities introduced laws and regulations. In London at 1297 a law was brought in to ensure that householders kept the frontage of their houses clean but it produced little effect. It was not until 1354 assistants to the Beadle of each London ward, also called "rakers", were given the job of raking the rubbish together, loading it into carts and removing it once a week. By 1407 Londoners were ordered to keep their rubbish indoors until the rakers called for it. However, it was reported that not everyone followed this regulation and Beadles had to pay informers to report on people seen dumping rubbish carelessly. It is recorded that in 1515 Shakespeare's father was fined for depositing filth in Public Street.

The British public was for many decades apathetic about sanitation, except briefly during occasional outbreaks of cholera and typhoid, and reluctant to pay for enhanced services. By the 1840's conditions in Manchester had deteriorated to the point where the life span of members of labourers, families averaged 17 years; the corresponding lifespan in a rural areas were 38 years (Briggs, 1968).

At the height of the industrial revolution there was minimal consideration on the likely health and environmental impact caused by industrial, commercial or hazardous waste. By 1857 a Public Health Act was passed to regulate the disposal of household waste in the UK and which requested that each householder should keep their rubbish in a "movable receptacle", today commonly known as a dustbin. The Clean Air Act introduced in 1956 recorded an increase in the amount of puterscible waste when this waste was no longer burned together with fuel in the open coal fires for heating homes. The increase in "fly-tipping" of hazardous waste lead parliament to introduce the Deposit of Poisons Waste Act in 1972.

By 1989 the EC produced a Waste Management Strategy that provided guidelines on waste disposal methods. In January 1995, a consultation paper on a Waste Strategy for England and Wales by the UK Governorate as part of Sustainable Development Strategy (DoE, 1995) was drafted. Waste cannot be made to disappear but it can be managed so that it minimizes harm to people and to the environment.

3.3 Solid Waste Management Existing Situation

After the UN conference of the Environment and Development in Rio de Janeiro, Brazil, the industrialized nations produced an agenda of strategies on how to reduce the production of waste at the source of its generation. Many local authorities have now to review and identify their waste management strategies. When preparing their waste management strategies, local authorities have three basic questions to take into consideration (John, 1995b);

- What is the environmental effect arising from waste management activities?
- Are there interruptions and changes to the present waste services?
- What is the cost implication for each type of waste activity?

Jorgensen and Jakobsen's (1994) study on MSW in the Mediterranean region concluded that any waste strategy adopted by any authority must include the provision of an appropriate and effective waste collection service. It must provide an effective and economical transportation system to the disposal facilities. The most important part of this strategy is that all waste related services are environmentally safe and running at a practicable low cost for the waste disposal system over the long-term.

It is also a common phenomenon today, that many countries are experiencing waste disposal problems stemming from shortage of landfill space like the case in the Gaza Strip. The increase in public concern on the environmental impacts and the appearance of these landfills has long been debated. The change in approach and methods of waste disposal world-wide are due to increasing concerns regarding the impact of solid waste on health, safety and the environment. The disposal methods have not only changed over time but have improved with the application of the latest technology in waste disposal (Coad, 1997).

Despite all the remedial plans to combat an increase in the production of waste, the industrialized nations are still facing the major issues of finding and adopting an environmentally sound means of waste disposal. The main concern for many nations is waste originating from the municipalities, hospitals and clinics and in particular the industrial hazardous wastes from industries. The amount of waste generated has grown annually over the past decades and improper disposal may result in numerous and serious environmental problems (Coad, 1997).

Incineration, at one time was a popular alternative to landfill to solve these problems. However, it is now facing more stringent emissions regulations since many of the old installations are producing poor environmental records such as air pollution and had no additional benefits besides the disposal of waste (Donnelley, 1991). A properly designed incinerator will, however, meet the emission standard requirements and it should produce a very high degree of destruction to this waste. Nevertheless, records have shown that incineration of municipal and hazardous waste has the potential for increasing air pollution as well as causing ground water contamination due to the leaching of ash residue (Donnelley, 1991; Hill, et al. 1991, Morselli, et al. 1992).

Although landfill is still the cheapest form of disposal, the cost is rising due to the implementation of environmentally acceptable landfill techniques. Thus, cost-competitive alternative methods such as recycling and conversion of waste to other products such as fuel have recently increased in popularity. Such conversion is now feasible due to recent advances in waste disposal techniques and methodologies (Sharp and Ness 1991). It has also been reported that landfilling of unprocessed MSW is or is soon to be banned in countries such as Denmark, France, Germany and the Netherlands (Palin, 1995).

Coad (1997) argues that SWM continues to be seen as an important issue. There is particular concern in the Gaza Strip about the area of land that will be required for landfill disposal of waste, and whether sanitary landfilling is a sustainable option for Gaza. In the West Bank there is insufficient storage and collection equipment and there are no sanitary landfills. Now the World Bank is in the process of creating what is called the "Joint Service Council" which is similar to the Solid Waste Management Council (SWMC) in Gaza as discussed in chapter six. The uncertainty over the political future of many West Bank communities makes the situation much more difficult, and in many towns and villages waste is burned in the streets - often in overfilled containers) - or dumped beside a road just outside the built-up area.

In the Gaza Strip, waste management services have been provided by municipal and village councils at the towns and villages. The UNRWA has provided similar services at the refugee camps also since 1950. The collected waste is generally disposed of at sites run by municipalities, and in most of the cases a fee is paid to the operating organization. The UNRWA has also given assistance to municipalities in the Gaza Strip by being the channel through which equipment, provided by bilateral donors, has been provided. There would appear to be a considerable amount of overlap between the roles of the UNRWA and the municipalities. At the same time there is a need for a standardized approach to SWM and cooperation throughout the Gaza Strip (UNRWA, 1996).

3.4 Integrated Solid Waste Management - ISWM

There have been long discussions about the use of the term "integrated". Diaz et al. (1993, p268) highlighted the widespread use of the term integrated in SWM nomenclature. They argued that the term "integrated management" should be reserved for systems, schemes, operations or elements in which the constituent units can be designed or arranged in such a way that one meshes with another, to achieve a common overall objective.

Integrated solid waste management (ISWM) is defined by Tchobanoglous et al. (1993) as "the selection and application of appropriate techniques, technologies, and management programs to achieve specific waste management objectives and goals". Understanding the inter-relationships among various waste activities makes it possible to create an ISWM plan where individual components complement one another.

All functional elements of the waste management system need to be evaluated for use. All of the interfaces and connections between elements need to match the concepts of sustainable principles. When that has been achieved, the community has developed an effective, economic and integrated waste system (Diaz et al. 1993, p268. According to Qasim and Chiang (1994), a successful SWM utilizes many functional elements associated with generation, on-site storage, collection, transfer, transport, characterization and processing, resource recovery and final disposal. All these elements are interrelated and must be studied and evaluated carefully before any SWM system can be adopted. Read, Phillips and Murphy (1997) refer to the UK National Strategy for waste management options as depicted in Figure 3.1.

Petts and Edulgee (1994:20) pointed out that a real framework for waste management must emphasize three elements:

- The formulation of policy
- The regulatory and control regime
- The availability of appropriate treatment and disposal techniques and facilities in order to implement the selected waste management route for a particular waste stream.

The selected waste management route is determined after considering the following hierarchy of options, which is stated in the European Union Solid Waste Strategy (EC, 1996c).

- Waste reduction at source, waste minimization in a prevention attitude.
- Waste reuse and recycling.
- Recovery of raw materials and /or of energy.
- Treatment of wastes.
- Disposal of the residues from treatment, and of other unavoidable waste.

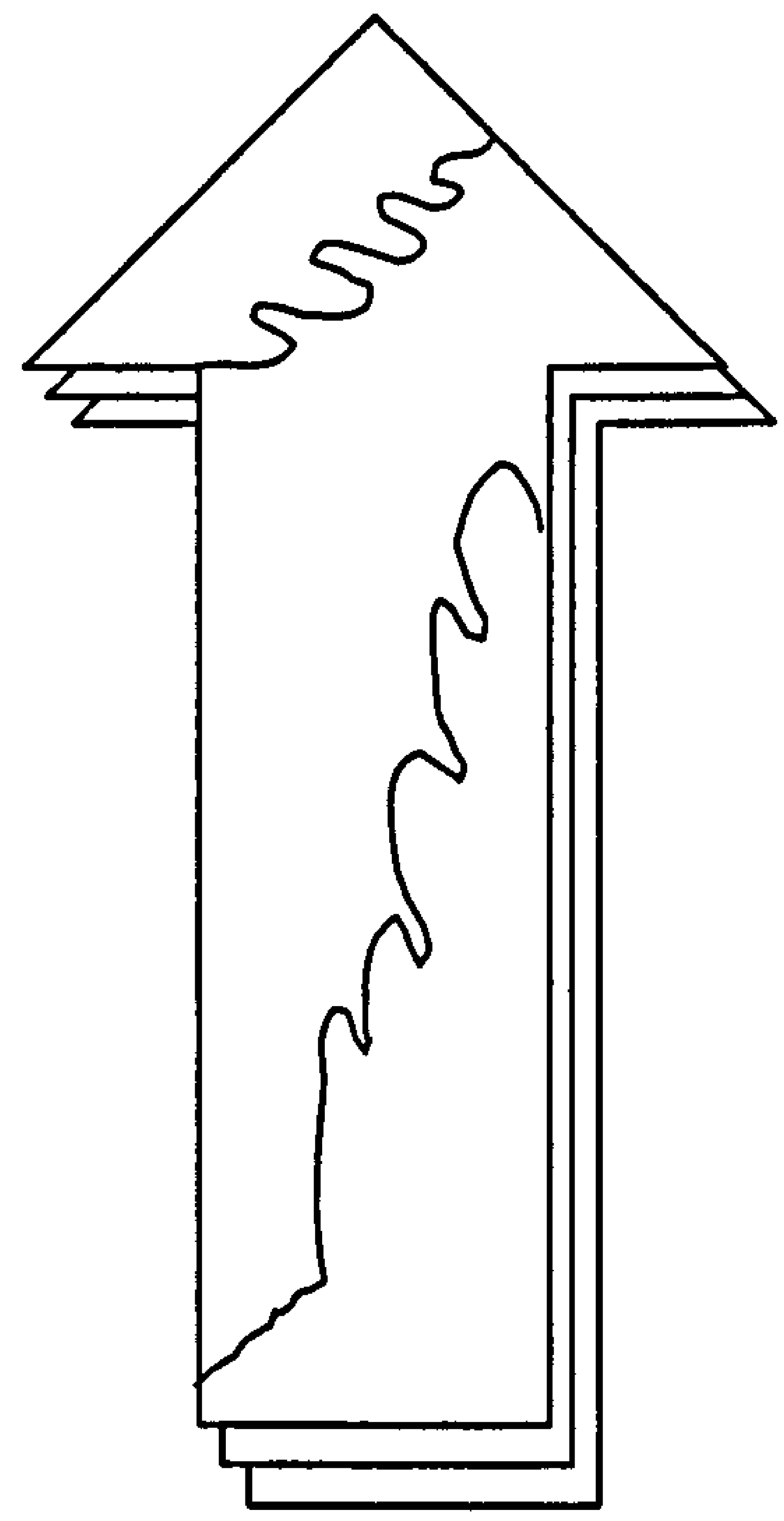
The UNEP International Environmental Technology Center (1996) describes the importance of viewing solid waste management from an integrated approach:

- Some problems can be solved more easily in combination with other aspects of the waste system than individually;
- Adjustments to one area of the waste system can disrupt existing practices in another area, unless the changes are made in a coordinated manner;
- Integration allows for capacity or resources to be completely used; economies of scale for equipment or management infrastructure can often only be achieved when all of the waste in a region is managed as part of a single system;
- Public, private, and informal sectors can be included in the waste management plan;
- An ISWM plan helps identify and select low cost alternatives;
- Some waste activities cannot handle any charges; some will always be net expenses, while others may show a profit. Without an ISWM plan, some revenue-producing activities are "skimmed off" and treated as profitable, while activities related to maintenance of public health and safety do not receive adequate funding and are managed insufficiently.

Waste hierarchies are usually established to identify key elements of an ISWM plan. The general waste hierarchy accepted by industrialized countries is reduce, reuse, recycle, recover waste transformation through physical, biological, or chemical processes (e.g., composting, incineration), landfilling (UNEP, 1996).

Re-use
This involves putting objects back into use so they do not enter waste stream, common examples are charity shops and milk and bottles

Disposal
This is the least attractive waste management option, usually landfill or incineration, and when used it must satisfy high standards



Reduction
This is the first priority for more sustainable waste management, involving reduction or minimization of waste production at source

Recovery
The recovery of value or energy from waste materials, this incorporates materials recycling, composting and the recovery of energy from waste, they are grouped which signifies that not one of these should be automatically preferred.

Figure 3-1: The UK Government current waste policy is based on a hierarchy of waste management options

Source: Philips and Murphy 1997.

The treatment and disposal of waste has developed from its early beginnings of mere dumping to a sophisticated range of options including re-use, recycling, incineration with energy recovery, advanced landfill design and engineering, and a range of alternative technologies, including paralysis, gasification, composting and anaerobic digestion. The further development of the industry is towards integration of the various options to produce an environmentally and economically sustainable waste management system.

Tchobanoglous et al (1993) define integrated waste management in terms of the integration of six functional elements. These are the following:

1. **Waste generation** – Assessment of waste generation and evaluation of waste reduction.

2. **Waste handling and separation, storage and processing at source** – Involves the activities associated with the management of wastes until they are placed in storage containers for collection.

3. **Collection** – This element of the waste management system covers the collection and transport of the waste to the location where the collection vehicle is emptied. This location may be, for example, a materials recycling facility, a waste transfer station or a landfill disposal site.

4. **Separation, processing and transformation of solid waste** – The recovery of separated materials, the separation and processing of waste components and transformation of wastes are elements, which occur primarily in locations away from the source of waste generation. This category includes waste treatment of materials at recycling facilities, activities at waste transfer stations, anaerobic digestion, composting and incineration with energy recovery.

5. **Transfer and transport** – This element involves the transfer of wastes from the smaller collection vehicles to the larger transport equipment and the subsequent transport of wastes, usually over long distances, to a processing or disposal site. The transfer usually takes place at a waste transfer station.

6. **Disposal** – Final disposal is usually landfill or land spreading i.e., the disposal of waste directly from source to a landfill site, and the disposal of residential materials from materials recycling facilities, residue from waste incineration, residue from composting or anaerobic digestion etc. to the final disposal in landfill. The inter-relationships of the six functional elements of an integrated solid waste management system are shown in Figure 3-2.

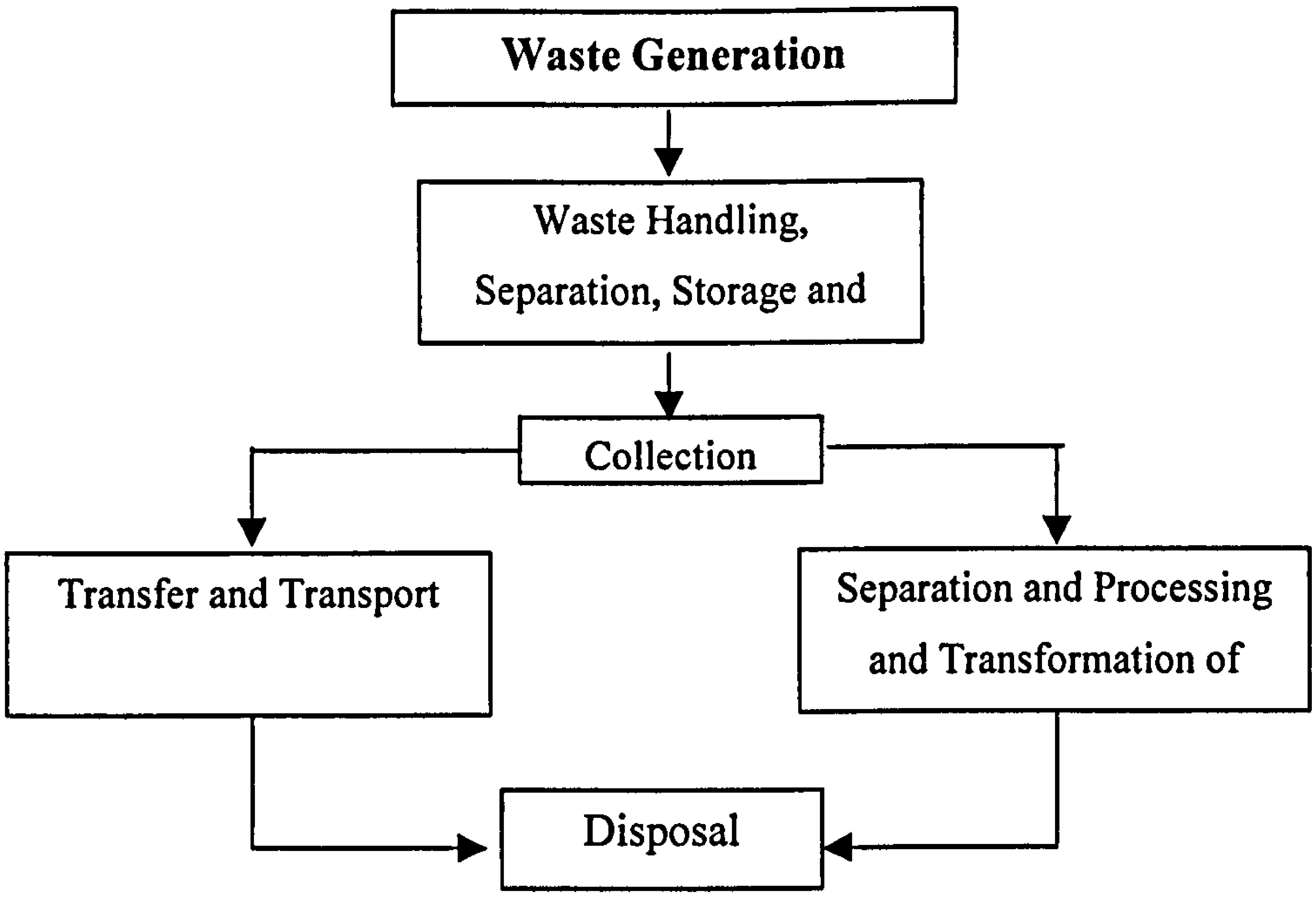


Figure 3-2: Simplified Diagram Showing the Inter-relationships Between the Functional Elements in a Solid Waste Management System.

Source: Tchobanoglous G., Thesisen H. and Vigil S., Integrated Solid Waste Management Issues. McGraw-Hill, New York, 1993. As stated in Paul T. Williams. Waste Treatment and Disposal. Chichester: John Wiley & Sons, 1998.

3.5 Integrated Solid Waste Management

Looking at historical citations one can assume that the concept of integrated solid waste management (integrated SWM) developed gradually over time. For example, in many European countries in the 1660s, burial in cotton or linen shrouds was banned to allow more cloth for paper making (World Resource Foundation, 1997). In 1896, the first combined waste incineration and electricity scheme began operation in East London. Until the early 1890s, New York's rubbish was mainly dumped in the Atlantic Ocean, polluting the beaches and resulting in protests by the resorts on the shores of New Jersey and New York. Then in 1894, a "program of source separation was implemented on the premise that mixed refuse limited the options for disposal, whereas the separation of wastes at the source allowed the city to recover some of the collection costs through the resale and reprocessing of materials" (Gandhy 1994). In the early part of this century, an ethnic minority in Cairo, Egypt, the Zabbaleen, was one of the world's first communities to integrate recovery and recycling of municipal waste (Baaijens, 1994).

Yet, it was the environmental movement in the late 1960s which formally presented integrated SWM as a guiding principle for managing societies' refuse. Since this was also a period of economic prosperity in most industrialized countries, waste managers were not constrained by narrow budgets. Thus, until the economic recessions of the early-1980s the new paradigm of integrated SWM was widely implemented in industrialized countries (Schall, 1995).

According to Lardinois and Klundert (1997), ISWM is a very broad concept. Figure 3.2 shows the overall framework, although it is not intended to be an exhaustive list of categories. Essentially integrated SWM implies that decisions on waste handling should take into account economic, environmental, social and institutional dimensions. Economic aspects may include the costs and benefits of implementation, the available municipal budgets for waste management, and the spin-off effects for other sectors in the economy in terms of investments. The environmental dimension may consist of local problems - e.g. increased risk of epidemics and groundwater pollution - regional problems - e.g. resource depletion and acid rain - and global problems - e.g. global warming and ozone depletion. Social aspects include employment effects for both the formal and the informal sector, impacts on human health and ethical issues such as the use of child labour. Finally, the institutional dimension of integrated SWM aims to develop a system, which effectively involves the main stakeholders.

The integrative aspect lies in the trade-off between these four dimensions. For example, in certain situations, although recycling may be preferred from an environmental perspective, the economic costs involved or the presence of institutional complications may prevent waste recycling from being promoted and implemented in integrated SWM. This is the case, for example, with recycling polyethylene bags in industrialized countries, where the environmental benefits are limited when weighed against the high labor costs and the absence of sufficient infrastructure. Obviously, trading-off between these four dimensions is a rather complex exercise. The actual integration can take place at various levels (Lardinois and Klundert, 1997):

1. The use of a range of different collection and treatment options. These include prevention, recycling, energy recovery and sound landfilling of solid waste. A

discussion on these options is presented below in the section on the waste hierarchy.

2. The involvement and participation of all the stakeholders. These may include waste processors such as formal and informal recyclers, waste generators such as households, industry and agriculture, and government institutions such as waste managers and urban planners.

3. The interactions between the waste system and other relevant systems such as industry. For example, product design at the industry level can have a significant impact on the 'recyclability' of the product after consumption. Since few examples from developing countries are reported in the literature, this category will not be considered in this chapter.

However, it may be very important in the concept of integrated SWM and should therefore be considered for future research.

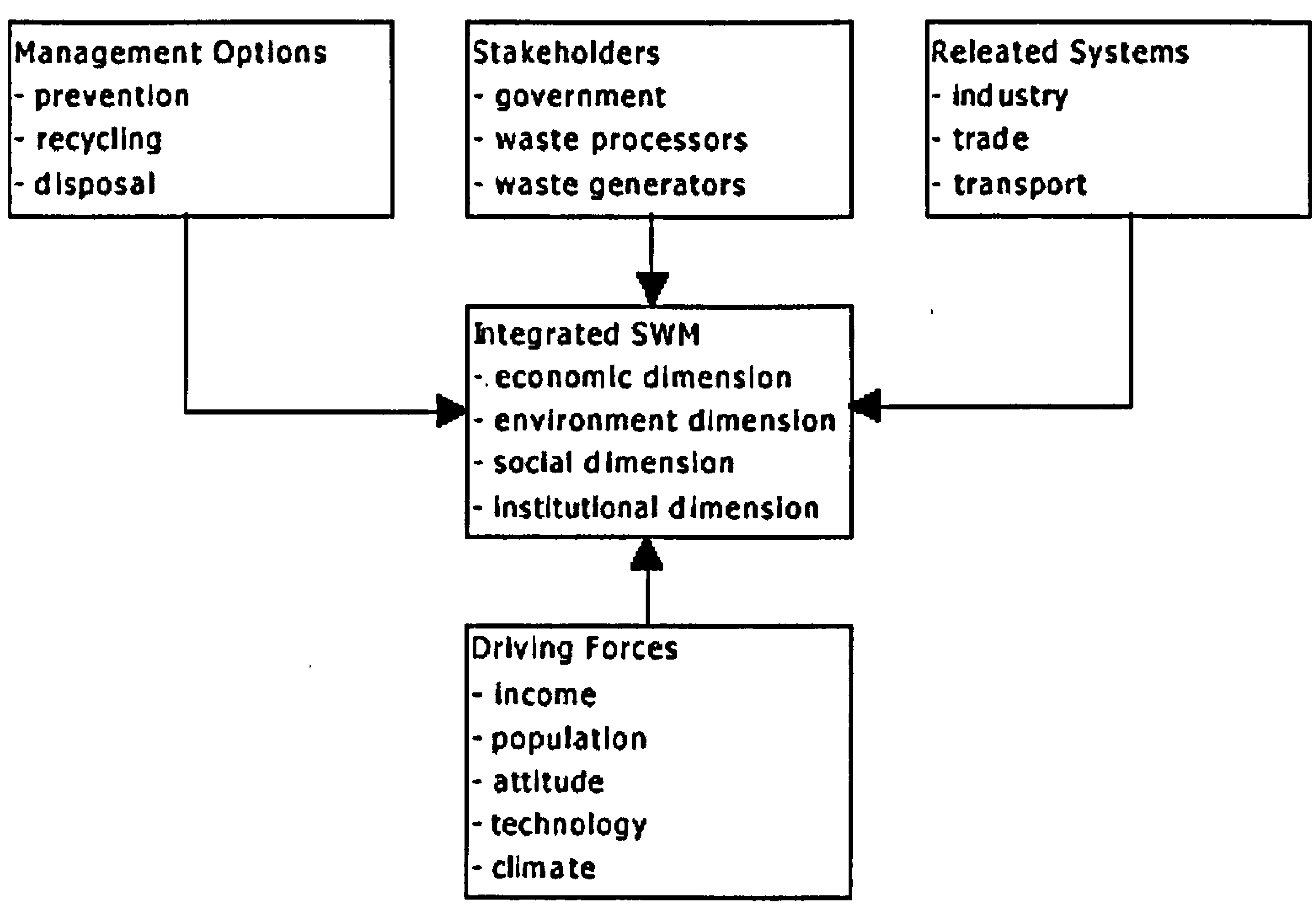


Figure 3-3: Framework for Analyzing the Concept of Integrated SWM

Source: (Lardinois and Klundert, 1997)

It is difficult to include all these aspects at the same time, since the factors affecting solid waste management are constantly changing, for example, income and population growth contribute significantly to the amount of waste, which has to be managed. Similarly, differences in educational background and environmental awareness result in the varying attitudes between waste generators. Finally, technological progress in the field of waste management is rapid, so certain technologies may become outdated more rapidly.

These problems are more severe in developing countries where limited municipal budgets for waste management exacerbate the difficulties of integration. As a result, policies tend to focus mainly on the waste hierarchy. This thesis will argue that since the social, economic and institutional factors in developing countries are quite different from those in the industrialized countries, for a waste management policy to be successful it needs to adapt concepts developed in the North to suit the circumstances in the South. In some cases, it is even doubtful if the concepts may be applied at all. For example, the prospects for curbside recycling programmes, which are very popular in Europe and the US, are questionable given both the expense and the potential impact on the existing informal recovery sector operating in most Southern cities (Beukering et al. 1996).

3.5.1 ISWM: Analysis and Understanding First, Then Problem-Solving

The ISWM insight is that most waste management problems have to do with something other – or more – than money and equipment. Some problems have to do with the attitude and behavior of citizens, waste management staff, private enterprises and waste pickers. Other problems are caused or made more serious by factors that are not technical or financial, but relate to managerial (in) capacities, the institutional framework, the environment, or the social or cultural context. In these cases, it is not money or equipment that provide solutions, but rather changing social, institutional, legal, or political conditions (Klundert et al. 2001).

The (ISWM) concept was developed to reflect this reality and as a means to articulate a vision of waste management that would pay attention to all these various aspects. ISWM promotes technically appropriate, economically viable and socially acceptable solutions to waste management problems in cities in the South, solutions, which do not degrade the environment. ISWM promotes the development of a waste management system that best suits the society, economy and environment in a particular location. ISWM commits itself to take into account the particular conditions in countries in the South and in Eastern Europe, which are quite different from those in OECD countries in the North, such as the United States and Canada, Europe, Japan and Australia (Klundert et al. 2001).

OECD countries have developed their own imperfect, unevenly functioning waste management models, systems and technologies that are suited to local conditions. These models are capital- and technology-intensive and labor extensive, like industries in the Northern industrial context. Exporting these models to the South where they may be less appropriate has proven to be ineffective; there are many examples of failures of incinerators, composting plants and collection with compactor trucks (Klundert et al. 2001).

ISWM provides some tools to look in more depth at the actual needs of communities and municipalities in the South and in Eastern Europe. It helps municipal managers and their technical staff to go beyond the simple importation of Northern models, systems and technologies (Klundert et al. 2001).

3.5.2 The ISWM Framework

3.5.2.1 ISWM Principles

According to Klundert et al. 2001, the ISWM concept takes as a point of departure four basic principles:

- **Equity**: all citizens are entitled to an appropriate waste management system for environmental health reasons
- **Effectiveness:** the waste management model applied will lead to the safe removal of all waste
- **Efficiency:** the management of all waste is done by maximizing the benefits, minimizing the costs and optimizing the use of resources, taking into account equity, effectiveness and sustainability

- **Sustainability:** the waste management system is appropriate to the local conditions and feasible from a technical, environmental, social, economic, financial, institutional and political perspective. It can maintain itself over time without exhausting the resources upon which it depends.

Equity goes beyond a moral imperative because:

- Pollution in one part of the city ultimately affects the rest of the city, including its air and water supply. Pollution 'travels' in the form of communicable diseases, flies, insects, rats, air and water pollution.
- Polluted areas lead to poor living conditions, which in turn foster social unrest, anti-governmental activities and terrorism. Abandoned waste is a symbol of a failed public service.
- Unclean neighborhoods can affect the city's economy and inhibit development. Investors will not invest in a dirty place and sick laborers have low productivity.

The effectiveness of a service is the extent to which the objectives of the service have been met in practice. For example, a street-sweeping service is effective if the streets are clean. Effectiveness for waste management in general means that all waste is removed as planned and all recoverable materials are recovered. When effectiveness is limited to the city center, tourist areas or business districts the overall waste management system is not fully effective. The less visible parts of the city are as important as – sometimes more important than – the visible ones!

The service is efficient when the benefits of clean streets are balanced by all beneficiaries paying a reasonable cost to keep them that way, using the optimal combination of labor, money, equipment, machinery and management.

Sustainability refers to the ways in which resources are used and how these fit into the local culture, context and society. These resources can be human - manpower - material - equipment - or natural resources - water, air, soil. Sustainability distinguishes between the use of renewable and non-renewable resources on the earth and also refers to the interplay of all aspects, such as social and political with technical and environmental. A system is considered sustainable when it can reproduce itself without reducing the possibilities open to the following generation of systems.

3.5.2.2 The dimensions of ISWM

According to Klundert et al (2001), ISWM has three major dimensions: (1) the stakeholders involved in waste management, (2) the practical and technical elements of the waste system and (3) the aspects of the local context that should be taken into account when assessing and planning a waste management system.

3.5.3 Stakeholders, The First ISWM Dimension

A stakeholder is person or organization that has a stake, an interest in –in this case-waste management. A number of potential stakeholders are listed in Figure 3-4. However, stakeholders in waste management differ in each city, so they need to be identified in the local context.

Stakeholders have various interests and roles within their particular type of waste management, but they can cooperate on issues of common interest. Their *influence* - the extent to which stakeholders are able to persuade or coerce others into making certain decisions or following certain courses of action - and importance - the extent to which the problems, needs and interests of a particular stakeholder are a priority in a project or plan - varies.

Klundert et al. (2001) argue that, the municipality is a major stakeholder, perhaps the most important one. But in ISWM the municipality is more than just the manager and operator of waste management services; it has roles as regulator, planner, facilitator and coordinator of multiple stakeholders. Overall responsibility for waste management in all areas of a city rests with the municipality to ensure adequate coordination and quality control for the benefit of citizens.

3.5.4 Waste System Elements, The Second ISWM Dimension

Klundert et al. (2001) argue that, all waste system elements should be looked upon as being stages in the movement, or flow, of materials from the mining stage, via processing, production and consumption stage towards final treatment and disposal. A waste management system is a combination of several stages in the management of the flow of materials within the city and the region. A waste management plan is part of an integrated materials management strategy, in which the city makes deliberate and normative decisions about how materials should flow. The waste elements then become specific tactics to deal with specific materials after they have been consumed.

Klundert et al. (2001) stressed that; ISWM recognizes the high-profile elements "collection", "transfer" and "disposal" or "treatment". It gives equal weight to the less well-understood elements of "waste minimization", "reuse" and "recycling and composting". These major elements all appear in Figure 3.4. The history and character of the locality influences which system elements are present and which are absent or under-developed. A full ISWM process seeks to supplement the existing system so that all elements are represented. Usually this means adding waste prevention or minimization, reuse and recycling to the existing mix.

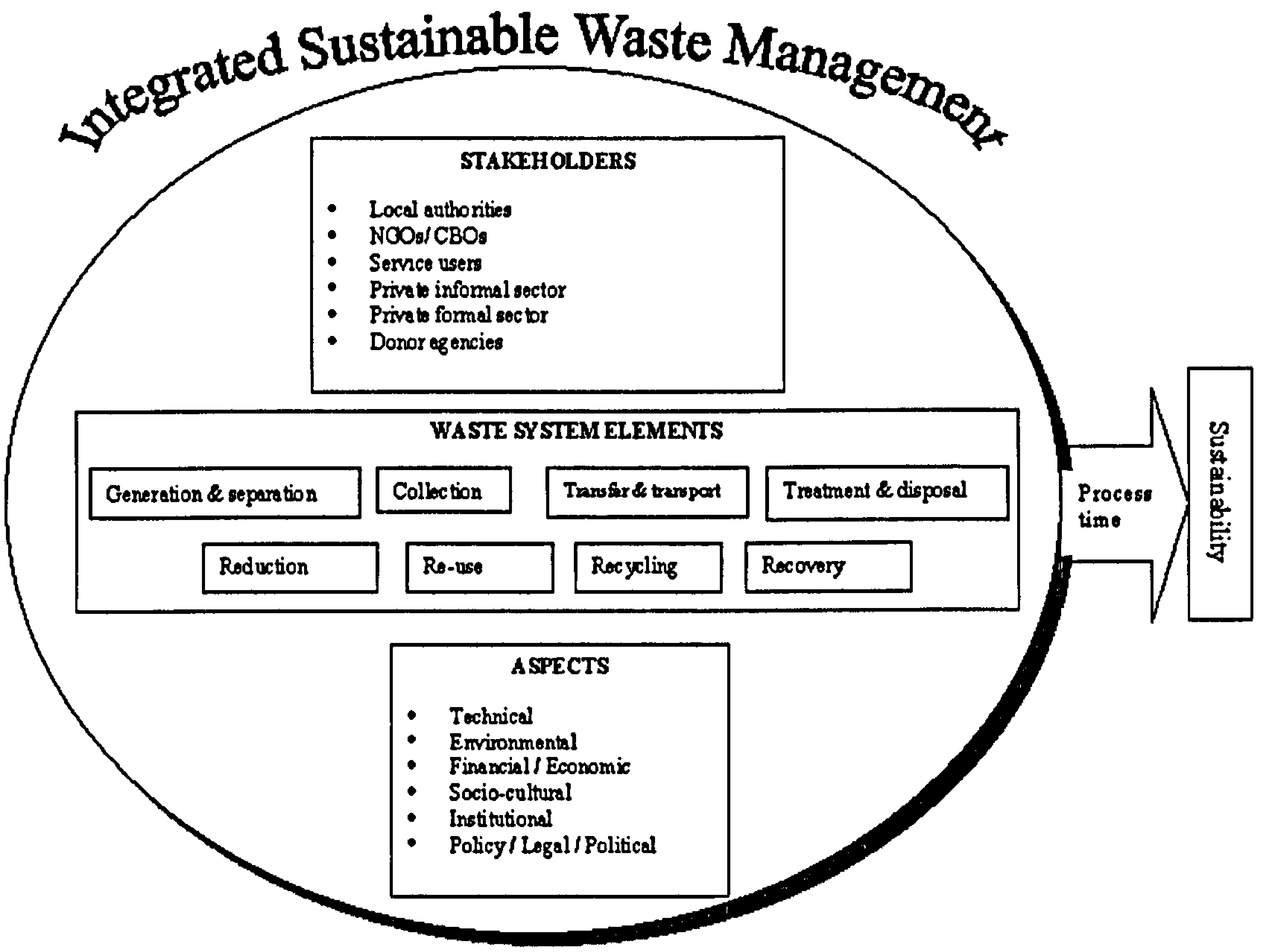


Figure 3-4: The ISWM Model

Source: Klundert and Anschutz (2001)

3.5.5 The Third Dimension: ISWM Aspects

The ISWM concept distinguishes six aspects, or lenses, through which the existing waste system can be assessed and with which a new or expanded system can be planned. The ISWM aspects give a municipal manager a set of tools to perceive, study and balance priorities and create measures to give the desired results.

Development and planning are long-term issues, which require time to occur and to mature. Foreign donor agencies and local decision-makers do not always realize this, which leads them to take ad hoc decisions or propose short-term projects that reflect well on their term in office.

Local and national elections may bring in new politicians who reverse previous policies and obstruct attempts to arrive at sustainable, long-term solutions. Under the best conditions, it still takes time to learn new habits, and to forget old, bad habits. It may take a while before new attitudes and behaviors, for example separation at source, are rooted in society and new measures and approaches prove their value.

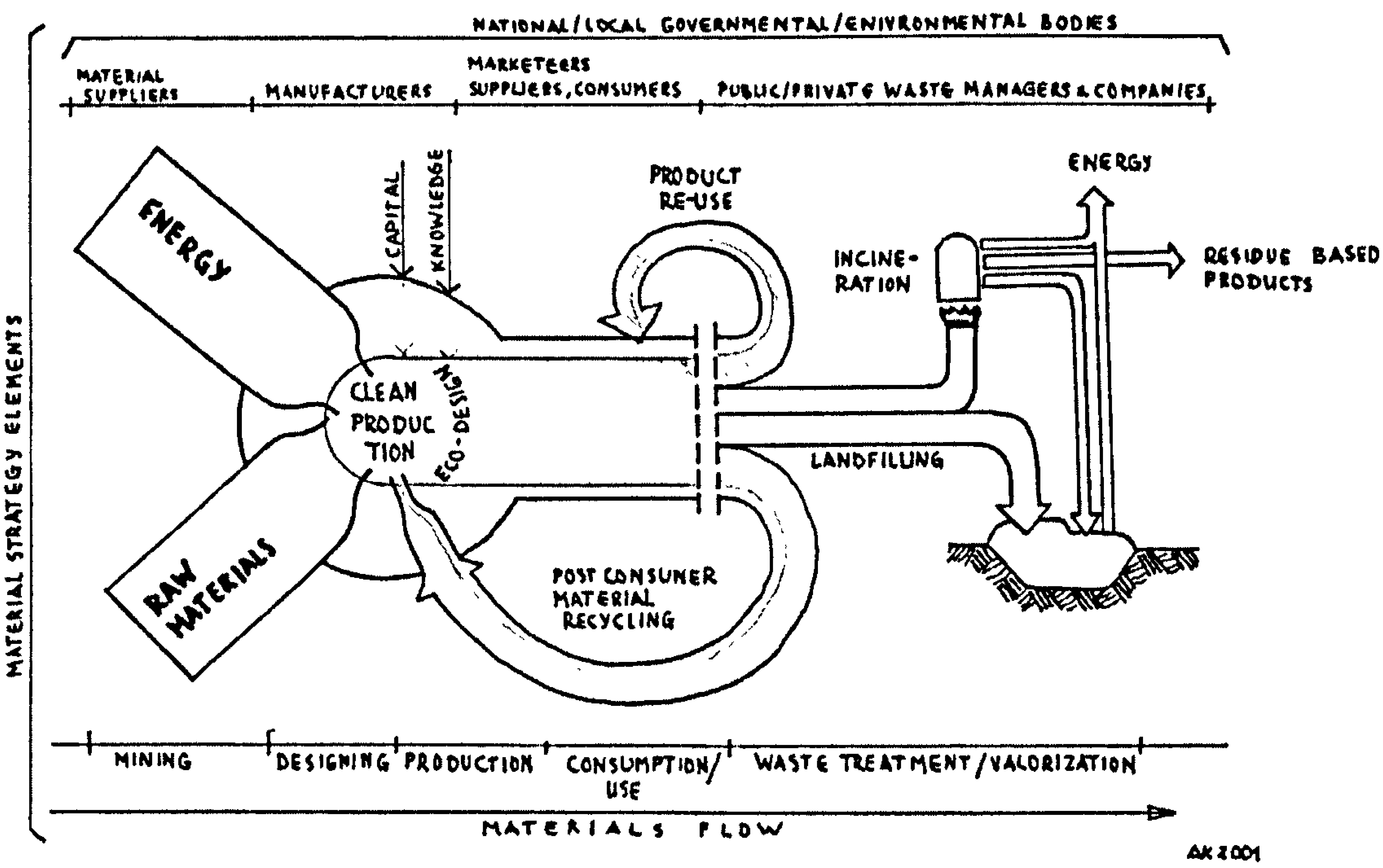


Figure 3-5: Materials Flow

Source: Drawing by Arnold van de Klundert, WASTE, 2001

3.6 The Waste Management Hierarchy

According to Beukering et al, (1999), the waste hierarchy is accepted as a key element in ISWM. The hierarchy is based on environmental principles which propose that waste should be handled by different methods according to its characteristics, i.e a certain amount should be prevented either by reducing the content of waste or by reusing the waste; another share of the waste stream should be converted into secondary raw materials; some parts can be composted or used as source of energy, and the remainder may be landfilled (see Figure 3-6). Reality does not adhere to this environmentally based sequence. Indeed, in developing countries, a large quantity of waste is dumped in an uncontrolled manner, or worse, burned in the open air. Obviously, these options do not belong to the waste hierarchy because of their unacceptable high levels of environmental damage. These latter two options are therefore added in the shaded area.

In addition, the hierarchy promotes the recovery – through reuse, recycling and composting – of as many waste materials as possible before disposal or incineration. According to Beukering et al, (1999), addressing the advantages of reuse and recycling are:

- Reduction of the amount of materials requiring collection and disposal, which means:
    - Longer lifetimes for landfills; more capacity for waste in other kinds of treatment facilities
    - Lower transportation and landfill costs
    - More reliable and local supply of raw materials to local industries, avoiding using foreign exchange and import procedures
    - Reduced extraction of non-renewable raw or virgin materials and associated environmental devastation
    - Reduced deforestation
- Conservation of resources, energy and water
- Provision of income and employment
- Availability of affordable products for the poor

Policies based on the hierarchy seek to maximize the recovery options and to minimize disposal through open dumping, controlled disposal and landfilling. Once possibilities for recovery have been exhausted, policies based on the hierarchy favor safe disposal, limiting negative impact on the environment and natural resources as much as possible.

The waste management hierarchy is an example of how ISWM adapts an existing environmental policy to support its environmental aspects in determining the form of the waste elements. Similar policy instruments support other aspects, such as non-discrimination policies, which support the social aspect. Like all policies, the hierarchy needs to be applied with certain flexibility. Sometimes recycling may not be the right solution and other solutions like incineration may be more appropriate, for example in the case of healthcare waste. Nevertheless, the waste management hierarchy is an important guideline for ISWM.

Although this ranking of waste management options provides policy makers with an effective base, integrated SWM goes beyond the waste hierarchy. It is generally known that the hierarchy has to be applied in a flexible way and it is only intended as a general guideline to achieve the best environmental solution in the long term. Still, the hierarchy has always been subject to fierce criticism for various reasons. First, although the ranking may indeed be correct in terms of environmental pressure for certain materials, this is not the case for all materials or products. For instance, it may be better to recycle an old refrigerator rather than reuse it because its inefficient energy consumption creates more environmental damage than the recycling related burdens. Second, the hierarchy only refers to environmental effects and not to economic or social criteria. Obviously, these aspects cannot be ignored.

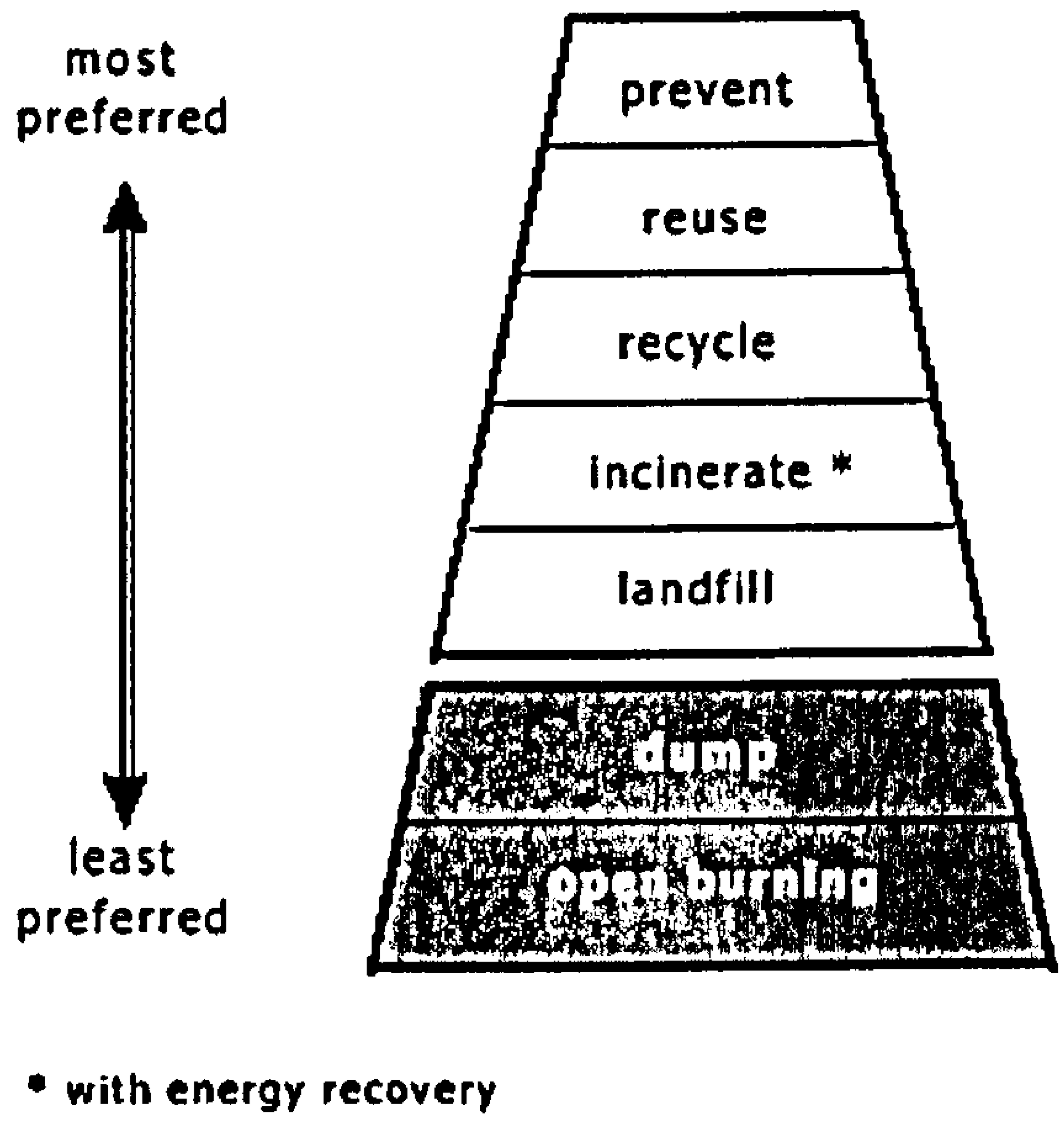


Figure 3-6: The Waste Hierarchy

Source: Beukering et al, (1999)

The waste management hierarchy is a tool that policymakers have used to rank waste management options according to their environmental benefits and it considers products from their 'cradle' to their 'grave'. Waste is seen as closely linked to production and consumption processes. The previous box outlines its main principles.

Separation at source, reuse and recycling take an important place in the waste management hierarchy. Waste materials should be separated at source as much as possible to improve the quality of materials for reuse and recycling - including organics for composting - to reduce energy use in collection and to improve working conditions at all stages. This will also benefit those earning a living from waste recovery (Lardinois and Furedy, 1999). Separation at source of hazardous waste has the additional advantage that it reduces the risks of handling municipal waste.

Therefore, many believe that the options should not be ranked in a particular order but should be considered as a "menu" of alternatives. "It is not a question of good and bad waste management options or technologies. Rather, each option was equally appropriate under the right set of conditions addressing the right set of waste stream components" (Schall, 1995). In an effort to determine whether the hierarchy is applicable in developing countries, the following section evaluates the essential differences between the North and the South.

3.7 Principles of Waste Management Strategies

The draft for the Waste Strategy for England and Wales (DOE) laid out important principles for consideration when planning and setting goals in waste management. These were principles adopted from numerous meetings and conferences and which have gained the attention of various environmental mangers, legislators and practitioners. These principles are applicable for all fields of environmental management.

3.7.1 The UK National Waste Strategy

The UK National Waste Strategy is a requirement for all member states of the European Union and is a document, which sets out the policies in relation to the recovery and disposal of waste. The strategy is a requirement of the EC Framework Directive (75/442/EEC) amended by EC Directive 91/156/EEC. In particular, the strategy must identify the type, quantity and origin of waste to be recovered or disposed of, the general technical requirements, any special arrangements for particular waste, and sustainable disposal sites or installations. The EC Directive has been incorporated into the 1995 Environmental Act as a statement by the Secretary of State for the Environment in England and Wales, but for Scotland the statement was written by the Scottish Environmental Protection Agency. The objective of the National Strategy (Environment Act 1995; Lane and Peto 1995) include:

- ensuring that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment;
- establishing an integrated and adequate network of waste disposal installations, taking account of the best available technology not involving excessive cost;
- ensuring self sufficiency in waste disposal;
- encouraging the prevention or reduction of waste production and its harmfulness;
- encouraging the recovery of waste by means of recycling, re-use or reclamation and the use of waste as a source of energy.

Preparing the strategy involves a wide range of bodies including the Environment Agency, local government, industry, local planning authorities etc.

Part of the waste Framework Directive requires the National Waste Strategy to relate to identifying suitable disposal sites or installations.

In addition to the requirement for the National Waste Strategy, the EC waste Directive includes the "self sufficiency principle," which states that Member States shall take appropriate measures to establish an integrated and adequate network of disposal installations which enable the Union as a whole to become self sufficient in waste disposal. A move towards individual member state self-sufficiency is also recommended. The plan should also reflect the "proximity principle", under which waste should be disposed of - or other wise managed - close to the point at which it is generated. This creates a more responsible approach to the generation of wastes, and also limits pollution from transport. It is therefore expected that each region should provide sufficient facilities to treat or dispose of all waste it produces, and such a strategy should be reflected in local development plans.

3.7.2 The UK Waste Management Policy – The Strategy for Sustainable Waste Management

The National Waste Strategy themes have developed from the ideas of "sustainable development," which led directly from the 1992 United Nations Rio Conference on Environment and Development (the Earth Summit). They require that society takes decisions with proper regard to their environmental impacts. The concept tries to strike balance between objectives, the continued economic development and achievement of higher standards of living both for today's society and for future generations, and the need to protect and enhance the environment. The economic development of society clearly has an impact on the environment since natural resources are used and by-product pollution and waste are produced in many processes. However, sustainable development promotes development by encouraging environmentally friendly economic activity and discouraging environmentally damaging activities. Such activities include energy efficiency measures, improved technology and techniques of management, better product design and marketing, environmentally friendly farming practices, making better use of land and buildings, improved transport efficiency and waste minimization (Sustainable Development 1994; This Common Inheritance 1996).

The strategy for sustainable waste management in England and Wales is drawn up by the Secretary of State for the Environment and is entitled “Making Waste Work” (Development of the Environment and Welsh Office 1995). The strategy sets out the waste management policy for England and Wales until the year 2005. The document “Making Waste Work” takes the concepts of “sustainable development” as a strategy for waste management.

The EC strategy has been developed by the UK into the concept of “a hierarchy of waste management” (Figure 3-7) (Sustainable Development 1994; Department of the Environment and Welsh Office, 1995):

1. **Reduction:** Uppermost in the hierarchy is the strategy that waste production from industrial manufacturing processes should be reduced. Reduction of waste at source should be achieved by developing clean technologies and processes that require less material in the end products and produce less waste during manufacture. This may involve the development of new technologies or adaptations of existing processes. Other methods include the development and manufacture of longer lasting products and products which are likely to result in less waste when they are used. The manufacturing process should also avoid producing waste, especially hazardous waste, or it should reduce the toxicity of such waste. Waste reduction has the incentive of making significant savings in raw materials, energy use and production and waste disposal costs.

2. **Re-use:** The collection and re-use of materials, for example doorstep milk delivery in the UK which involves collection, cleaning and reuse of glass bottles. ‘Recycling tyres’ would also come under this category, and many truck tyres could be re-treated many times throughout their lifetime. Re-use can be commercially attractive in some circumstances like the case of second hand items coming into the Gaza Strip from Israel. However, re-use may not be desirable in all cases since the environmental and economic cost of re-use in terms of energy use, cleaning, recovery, transportation etc may outweigh the benefits.

3. **Recovery:** There are a number of different types of waste recovery.

(i) Materials recycling. The recovery of materials from waste and processing them to produce a marketable product - for example, the well established recycling of glass and aluminum cans - with a net saving in energy costs of the recycled materials from waste is high. However, it may not be appropriate in all cases, for example, where the abundance of the raw material, energy consumption during collection and re-processing, or the emission of pollutants has a greater impact on the environment or is not cost-effective. Materials recycling also imply that there is a market for the recycled materials. The collection of materials from waste where there is no end market for them merely results in large surpluses of unwanted materials and also wastes additional energy with no overall environmental gain.

(ii) Composting. This is the decomposition of the organic fraction of waste to produce a stable product such as soil conditioners and growing materials for plants. Composting is an extension of garden composting on a larger scale, and attempts have been made to use municipal solid waste for composting. However, contamination by heavy metals, glass and plastics has limited its application. Successful schemes using waste from gardens and parks have proved more acceptable, and there is research into the use of sewage sludge as a composting material.

(iii) Energy recovery. Producing energy by incinerating waste or combustion of landfill gas. Many wastes, including MSW, sewage sludge and scrap tyres, contain an organic fraction which can be burnt in an incinerator. The energy is recovered via a boiler to provide hot water for district heating of buildings or high-temperature steam for electricity generation. The incinerator installation represents a high initial capital cost, and sophisticated emissions control measures are required to clean up the flue gases. The anaerobic digestion of puterscible organic fraction of wastes such as domestic waste and sewage sludge in a landfill site produces a gas consisting mainly of methane, which can be collected in a controlled, engineered way and burnt. Again the derived energy is used for either district heating or power generation.

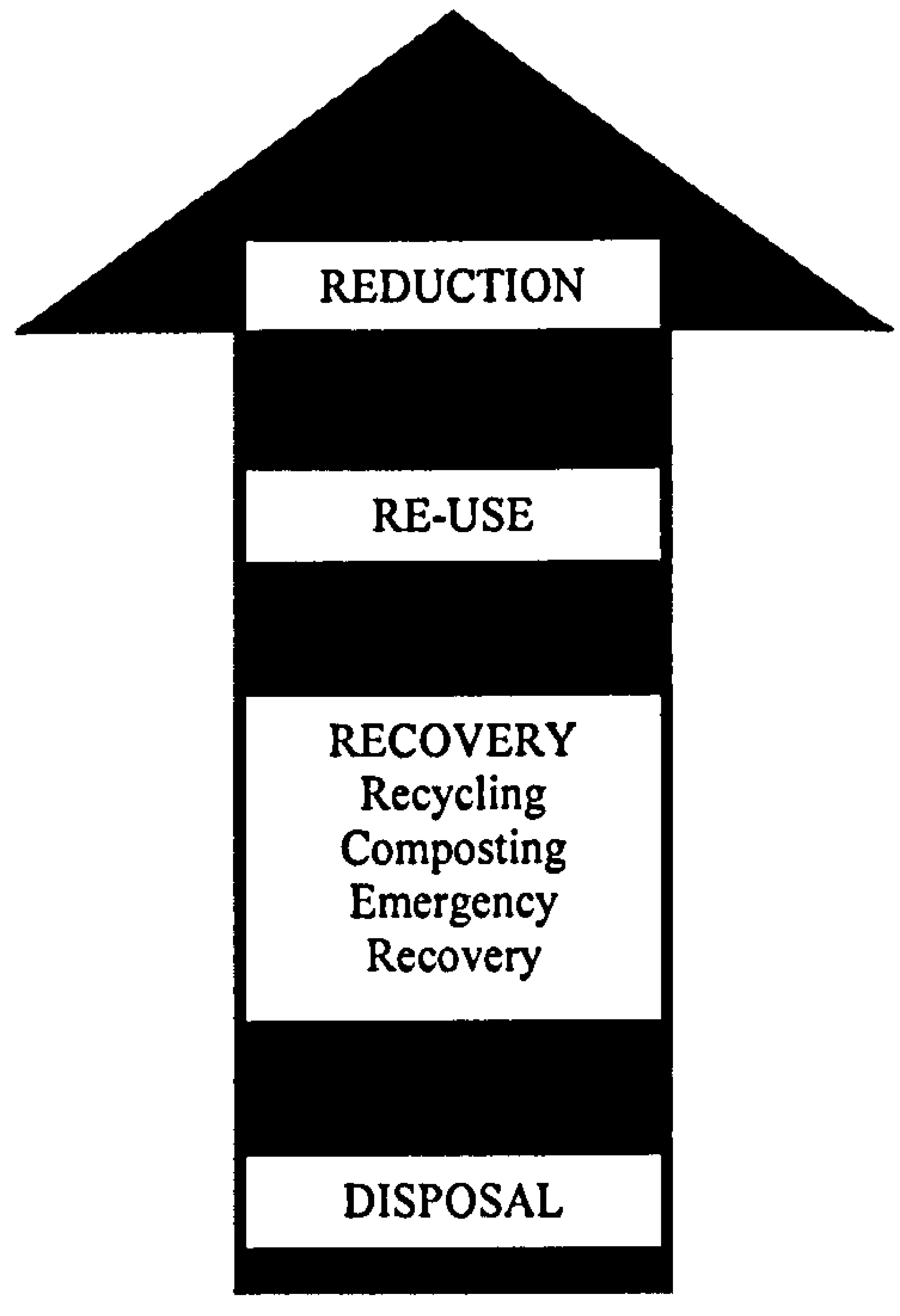


Figure 3-7: The Hierarchy of Waste Management.

Sources: (1) Sustainable Development: The UK Strategy. HMSO, London 1994; Department of the Environment and Welsh Office, Making Waste Work, 1995. HMSO, London

4. **Disposal:** The disposal of waste using processes or methods that do not endanger human health and which cannot harm the environment, such as by incineration or controlled landfill without energy recovery. For newly constructed, large scale waste incinerators, some recovery is essential to ensure the economic viability of such schemes. Landfill is the predominant route for waste disposal in the UK and throughout Europe and North America. Biological process within the landfill ensures that over a period of time, the waste is degraded, neutralized and stabilized to form an essentially inert material. Also, the sites used for landfill are often used mineral workings, which are required to be filled in, and can eventually become re-claimed land. Methane (landfill gas) will still be produced at such sites and therefore the control of the gas emissions is essential to prevent potential uncontrolled combustion. A further major consideration for landfill disposal is the leachate, i.e. the potentially toxic liquid residue from the site, which may enter the watercourse.

The strategy and the overall policy aim of the UK Government, encompassing sustainable development, requires that waste management practices move up the hierarchy s that waste is not merely disposed of, but should, where possible, be recovered, reused or minimized. However, this may not be achievable in all cases, and in some cases may not be desirable. For example, some types of waste are best land-filled or incinerated since the environmental and the economic cost of trying to sort and decontaminate the waste to produce a useable product outweighs the benefits. Consequently, the principle of Best Practicable Environmental Option (BPEO) should be applied to the process under integrated pollution control. In England and Wales the management of waste is concentrated towards the bottom of the hierarchy, partly due to the fact that the different waste management options do not fully reflect their environmental costs and benefits in all cases, and little information is available about the competitive benefits of waste minimization (Department of Environment and Welsh Office, 1995).

The waste management strategy in the UK is also influenced by the mixture of public and private sector industries. The UK has a large private waste management sector, particularly for the industrial and commercial sectors. In addition, the 1990 Environmental Protection Act required Waste Disposal Authorities to divest themselves of their operations. Waste disposal is now in the hands of private companies, local authority waste disposal companies or is a co-owned private and local authority concern. Disposal of waste for local authorities is the responsibility of the Local Waste Disposal Authority, which uses competitive tendering contracts. The authority doesn't have to accept the lowest tendered cost where an alternative offers environmental benefits. The award of contracts by the authority on this basis can be used to promote the policy of sustainable waste management. Waste collection is now also subject to compulsory competitive tendering, which may be through Local Authority Waste Collection Companies or the private sector.

With the aim of moving waste management policies up the hierarchy, the UK Government has set a number of indicative, but not legally binding, targets for industry and waste sectors to minimize or recycle waste (Department of Environment and Welsh Office, 1995).

- To reduce the proportion of controlled (household, commercial and industrial) waste going to landfill to 60% (from 70%) by 2005;

- To recover, including materials recycling, energy recovery and composting, 40% of municipal waste by 2005;
- To reduce the waste produced by the government itself by aiming for two-thirds of Government Departments to have in place office waste minimization targets by the end of 1996;
- To recycle or compost 25% of household waste by the year 2000. To help achieve this target, further targets are set of 40% of domestic properties with a garden to carry out composting by the 2000. Also, all waste Disposal Authorities are to cost and consider the potential for centralized composting schemes, resulting in the composting of 1 million tonnes/year of organic waste. To help achieve the recycling target, 80% of households should have easy access to recycling facilities;
- To increase the use of secondary and recycled waste materials, such as construction, demolition, mining and quarrying wastes, as aggregates in the construction industry in England from 30 million tonnes/year to 55 million tonnes/year by 2005;
- To have in place Government targets before the end of 1998 for the overall reduction of waste.

The introduction of producer reasonability in the 1995 Environment Act and in response to European Union response Directives has led to a number of industries setting their own re-use and recovery targets, for example recycling or recovering 58% of packaging waste, 50% of aluminum cans, 37% of steel cans, 40% of newspapers and 56% of scrap tyres by 2000. Clearly, the setting and achieving of targets requires accurate data on the waste arising, treated and disposed of, the provision of which is a major function of the Environment Agency.

3.8 Principles of Waste Management Strategy

The overall goal of solid waste management should be to collect, treat and dispose of solid wastes generated by all population groups in an environmentally and socially satisfactory manner using the most economical means available (CEPIS, 2001). Large municipalities and metropolitan regions should be encouraged to undertake city-wide strategic planning to design and implement integrated solid waste systems that are responsive to dynamic demographic and industrial growth. Strategic planning (ERM, 2000) starts with the formulation of long-term goals based on the needs of a particular municipality, followed by a medium and short-term action plan to meet the goals. The strategy and action plan should identify a clear set of integrated actions, responsible parties and the required human, physical and financial resources. The city-wide strategic plan should match service levels to user demand and affordability especially for the urban poor. It should also integrate all components of the service - minimization, collection, transfer and transport, recycling, treatment and final disposal.

A more comprehensive policy framework is also needed at the national and provincial level. It should link public health, environmental and decentralization policies more closely together so that they are mutually supportive. It should also provide incentives to municipal authorities to deliver better services, recover more costs from users, and cooperate with neighboring municipalities. For smaller or weaker municipalities, there should be a focus on technical and financial assistance. Also, the economies of scale resulting from grouping smaller municipalities and sharing facilities can significantly affect the affordability of services, particularly disposal operations. The main roles of central authorities should be to establish an appropriate policy and regulatory framework, carry out institutional reforms, and provide technical assistance and access to finance for local authorities. To assist in the development of national strategies, a framework and methodology for conducting national solid waste sector assessments has been prepared by the Pan American Health Organization (PAHO, 1994) in collaboration with the World Bank and other donors.

One attempt to define a comprehensive framework has been developed by the Collaborative Working Group on municipal solid waste management (Schubeler et al., 1996). The schematic approach to integrated solid waste management is shown in Table 3.1. The authors stress that all comprehensive projects must deal with these elements.

Table 3.1: Integrated Framework for MSWM

(Source: Schubeler, et al., 1996).

WHAT? (Functional Scope)	WHO? (Stakeholders)	HOW? (Strategic Aspects)
- Planning & Management - Strategic planning - Legal/regulatory framework - Public participation - Financial management - Institutional arrangements - Disposal facility sitting - Waste Generation - Waste characteristics - Waste minimization - Waste Handling - Collection, Transfer, treatment, recycling and disposal. - Special wastes	- Local government - National government - Service users - Private sector - Informal sector - NGOs - Donors	- Political - Institutional - Social - Financial - Economic - Technical - Environmental

For more than a decade the World Bank has been concerned with environmental planning and management of solid waste services, and has supported the development of two strategic planning guides (Cointreau, 1982; ERM, 2000). The challenge now is to support cities in their efforts to move toward integrated waste management systems.

An integrated MSWM system starts with the collection and transport operations, and ends with final disposal in a sanitary landfill. These are the essential building blocks of any SWM system. In between, additional operations take place such as transfer, resource recovery and recycling, and treatment - for example, composting or incineration. Decisions about added operations will depend on both technical and financial feasibility, as well as social acceptability, as household and business participation is essential. These intermediate operations may also require the prevention of indiscriminate mixing of waste streams, which in turn may necessitate household segregation and special storage, collection and handling of some waste streams, which always entails extra costs. Whatever the recycling or treatment that may take place, there will always be significant residuals that require landfilling: typical recycling rates reach 25-35% and may take a decade to achieve, while compost rejects are about 40-45% and incineration ash 15-20% of the original waste by weight. Markets for recyclables and compost must also be verified. These considerations highlight the need for a comprehensive study of options. Selection for long-term success should be based upon the best mix of cost-effectiveness, public education and participation criteria.

3.9 Defining Sustainability and Sustainable Development

The ongoing and lengthy debate about the definition of sustainability has often revolved around the auditor's worldview (Turner, 1993). Different worldviews make different definitions and debates about these almost inevitable, and often incompatible (Turner, 1993). The situation is further confused by the debate about sustainable development versus sustainability.

Sustainability is a complex concept. There are also a number of related concepts such as sustainable development, sustainable construction and waste management. The definitions of sustainability and its key principles will be covered in this chapter:

- ✓ The definition and key principles of sustainable development
- ✓ Indicators of sustainable development
- ✓ An introduction to sustainable waste management
- ✓ The definition and key principles of waste management

"A number of definitions of sustainable development that is likely to achieve lasting satisfaction of human needs and improvement of the quality of life" (Allen, 1997 p23).

For Goodland and Ledoc (1987) sustainable development here is defined as a pattern of social and structural economic transformations, i.e. "development, which optimizes the economic and social benefits available in the present, without jeopardizing the likely potential for similar benefits in future". "A primary goal for sustainable development is to achieve a reasonable (however defined) and equitably distributed level for economic well-being that can be perpetuated continually for many generations." ".....Sustainable development implies using renewable natural resources in a manner which does not eliminate or degrade them, or otherwise diminish their usefulness for future generations....Sustainable development further implies using non-renewable (exhaustible) mineral resources in a manner which does not unnecessarily preclude easy access to them by future generations....

Some definitions or interpretations have been criticized as too vague or even ambiguous (Mitchell, 1997 p29). Also Wood (1994) states that sustainable development has attracted both criticism and support. There is considerable discussion over whether growth can be sustainable in all circumstances. The Brutland Commission was explicit that while growth is essential to meet basic human needs, sustainable development involves more than growth. It necessitates a change in the nature of growth, to make it less material and energy-intensive, and to make it more equitable in its impacts (Mitchell 1997:26). The economist Herman Doyle clarifies the difference by defining "growth" as an increase in size through material accretion while referring to "development" as the realization of fuller and greater potential. In short, growth means getting bigger while development means getting better (Wackernagel and Rees, 1996 p33).

The concept of sustainable development was popularized by the report "Our Common Future" (WCED 1987). This report is also known as the Bruntland Commission Report. Its chair was Ms. Gro Harlem Bruntland, then the Prime Minister of Norway. In December 1983, the secretary general of the United Nations invited the Prime Minister to conduct an inquiry and prepare a report to provide a global agenda for change. Considerable discussion has derived from one short statement in the Bruntland Report (WCED, 1987), the sustainable development definition: "Sustainable development is the development that meets the needs for the present without compromising the ability of future generations to meet their own needs". This is taken to mean that for those developing a waste service in a municipality, to be sustainable they should not use more resources – materials, labor, equipment and finance – than they have access to in their locality and that they should be used in such away as not to squander them or create lasting problems for future generations. Within this statement, there are three concepts that require more precise definition.

As Wackernagel and Ress (1996) argue despite agreement on the concept, there is no general agreement on the policy implications of the concept. One thing is certainly true, existing consumer lifestyles threaten the environment and nature and also threaten geopolitical stability. Unsustainable population increases and growing resource hungry lifestyles are the norm (UGT, 1993).

Transitional consumerism and the globalization of production and trade (Santos, 1994) highlight the real necessity for a global consumer policy, in the context of the sustainability concept. The Mastricht Treaty of the European Union addresses these issues (Nunes, 1994 p97). Additionally the increasing economic gap between rich and poor countries (PNUD, 1998) does not facilitate the move towards sustainability.

In this thesis, sustainable development can be considered to be development linked with economic growth, and it is sustainable growth that allows human needs to be met fairly within the resources of our planet. This sustainable growth will remain within the ecological carrying capacity. This carrying capacity is environmentally defined as the maximum population size of a given species that an area can support without reducing its ability to support the same species in the future (Wackernagel and Ress 1996, p158).

Having established a working definition of sustainable development and a basic understanding of sustainability, it is necessary to discuss the principals of sustainability.

3.9.1 Key Principles of Sustainability

One view of sustainability is that concerns about the future of the earth in terms of the needs of humans, and the ability of the earth's resources to meet those needs should be emphasised. Sustainability within that view is a simple concept: it means living in material comfort and peacefully with each other within the means of nature. Despite this seeming simplicity, however, there is no general agreement on the policy implications of the concept (Wackernagel and Ress, 1996 p32). In the Bruntland Report, sustainability is defined as meeting the basic needs of all people and extending to all the opportunity to satisfy their aspirations for a better life.

Another view on the nature of sustainability is contained within the Gaia hypothesis (Lovelock, 1988). The hypothesis posits that the biosphere modifies itself to maintain its continued existence. It is implicit in the hypothesis that this may not include conditions for the continual existence of humankind. This position on sustainability is not pursued further in this thesis.

Much has been written about achieving sustainable waste management in higher income countries and almost all of it refers to sustainability in a way that is too vague to be practical to implement (Rushbrook, 2000).

Several authors have developed the principles and practices of sustainability. Robinson et al (1990, p44) points out that the application of technology has allowed an improvement in the standard of living of many people around the world. However, some societies have become very dependent on technology. This has also led to increasing resource consumption and production of waste. The role of technology, education, development and culture are different in different societies. However, they tend to be interactive and complementary. Robinson et al. (1990, p44) develop this idea within their principle of sustainability. These principles are divided into two types – environmental and ecological principles, and socio-political principles.

3.9.2 Sustainable Development Indicators

In order to properly understand sustainable development we have to measure it. There are number of possible indicators relating to sustainable development. This section considers a range of those indicators that are relevant to SWM. Indicators for SWM will be explained explicitly in chapter seven.

It is fundamental to have targets and indicator systems to evaluate progress. Good policy-making depends on good information about the problems, their magnitude their causes and the success or otherwise of present policies in dealing with them. On the output side, indicators can relate to emissions to air, water, noise and generation of solid waste and hazardous substances among others. On the input side, indicators relate to resource extraction and consumption, energy consumption, materials consumption, growth of built up land and many other indicators.

An important contribution to this knowledge, environmental indicators at an international level, is the "Core Set" of indicators of development by the OECD (OECD, 1994). This set includes 72 indicators in all, but only 30 are currently operational. They are classified in two ways: according to the issues to which they relate, and as indicators of "pressure", "states" or "responses". Pressure indicators may be polluting emissions for example, "state" may be air or water quality, and "response" may be expenditure or cleaning measures.

Within the 5th European Union Environmental Action Program, the European Environmental Agency has been involved in defining 84 indicators. These indicators show the European Union share of world population, energy and mineral consumption targets based on global equity (EEA 1995, p33).

The EUROSTAT (Eurostat, 1997) has an important role in coordinating work on the development of an "Environmental Pressure Index" (EEA, 1998a). This will be aggregated from indicators from 10 identified "problem areas" of which "resource depletion" has been recognized as one of them. However, the specific indicators in this area have yet to be identified.

Since the United Nations Conference on Environment and Development held in 1992, several proposals have been advanced at international level for more comprehensive sets of "sustainability" or "sustainable development" indicators. These have a narrower focus than the environmental indicators. Indicators proposed by the United Nations and those proposed by the should this be Wildlife Fund for Nature (WEF/NEF, 1997), in cooperation with the New Economist Foundation, consist of a large number of indicators on human development and welfare.

Sustainable development indicators are necessary for decisions on different levels and in different areas. Various initiatives and project developments throughout the world have emerged with the objective of defining sustainable development indicators, not only for broad management solutions at a national level, but also at a regional level (Cummings and Cayer, 1993). One objective of the United Nations Commission on Sustainable Development (UNCSD) is the creation of a global framework of indicators. The framework could ensure the technical validity, the comparison and the acceptance of these indicators (Gouze, Mazinng and Bilhaz, 1995). The use of this type of agreed indicators has been gaining support among the research community, which has to utilize, treat and transmit technical and scientific information. An agreed indicator makes it easier to utilize existing data by decision-makers, managers, politicians, interest or pressure groups, technicians, scientists and the public in general.

At an international level there are different organizations developing work in this area, including the Environment Agency, the Organization of Economic Cooperation Development (OECD), the United Nations Environment Program (UNEP) and the USA Environment Protection Agency (US EPA).

The United Nations Commission on Sustainable Development (UN, 1996) proposed a working list of indicators of sustainable development as follows:

- Indicators for social aspects of Sustainable Development
- Indicators for economic aspects of Sustainable Development
- Indicators for environmental aspects of Sustainable Development
- Indicators for institutional aspects of Sustainable Development

These reflect some of the groups working on sustainable development indicators in the Gaza Strip mainly at the Ministry of Environmental Affairs. However, there are various applications of sustainable development indicators that can be useful – see chapter seven for more details.

3.9.3 Applications of Sustainable Development Indicators

Sustainable development indicators, as Ott (1978) points out, could have a significant amount of practical applications. He identifies a number of applications (Ott, 1978) as follows:

- Resources attrition – Indicators can help the decision-makers or managers in funds application, natural resources allocation and prioritisation.
- Site classification – Indicators can allow comparison between different sites geographic areas.

- Legal regulation observances - Indicators can clarify and synthesise the level of legal regulations required.
- Tendency analysis – Indicators can be used to detect time and space tendencies, with special attention to analysis that is easy to interpret.
- Public information – Sustainable development indicators support the public information process.
- Scientific research – Indicators can provide scientific development with the information about areas to develop further and deeper scientific studies into specific situations.

The OECD (1994) also identifies four wider areas for application of the indicators

- Environmental systems operation assessment
- Environmental issues concerning consideration in sector policies
- Environmental accountancy
- Environmental state report

According to Ramos, Rodrigues and Gomes (1998, p17) these wider areas and information from them are fundamental for good policy-making. This means that it is important to know the problems, their magnitude, their causes and the success or otherwise of the present policies used to deal with the problems.

As it will be explained in chapter seven, there is also a three-way classification of indicators called Pressure State Response (PSR) that has gained wide acceptance (OECD, 1994). In this model, the terminology "pressure" refers to indicators that relate to impact and problems such as pollution emissions, and they put pressure on the environmental system. "State" refers to indicators relating to the current position, for example air or water quality. "Response" relates to indicators associated with remedial actions to deal with environmental problems (EEA, 1998a: 35).

More recently the United Nations and the EEA has been developing models with terms such as "driving forces" and interrelationships more adapted to the practical world. For instance, increasing recycling rates may be interpreted as a "response" leading primarily to a lower material consumption. Decreasing or static recycling rates may be regarded as a "driving force" or pressure for the level of the consumption.

Figure 3-8 is a simplified illustration of the relationships between driving forces, pressure, state and responses. Ideally responses should lead to reduced pressures, either directly if the responses are of the "end of pipe[1]" or indirectly by damping the driving forces. The application of these models and indicators to the Gaza Strip was initiated first by the Ministry of Environmental Affairs (MEnA) but due to the current political situation, this activity has been frozen.

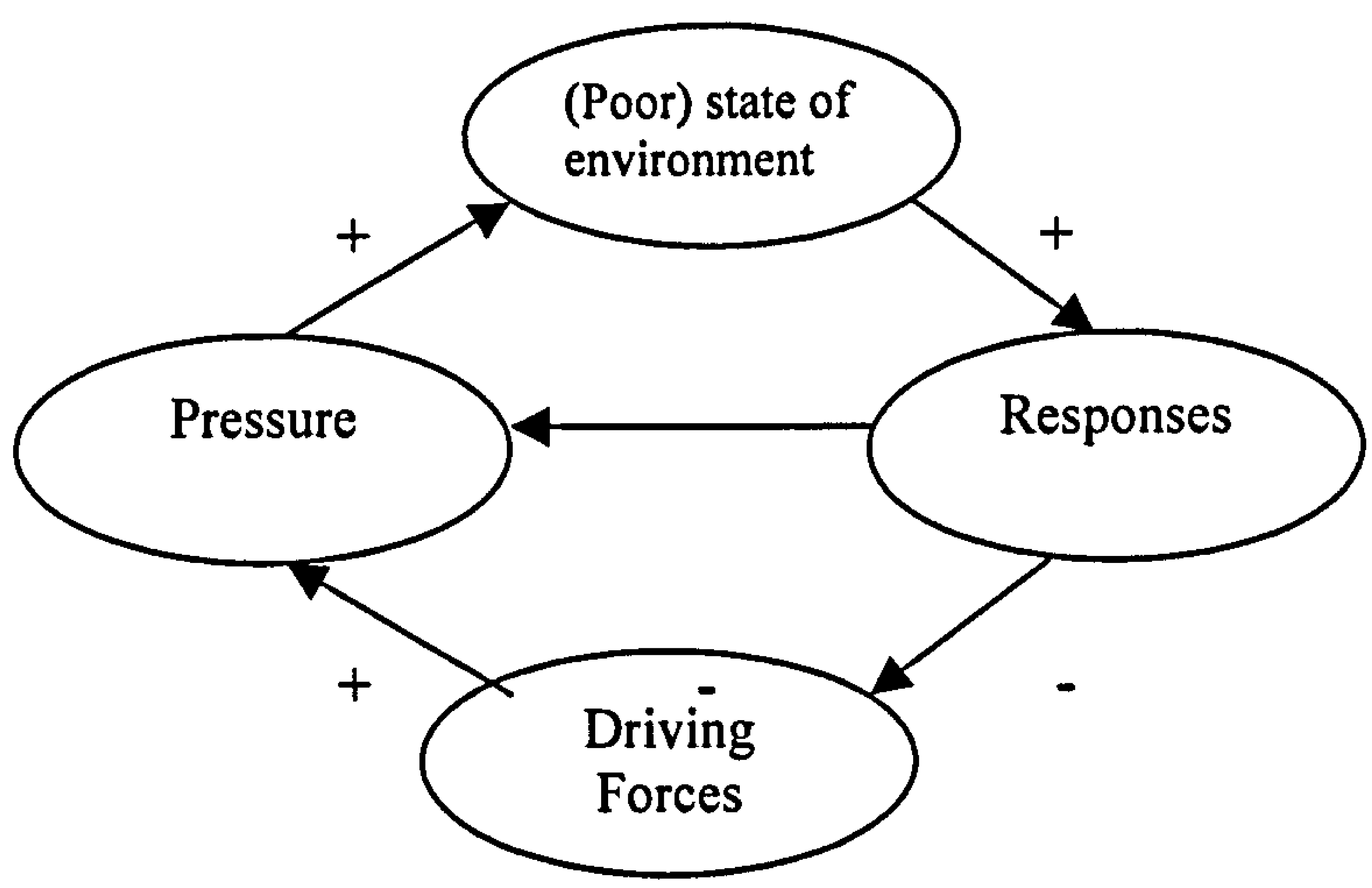


Figure 3-8: Relationships between driving forces

Source: EEA 1998:3

3.9.4 Waste and Sustainable Development

Waste materials are a consequence of life, and they are also fundamental to defining the way forward for sustainability. The objective of this section is to present an overview of the waste problem in an historical context of the Gaza Strip. There is a review of the European Community context, and a discussion of the definition of waste.

[1] "End of Pipe" technologies are technologies not concentrated on environmental and prevention attitudes, efficiency and performance, needing expensive treatment of their emissions (Barratt 1996).

Definition of Waste

There are two views of "waste". The traditional view is of an unwanted item, discarded in a 'throwaway society'. It is something to be removed as far away from us as possible and preferably "not in my back yard" (NIMBY) (Petts and Eduljee 1994 p389). Municipal Solid Waste (MSW) is defined as the waste emanating from human and animal activities that are discarded as useless or unwanted. It includes industrial waste from the burgeoning new large scale manufacturing process (William, 1998), and although normally solid in form, it may include liquids. This definition is relative and therefore compatible with the new ideas and trends from a sustainability point of view. What is waste, and useless for one generation, may be useful and resource materials for the next.

The alternative view sees waste as a raw material substitute with the resulting environmental advantages. Rather than being useless, waste then becomes purposeful for example as a potential "fuel" in composition operations designed to produce heat and generate stream (Diaz et al. 1993 p4).

EC Directive 91/156/CEE of the 18th March 1991 contains a key definition of waste: it is described as "...any substance or object which the holder discards or intends or is required to discard". However, many people argue that this definition is imprecise and open-ended. Salter (1998) supports this view by referring to twenty-seven cases concerning community legislation on waste, which still remain unresolved by the EC Court from as far back as September 12th 1996.

The definition of waste, and its importance and role in the sustainable development agenda is subject to an on going debate at European Union level and also in the OECD. A study by the Institute for Perspective Technological Studies observed the legal definition of waste and its influence on waste management in Europe. The Institute is a joint research Center under the European Commission organization based in Seville, Spain. The study revealed some important insights into the discussion on the definition of waste (EC/IPTS, 1997). It compared the Framework Directive of waste with other Directives and regulations, the OECD and the national definitions of waste in the European Union countries. It also studied waste lists such as the European Waste Catalogue, the list from Regulation 259/93, the European hazardous wastes list, the OECD lists and the Basle Convention lists. On 22nd March 1989 the Basle Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal was adopted. It was signed also by the European Community. The Convention contains basic principles on the methods of identification, publication and control of trans-boundary movements of certain types. The recognized goals of all the signatory states of the convention include waste prevention, minimization of trans-frontier movement of the wastes listed and waste disposal consistent with the protection of human health and the environment.

The 3 R's

As the debate on waste between environmental, social psychological, institutional, economical and political positions has developed, a number of concepts and terms have become significant. Originally, the debate focused on the idea of Reduction, Reuse and Recycling (the three R's). According to Tecobanoglous, Theisen and Vigil (1993), reuse is the use of a waste material or product more than once for the same or similar use, for example the cleaning and reuse of a glass jar. Recycling consists of re-processing a waste material so that it may be used again as a useful material for products, which may or may not be similar to the original, for example, the reduction to cullet of glass items so that they may be remanufactured into new articles. Reduction is about reducing the amount of waste produced, for example, reducing the amount of short life objects such as packaging and increasing the reparability of articles. This 3 R's policy is only known and disseminated in the Gaza Strip through a number of environmental NGO's (El-Hawi, 1997). The 3 R's is discussed in more detail in the Gaza Municipality case study in chapter seven.

The debate has moved onto the 4 R's with the introduction of Recovery. According to Tecobanoglous, Theisen and Vigil (1993), recovery or resource recovery is a general term used to describe the extraction of economically usable materials or energy from waste. One example is the thermal processing[2] of solid waste – used both for volume reduction and energy recovery – which is an important element in many integrated waste management systems (Tecobanoglous, Theisen and Vigil 1993 p 611).

[2] Thermal processing of solid waste can be defined as the conversion of solid waste into gaseous, liquid, and solid conversion products, with the concurrent or subsequent release of heat energy (Tecobanoglous, Theisen and Vigil 1993:611).

Responsibility is to have the control, the authority and to be accountable for one's actions and decisions. Rationalization is to apply logic or reasons to something, or to eliminate unnecessary equipment (Oxford Dictionary, 1995). Both definitions in the solid waste context should contribute to a better quality management. The 6 R's are considered to be the way to achieve the integrated and sustainable waste management concept (Diaz et al 1993 p267). With a basic understanding of what is meant by waste and associated concepts, it is also worth considering the nature of waste in the historical and environmental context in the Gaza Strip.

Background Concepts

With the advance of technology-based societies, waste is being generated on a greater scale than ever before. This rate of change outstripped a responsible approach to the control of the wastes generated. Solid waste is generated at every step of the industrial process. At the beginning, mining the raw materials leaves a trail of waste and visual pollution. Throughout the process, from the conversion of raw materials to goods to the point of consumption and disposal, further waste is produced and excess energy consumed (Tecobanoglous, Theisen and Vigil, 1993). This is shown in Figure 3-9.

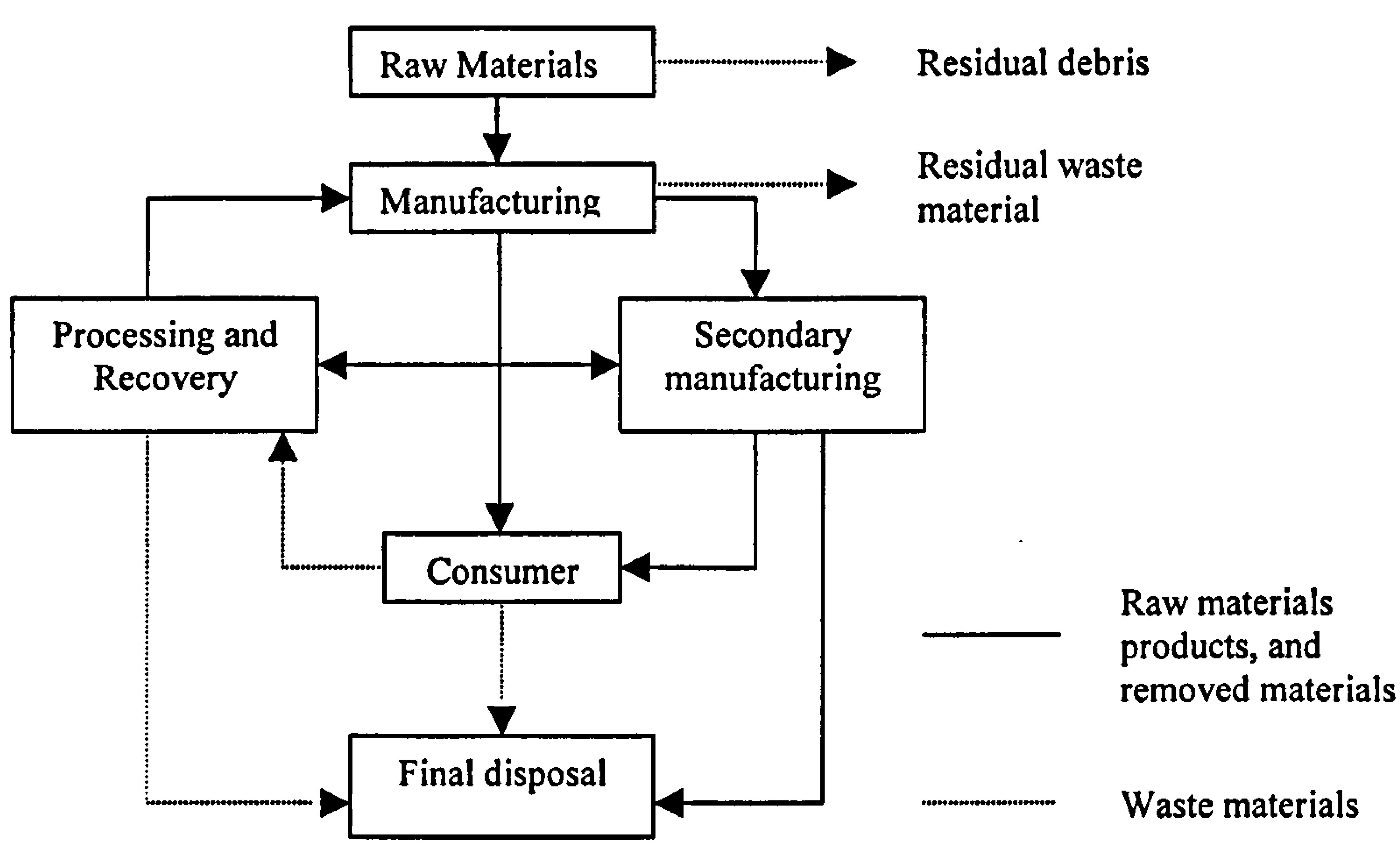


Figure 3-9: Materials flow & generation of solid wastes in a technological society
Source: Tecobanoglous, Theisen and Vigil, 1993

Figure 3-9 indicates that one of the best ways to reduce the amount of solid waste is to limit the consumption of raw materials and to increase the rate of recovery and reuse of waste materials. The best way to reduce solid waste, from a sustainable point of view, is to minimize the production of waste by adopting new attitudes and behaviors as well as selecting appropriate technologies.

The characteristics of the waste produced are a manifestation of the society in which they were produced. Archaeologists, ethnologists and anthropologists have been excavating, studying and investigating mankind's history by studying the different layers of waste (AGTHM, 1997).

Certainly in earlier times, the disposal of human and other wastes did not pose a specific problem. The population was small and the amount of land for the accumulation of waste was large. Even so, many historical civilizations gave emphasis to careful waste disposal with naturally sustainable practices such as fertilizing the soils with manure (Tecobanoglous, Theisen and Vigil, 1993).

The problems with waste disposal probably began when humans first joined together in tribes, then in villages and communities, and later on in medieval towns. As Tecobanoglous, Theisen and Vigil (1993 p5) tell us "littering of food and other solid waste in medieval towns – the practice of throwing wastes into the unpaved streets, roadways and vacant land – led to the breeding of rats, with their attendant fleas carrying bubonic plaque, the Black Death, that killed half of the fourteenth century Europeans and caused many subsequent epidemics with high death tolls".

Early humans did not have a solid waste management strategy per se, simply because the hunter-gatherer existence did not require one. The human groups never stayed in one place long enough to accumulate significant amounts of solid waste. As scarce resources were depleted, the group would move on allowing the land to recover without causing concern for other actions. However, as humans began to settle in permanent communities with higher concentrations of waste-producing individuals and activities, the need for waste management became evident (Ruiz, 1993 p1.1).

The advent of the Industrial Revolution and the development of technological society increased production and the waste disposal problems in Europe and the industrialized world. In England, The Urban Sanitary Act of 1988 prohibited the throwing of solid wastes into ditches, rivers and waters (Tecobanoglous, Theisen and Vigil, 1993 p5).

The act was passed stop the practices which the new public health management, technology and infrastructure had been developed to overcome. It demonstrates the need for a combination of social and technical responses to waste management issues (Tecobanoglous, Theisen and Vigil, 1993).

Solid waste treatment and final disposal have been some of the principle challenges, which the PNA have faced. However, considerable assistance from donor communities to improve capacities of institutions involved in solid waste service delivery has been provided. The strategy plans, the challenges and the efforts within the Gaza Strip have been undertaken with significant management and guidance from the Public administration and Local Authorities. Also, private and public entities in the MSW have been making a good contribution in order to achieve national targets and goals. Public participation has recently been introduced to the PNA as part of the donor emphasis upon the fundamental issue of providing information, environmental education, and training and monitoring, but at the same time it's a also seen as a priority to resolve social and economic problems.

3.9.5 Public Participation

In the 1990s community-based approaches to environmental problems became widespread, due to the emerging global consensus that the implementation of sustainable development should be based on local-level solutions and community participation. In this section, the concept and benefits of community participation will be elaborated and then it will be described how communities can be involved in SWM decision-making processes.

3.9.5.1 Concepts of Community and Community Participation

In many development projects communities are seen as a homogeneous and harmonious unity, where the members are considered to have the same priorities and concerns. Several assumptions underlie approaches to community-based sustainable development, like the existence of homogeneous, consensual communities and of potentially harmonious relationships between different communities. Also many projects assume that a deteriorated local environment has the potential to be managed in a sustainable way, and the community is seen as the appropriate unit to carry out such management. Most of the time, community is considered to be capable of acting collectively towards common environmental interests (Leach et al., 1997 p4, 5).

Apart from the concept of community, no clear consensus exists about the concept of community participation and the result is that community participation is used in various ways with different meanings (Moser, 1989: 81; Desai, 1994 p170). According to Paul (1987 p2), community participation is an active process by which the community influences "the direction and execution of a development project in order to enhance their well being in terms of income, personal growth, self reliance or other values they cherish" (Paul, 1987 p2). Planning for public education and involvement requires that decision-makers understand their audience, prepare a formal plan, and establish a method for evaluating programs delivering educational messages. Maintaining participation in programs and the funding of activities are challenges that face decision-makers who implement education and involvement programs (EPA, 1995).

Education information for the public should answer the questions of 'how,' 'where,' 'when' and 'why,' and the education program should be positive and provide simple instructions on how to participate. Opportunities for communicating with and involving the public should be established early in the planning process (EPA, 1995).

Public education stimulates interest in how waste management decisions are made. And when citizens become interested in their community's waste management programs, they frequently demand to be involved in the decision-making process. Communities should anticipate such interest and develop procedures for involving the public. When the public is involved in program design, it helps ensure that programs run smoothly (EPA, 1995).

During the Israeli occupation, no environmental awareness programs were implemented, but for the moment most of the municipalities in the Gaza Strip are giving more attention to such programs. The newly formed Neighborhood Municipal Committees in Gaza, the Middle area and Rafah with the assistance of donor countries have had great impact and enhanced public participation in municipal affairs, mainly in solid waste operations. (El-Hawi, 1997).

A paper by El-Hawi & Hamilton, (2003) has stressed the importance for decision-makers to work with the community in the initial planning process since the effectiveness of SWM requires sustained participation. Through participation, the public can influence policy formulation, design alternatives, investment choices and management decisions. The paper was aiming to understand and assess public cooperation with municipalities, willingness to participate, willingness to be involved in SWM decision-making and willingness to pay for better SWM services. In addition to the interpretation of a semi-structured interview, qualitative and quantitative research techniques were applied to the results related to efficient tools in addition to the semi structured interview and interpretation. 50 copies of the questionnaire (attached in the appendix) were distributed and this consisted of various sections to assess the perception and participation of the public in SWM decision-making. The interviews carried out with the Palestinians were concerned with SWM decision-making processes and showed a low level of public participation as supported by the following results from the questionnaire as discussed in the published paper in 2002: 25% of respondents were willing to cooperate with municipalities; 54% were willing to participate; 62% were willing to be involved in SWM decision-making; 44% were willing to pay for better SWM services. The results showed that health aspects are the major concern of people followed by religious aspects. In the Gaza Strip there are no available incentives, motivations nor programs to encourage and enhance public participation in decision-making in SWM. According to El-Hawi & Hamilton, (2002), several organizations are involved in environmental and health improvement in Gaza City and more generally in the Gaza Strip. The cleaning of Gaza is a declared top priority at the highest level of the Palestinian National Authority (PNA). Many efforts have been made to clean Gaza in the past three years (1995-1998), including:

- First lady Ms. Arafat led a group of women to clean up the beach;
- Bir Zeit University sent 400 students to Gaza city to clean up the main streets;
- The Mental Health Program (local NGO) organizes an annual beach clean-up activity;

- Gaza City was cleaned up in a period of about six months as part of the "Environment Reshape of the Gaza Strip" project, with funding from Japan (US$5 million for the Gaza Strip, US$1.4 million for Gaza City);

- Save the Children Federation SCF organized community programs regarding household collection in the Shijaiah area;

- The Municipality of Gaza enhanced its collection and disposal services and increased its environmental health education and community participation efforts with support from the European Union (the Gaza City Solid Waste Disposal Project).

- From the outset of the Gaza City Solid Waste Disposal Project, the EHE/CP section of the Municipality of Gaza, Department of Health Education DHE coordinated activities with other ongoing health or environmental educational activities. The project was not only concerned with improving the waste collection and disposal system, but also covered general health issues, such as infectious diseases, personal hygiene, drinking water, and community participation.

3.9.5.2 Benefits of Community Participation

Community participation has several benefits, which can be divided into benefits for the community and benefits for the project. On the one hand, community participation can be seen as an end in itself and a way to strengthen the community. On the other hand, community participation can be seen as a means to execute projects in a more efficient way (Moser, 1989 p 84).

With the emergent concepts of sustainable development in the 1980's, especially after the Brundtland Report (WCED, 1987), and the Rio Declaration Agenda 21 (UNCED,1992), public involvement management was seen as an indispensable condition for the achievement of the objectives – social, economic, and ecological – of sustainability.

Possible benefits of community participation for projects are:

- Improvement of project design and effectiveness. If the community is involved in the design of the project, it is possible to integrate its needs and constraints in the objectives of the project and in this way come to a more effective implementation.

- Enhancement of the impact and sustainability of projects. Involving the community in the project may increase local ownership of projects and enhance a sense of responsibility for maintaining services provided by projects. These aspects are both essential for the durability and continuity of projects (Imperato and Ruster, 1999 p I-1, I-2).

- Improvement of project efficiency. Community participation may be used to enhance the understanding and agreement of cost sharing, both financial and physical contributions. Furthermore, community participation can be used to prevent conflicts and to stimulate cooperation and agreement between different actors. In this way delays in project execution can be reduced and overall costs minimized (Paul, 1987 p 3, 4).

Possible benefits of participation for communities include:

- Building local capacities and capabilities. Community participation may for instance increase awareness of knowledge and capacities, may improve the ability to negotiate as equals with authorities and other stakeholders to promote common objectives, and increase responsiveness to conflicts within the community.

- Involvement in decision-making. Participation can ensure that the different needs and problems of the community are integrated in the project's objectives.

- Empowerment. Community participation may give people the opportunity to devise and initiate strategies to improve their situation (Miltin and Thompson, 1995; Imperato and Ruster, 1999 p I-2).

In order to obtain above-mentioned benefits of community participation, projects should:

- Involve communities in the planning.
- Involve communities in the implementation, operation and maintenance.
- Let the whole community share in the benefits.
- Include the community's opinion in the evaluation and modification (Whyte, 1986 p 7,8).

3.9.5.3 Community Participation in SWM

Since the members of a community have different roles, there are also various ways in which they can participate in SWM. At the individual level, residents are responsible as users. This involves actions like storing waste in a proper way in a bag or bin, separating recyclable or organic materials from other waste, offering waste at the right place at the proper time for collection, and cleaning the area around the house (Bulle, 1999 p20; Muller, internal document).

Apart from individual responsibility, people can be collectively responsible and this means participation in more or less organized activities, like meetings, clean-up campaigns, and awareness-raising activities. Furthermore, community participation may involve making material, financial or physical contributions to activities of SWM, for instance working as a cart operator or a sweeper, and paying fees for waste collection (Bulle, 1999 p20).

A step further involves active participation in formulating the project, meaning participation in meetings and expressing opinions and ideas about the objectives and activities of the project, and closely following the project and its progress. The highest level of community participation is community management and this may entail becoming a member of committees, being involved in controlling the project, and being accountable to other community members about the decisions taken. Often community management is carried out by a smaller group within the community, through, for example, a newly established committee or an existing community-based organization (Anschütz, 1996: 14; Bulle, 1999 p 20).

Apart from various ways to participate, there are several degrees of participation by different community members. Not all members of the community like the poorest or most marginalized groups have equal access to information or are sufficiently represented by community leaders or organizations and this may obstruct the participation of those groups.

The success of community participation in SWM depends on the other actors involved, such as the municipality, community-based organizations (CBOs), micro-enterprises, and local leaders. In particular, the municipality plays a vital role since in most countries the local government is responsible for the delivery of basic services like waste collection and disposal, and for the implementation and enforcement of environmental legislation. If, for instance, the municipality does not collect the waste separately, it has no use for the community to separate their waste.

CBOs active in SWM aim to improve the solid waste situation of a neighborhood. They can be involved in various activities such as promoting re-use and recycling of materials, hiring waste collectors, collecting fees for waste removal and making arrangements with local authorities (Van de Klundert and Lardinois, 1995, p12; Pfammatter and Schertenleib, 1996, p5). Micro-enterprises are small enterprises, which can be active in recycling or in waste collection at a low cost. The small size makes them flexible and able to adapt waste services to local demand.

3.9.5.4 Public Participation and Sustainable Development

In the 1980s, the debates about the environment became more complex and finally led to the dominant concept of sustainable development as a way of balancing economic development and environmental conservation. This concept, introduced by the Brundtland Commission in 1987, can be considered as the starting point for a new conceptual basis for urban development. Sustainable development is development that meets the needs of the present generations, without compromising the ability of future generations to meet their own needs (WCED, 1987 p 43).

Most reports focus on the environmental part of sustainable development, but sustainability is a much broader concept than just environmental protection. Sustainable development is related to the quality of life in a community, meaning that the environmental, social and economic systems that form the community must provide a healthy, productive, meaningful life for all community residents, both in the present and in the future (HED, 1999). Applied to cities the multiple goals of sustainable development can be described (Mitlin and Satterthwaite, 1994 p5) as fulfilling the present...

- **Social, cultural and health needs:** include shelter which is healthy, safe, affordable and secure, within a neighborhood with provision for piped water, sanitation, solid waste collection, drainage, transport, health care, education and child development. Also they include a home, workplace and living environment protected from environmental hazards.

Furthermore, social, cultural and health needs relate to people's choice and control, like homes and neighborhoods which they value and where their social and cultural priorities are met.

- **Economic needs:** mean access to an adequate livelihood or productive assets and to economic security when unemployed, ill, disabled or otherwise unable to secure a livelihood.

- **Political needs:** mean freedom to participate in national and local politics and in decisions regarding management and development of one's home and neighborhood. Community participation in the broader framework of SWM means respect for civil and political rights and the implementation of environmental legislation, without compromising the ability of future generations to meet their own needs. Minimizing the usage or wastage of non-renewable resources includes minimizing the consumption of fossil fuels in housing, commerce, industry and transport and substituting renewable sources where feasible. Furthermore, it entails minimizing waste of scarce mineral resources through reducing use of resources, and re-using, recycling and reclaiming waste.

Sustainable development combines improving the quality of life and controlling or limiting the harmful impacts of human activities on the environment (Hardoy et al., 1992 p172).

3.9.6 Developing Sustainable Waste Management

Van de Klundert & Lardions, (1995) stress that, most cities in developing countries face urban environmental problems and these are partly caused by inadequate provision of basic services such as water supply, sanitation facilities, transport infrastructure and waste collection. Due to a lack of financial, human and technical resources, municipalities are not able – or willing – to provide basic services to all neighborhoods within their city. The poor neighborhoods in particular are deprived of basic services and they end up paying more for e.g. water to private providers than they would if the municipality delivered those services. Moreover, the limited resources available are invested in middle and upper income neighborhoods and the needs of the urban poor are not taken into account.

This situation also holds true for SWM. On estimation about 30 to 50 percent of the generated solid waste remains uncollected and this causes health hazards, smell nuisance, pests, environmental problems etc. The need for sustainable SWM systems is high and such a system should involve environmental, social and economic objectives.

For environmental sustainability, SWM needs to work towards the following objectives:

- The generation of waste, both by consumers and producers, should be minimized. At the production site, waste minimization can be achieved through a new organization of production processes, which makes use of clean technology and uses less packaging materials. At the consumption site, waste generation can be reduced by awareness raising.

- Campaigns on the environmental impacts of waste and on recycling and re-use. Attention should be paid to the waste generating behavior of the target group. For example, upper and middle-income households import a lot of products and therefore the amount and kind of waste is different to the waste produced by low-income groups, e.g. more plastic and packaging materials. Poor people produce less waste since they often re-use or sell valuable materials and the main part of their waste consists of organic materials. Re-use and recycling should be maximized. This includes recognizing and making use of the informal sector and micro-enterprises that are already involved in collecting and selling recyclable materials.

- The remaining waste should be disposed of in a controlled manner in order to stay within the absorption capacity of local and global sinks. For developing countries the best method, regarding technical and financial means, is disposal at landfills. However, the ultimate goal is to reduce waste generation and optimize recycling in such a way that waste becomes a closed-cycle system, preventing loss of raw materials, energy and nutrients (Van de Klundert & Lardinois, 1995 p41; Grafakos and Baud, 1999 p8,9). Apart from environmental goals, a sustainable solid waste management system should also include social and economic objectives, like equivalent access to waste collection, and efficient and financial viable waste services. In more detail, these objectives entail:

- Waste services, like waste collection and the cleaning of public spaces, should be provided to all strata of society, regardless of income, ethnic group or social status. At present, most poor neighborhoods are deprived of waste collection and suffer from the environmental and health risks of uncollected waste, like smells and diseases. One of the reasons is that poor neighborhoods are not accessible for garbage trucks, and therefore use should be made of appropriate technology, like hand-pushed carts. In this way, at least an equivalent service can be provided.

Safe and healthy employment with a living wage should be maximized through the organization of the SWM system. This also encompasses broader issues like poverty alleviation and improvement of the local economic situation. This may entail involvement of other actors, like private enterprises, micro-enterprises or the informal sector, but ultimately local government must be accountable for the functioning of the SWM system. The system should remain financially viable for all the actors involved. This includes introducing a fee system that aims at full-cost recovery from those who receive high levels of service. Fees must be in accordance to the economic situation of the receivers of waste services (Van de Klundert & Lardinois, 1995 p 39-41; Grafakos and Baud, 1999 p8, 9).

3.10Developing Sustainable Waste Management: Steps To Be Taken

According to Klundert et al., (2001), there are six basic steps to arrive at a sustainable waste management system:

1. Start a participatory planning process
2. Analyze the existing waste management situation
3. Publish and circulate the findings of the analysis
4. Formulate a draft action plan and budget, including a plan for cost recovery
5. Present the action plan to the stakeholders and incorporate their comments and input.
6. Refine and formulate a final action plan, which is approved by the City Council or other legislative body.
7. Implement the action plan and monitor the results.

3.10.1 Step 1 - Start a Participatory Planning Process

According to Klundert et al., (2001), a participatory planning process involves planning together with other stakeholders, ensuring all groups have a say in preparation and decision-making. Each set of stakeholders involved in waste management – waste producers, waste collectors, recyclers, clients of waste collection services, waste buyers – have different interests, backgrounds and preferences. New and perhaps unexpected stakeholders should be invited too: chambers of commerce, the union of waste pickers or the union of municipal workers. The latter are often powerful and vital bodies to deal with when planning an improved waste management system.

Stakeholders do not all have an equal starting position. It is necessary to consistently empower and support the weaker, underprivileged groups such as low-income households, waste pickers, small-scale entrepreneurs, women, children, ethnic groups and other low social status groups. In a participatory process all stakeholders should have access to information vital for their role. This may be considered a political risk for the local authorities, but they need to be convinced that sharing information is vital for good cooperation. Support to the weaker stakeholders may include: establishing citizen's associations and platforms, training such groups in waste management and the ISWM concept in all its aspects.

A participatory process works best when the meeting is moderated by a trained facilitator who sets the agenda and prepares the agenda items with the municipal staff or consultant responsible for planning. In most cases the agenda should include:

- Goals of the participatory planning process for each stakeholder
- An introduction to the waste management system and its problems, from the point of view from each stakeholder
- Explanation of ISWM by a trainer or experienced person
- A presentation of one or more specific issues and items, such as separation at source, a proposed fee system
- Discussion of these issues, sometimes facilitated by games, role playing, or small group exercises
- Exploration of potential roles of the various stakeholders in implementation of ISWM
- Discussion of the plans for assessing the waste management

A participatory planning process can lead to a bundling of resources to start the assessment of the existing waste management situation. For example some stakeholders – a non-governmental or community-based organization, a research institute or university – may be able to provide volunteers to carry out the study; some could provide specific information – researchers, libraries, web sites, consultants, donor organizations. Others could sponsor the study financially – private companies, social organizations – or be able to provide space for meetings – the municipality itself, companies, larger non-governmental organizations – lend a car, or provide office space with computers or typing machines to work out the results. There is often an astonishing willingness of stakeholders to cooperate, also financially, when the atmosphere of the group meeting is positive and all participants understand their intertwined interests.

3.10.2 Step 2 - Analyze The Existing Waste Management Situation

The next step is to analyze or assess the present patterns of waste management: where the materials are generated, where they are manufactured into products, where they are sold and consumed and by whom, if the waste materials are recovered and where they are disposed of. The analysis when complete offers a comprehensive picture of materials flow in the city.

An assessment of the present waste management system using the ISWM aspects gives you the opportunity to make a collective diagnosis of the kind of problems that exist in your city related to waste management. It is a basis for the development of an action plan to improve waste management.

3.10.3 Step 3 - Publish And Circulate The Findings Of The Analysis

The findings of the assessment should be published and made available to all stakeholders. This can best be done through the local media – newspapers, radio, TV. Copies could be sent to stakeholders directly involved in the planning process. Then one or more meetings should be organized to present and discuss the findings. These meetings can include brainstorming about possible solutions to the problems presented. The meetings will thus be the basis for the formulation of a local waste management action plan. The meetings can focus on:

- What does the assessment report say?
- What are the main problems?
- How can we change the situation and make waste management more sustainable?
- Which issues deserve priority attention?

3.10.4 Step 4 - Formulate A Draft Action Plan And Budget, Including A Plan For Cost Recovery

The next step in implementing ISWM focuses on developing a draft integrated sustainable waste management action plan. This starts with collecting all opinions and ideas voiced during meetings and the results of the assessment and compiling them. It is useful to engage a local expert or consultant to evaluate the potential steps that could go into a draft action plan, including:

- Goals and targets to be achieved in certain number of years
- Measures to be taken to achieve goals
- Pilot projects to be set up
- Resources needed – financial, material, human
- Division of responsibilities between various stakeholders
- Commitment to deliver resources by various stakeholders
- Implementation schedule and timeline
- Monitoring indicators to measure success

Goals can be set according to ISWM principles, covering technical, social, environmental, institutional, organizational and policy aspects. The goals should be supported by specific, verifiable indicators for monitoring and evaluation. These indicators should also be acceptable to the stakeholders. Planned activities will tend to cluster around the eight waste system elements and no plan is complete without addressing them all. Such plan ideally results in a comprehensive view of the flow of materials in the city and the various levels of actions that are needed to intervene and to manage them sustainably.

3.10.5 Step 5 - Present The Action Plan To The Stakeholders And Incorporate Their Comments And Input

Then the draft action plan needs to be presented or delivered to the various stakeholders, who are invited to discuss it among their constituencies and also in large group meetings. The feedback from these meetings then goes to the coordinator of the process, for incorporation into the final plan.

3.10.6 Step 6 - Refine And Formulate A Final Action Plan, Which Is Approved By The City Council Or Other Legislative Body

Once the stakeholders are in agreement, those staff, local experts and/or consultants in charge of the processes finalize the plan, which is then presented to the political authorities for discussion and approval. This step is critical to get the authorities to "buy in" to the ideas in the plan, since they will have to approve budgets and other items later in the implementation process.

3.10.7 Step 7 - Implement Action Plan And Monitor The Results

Once the City Council or other body approves the action plan, implementation can begin. A launching party or parade can be organized to attract public attention to the start of the implementation phase. Starting with a high profile activity, such as a clean-up campaign in a particularly dirty area, helps to motivate participation, as people can see something is actually happening. It is good to organise a follow-up Meeting with the public immediately, so the process gains credibility from the beginning.

After implementation has started, keeping track of improvements through a monitoring process becomes important. Monitoring involves collection of data, storage of this data in a database or other structure, analysis of the information and publication and dissemination of the results. The municipality does not have to do all the monitoring on its own, but it needs to be involved with establishing indicators and it has a role in quality control. The UWEP programme had success with monitoring community and non-governmental organizations. The stakeholder platform may be a good forum for discussing or presenting the results of the monitoring. The information should be accessible to other stakeholders so that they feel involved and can be stimulated to take action by themselves.

3.11 Summary

Many key issues supporting SWM were discussed in this chapter. The existing situation of SWM in developing countries as well as in the Gaza Strip, Integrated SWM, sustainability of the service and public participation were discussed. As discussed earlier in chapter two, the Gaza Strip like other developing countries is experiencing waste disposal problems stemming from shortage of landfill space. The change in approach and methods of waste disposal world-wide are due to increasing concerns regarding the impact of solid waste on health, safety and the environment. In the Gaza Strip, the disposal methods have not only changed over time but have improved with the application of the latest technology in waste disposal. The amount of waste generated has grown annually and improper disposal may result in numerous and serious environmental problems. There is a particular concern in the Gaza Strip about the area of land that will be required for landfill disposal of waste, and whether sanitary landfilling is the sustainable option for Gaza. Palestinian municipalities and village councils are responsible for providing the SWM service in towns and villages while UNRWA provides the service to refugee camps. Fees are being paid to the operating municipalities. UNRWA sometimes provides assistance to Palestinian municipalities through bilateral donors. Public participation in waste management has been introduced by some donors like the case with the EU in Gaza municipality (see case study three in chapter 7). The low level of willingness among the Palestinian public to cooperate with municipalities is due to the lack of two way communication process and lack of Palestinian awareness of municipal operations. Some Palestinians are willing to be involved in municipal decision-making process as part of social and political interest. Now public participation is being fully addressed by donors as a key issue of the sustainability. Finally, sustainable waste management has been explicitly elaborated in such a way that it supports the strategic vision of sustainable disposal options where the Palestinian National Authority can follow.

CHAPTER

4

CHAPTER FOUR: METHODS OF WASTE COLLECTION AND DISPOSAL OPTIONS

CHAPTER 4: METHODS OF WASTE COLLECTION AND DISPOSAL OPTIONS

4.1 Introduction

The safe and reliable long-term collection and disposal of solid waste residues is an important component of integrated waste management. There are only two fundamental urban waste management tasks. The first, and usually the more crucial, is the effective collection of wastes from inhabited areas. This removes an easily accessible and potent source of health hazards, reduces squalor caused by accumulated waste, and enhances the social status of neighborhoods together with property values and the self-esteem of the inhabitants.

The second crucial waste management task is disposal. This is often the subject of much attention because proposed new waste disposal sites provide an easily identified focal issue that arouses great controversy in almost all major cities, prosperous and otherwise. This has become one of the most intractable political problems for civic leaders.

This chapter is focused on methods of waste collection and disposal. It provides the contextual background for the case studies analyzed in chapter seven. It discusses the main processes, highlighting the four disposal options. It contains three sections. ***Section one***: tackles storage, collection and transportation. ***Section two***: discusses the disposal methods and options; landfilling, composting, waste minimization and incineration and its applications in the developing countries and the Gaza Strip. This disposal option is very critical before any strategy or policy is adopted by any authorities or government. ***Section three***: discusses the influential aspects affecting the disposal alternatives in order to elaborate on their applicability on the case studies as explained in chapter seven.

4.2 Generation, Storage, Collection and Transportation

Waste generation encompasses activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal (Techobanoglous, et al. 1993). Broadly speaking, the material flow of waste from generation to ultimate disposal, comprises the following: generation, storage, collection / transportation, processing and disposal.

Cities produce waste from dwellings, commerce, industries, schools, parks, health care institutions, roads and other infrastructure such as water and wastewater treatment. While this waste is mostly solid, many Asian cities that lack adequate wastewater collection and treatment usually have substantial additions of human body waste as well as industrial, health care and household waste liquids and sludges. All this waste requires collection and disposal to prevent squalor, reduce the risks of serious diseases and permit the social and economic advancement of cities (Macfarlane and Rushbrock, 1996).

Accordingly, SWM encompasses the full range of activities for these streams, from the generation of used materials to their disposal (Beede and Bloom, 1995; Lardinois, 1996). Resource recovery includes all activities of waste segregation, collection and processing which are carried out taking into consideration the economic viability of the material (Cointreau, et. al.,1984; Baud and Schenk, 1994; Beede and Bloom, 1995). Re-use and recycling provide an opportunity to capture some of the values from the waste (Cointreau, et. al., 1984; Beede and Bloom, 1995). Of these two techniques, reuse is a simpler process involving reutilization of material in its end-use form without the necessity of reprocessing (Beukering, 1994). Recycling, on the other hand, involves processing waste through remanufacture and conversion of parts in order to recover an original raw matter (Cointreau, et. al., 1984; Beukering, 1994).

A review of existing literature reveals that a great number of studies on SWM have been undertaken, even prior to 1970. Earlier studies show that refuse management was assumed to be the main responsibility of the public officials whose prime consideration was the quick removal of waste and its destruction (Melosi, 1980). During the 1970s the debate shifted to issues of waste utilization. Studies during this time focused on the technical and economic issues surrounding the allocation and utilization of available resources, and examined existing state-of-the-art recovery techniques for managing urban grime (Bever, 1976; Heidenstam, 1977). The early studies reveal that recycling in the past was mostly industrial and based on financial considerations to reduce production cost, unlike the current emphasis on recycling as a way of reducing waste in the environment and preserving dwindling resources (Cointreau, et. al., 1984).

The collection of waste and its recovery from different waste generating points is carried out by many agents, formal and informal, which represent a variety of organizational structures and relationships (Cointreau, 1987). In most developing countries, including India, urban SWM comes under the auspices of the local municipal bodies who are the main formal stakeholders responsible for the collection, removal and disposal of garbage from public places and for the maintenance of dumping grounds (Hadker, 1995). Sometimes the private formal sector, such as private contractors and small and large reprocessing enterprises, as well as the non-government and community-based organizations (NGOs & CBOs), assist the municipal authorities in collecting, treating and disposing waste (Gidman, et. al., 1995).

Alongside the formal sector, in developing countries resource recovery and recycling activities are also marked by the involvement of local community. This comprises waste pickers, itinerant waste buyers (IWBs) and middlemen such as junk dealers and wholesalers (Aziz, 1984; Hardoy et. al., 1992; Huysman, 1994; Furedy, 1989). This informal sector mostly refers to those employers, which are classified as "own account" workers, eg unpaid family workers and those who collect and treat mostly unregistered waste material (World Bank, 1995).

4.2.1 Generation

On a global level, it is estimated that in 1990, approximately 1.3 billion metric tones of municipal solid waste was generated, averaging about two-thirds of a kilo per person per day (Beede and Bloom, 1995). Yet, the difference between high and low-income countries is considerable, especially in terms of composition. As economic prosperity increases, the amount of solid waste produced consists mostly of luxury waste such as paper, cardboard, plastic and heavier organic materials. In cities in the south, on the other hand, waste densities and moisture contents are much higher (Cointreau, et al., 1984). In addition, the hazardous content is quite high since the regulatory and enforcement systems to control such waste disposal are usually non-existent or not operating (Cointreau - Levine, 1997). This is a particular problem with waste from hospitals located within the city area, which is often found mixed with municipal waste in open dumps and landfills (Indapurkar, 1996).

These differences mean that waste management systems each require distinct approaches. For example, as the waste content in developing countries is highly organic and susceptible to rapid decay, the emphasis of the SWM process in these countries should be on the collection process. Studies have shown that expensive collection trucks and compactors developed and used in industrialized countries are difficult to operate and maintain, and are unsuitable for narrow lanes, the high traffic density and the nature of waste in developing countries (Cointreau and de Kadt, 1991).

In the Gaza Strip and during the Intifada, the solid waste generated is different from that produced in the situation above. Less waste is being generated due to the economic situation and waste generation is linked to lifestyle. In 2000, a total waste production of 650m3/day was calculated by the European Union Palestinian Solid Waste Institutional Building funded project. The production would increase during the summer seasons and the month of Ramadan. During this time, people's habits lead to an increase in the amount of solid waste production. Waste production was 0.8kg/c/d, waste density at collection points was 0.4kg/l and the total waste production was 1200 tonne/day. The moisture content is higher than 50%. The biodegradable organic matter was estimated by the EU in 1996 as 65% of the solid waste (UNRWA, 2000). UNRWA made a similar estimation for organic composition in 1993. More detail on this can be found in Chapter Three.

4.2.2 Storage

The storage of refuse has provided an eternal problem to civilized man and waste has been disposed by different methods without adequate public health measures. It is accepted that proper storage of waste within or near the premises generating it is a fundamental prerequisite to public health, aesthetic and environmental protection. It is the key determinant of the overall productivity of the various steps of SWM. The introduction of portable refuse containers has resulted in reduction collection costs - as refuse was previously shoveled from heaps containers into carts - and therefore a more thorough method of emptying refuse containers became possible.

In the Gaza Strip, most community storage occurs through the use of bulk bins provided by the municipalities. However, some areas are being served by house-to-house collections in the short term because this is the type of service that residents are accustomed to and any other service would lead to widespread dumping of domestic waste on the ground. Different systems - compactor trucks, roll-on, roll-off containers, open trucks etc. - are already in use, and in many cases it may be appropriate to provide items that are compatible with the existing equipment. It is probably necessary to empty community bins at least three times a week (Coad, 1997). Storage containers are frequently damaged by burning. The contents are probably set on fire deliberately by residents who think that burning is necessary because of the bulk or the smell of the waste. The resulting smoke, as the waste burns for many hours, is much more hazardous to health than the odour of the unburned waste, and the containers are damaged since they corrode quickly after their protective paint is burned off, and any plastic or rubber components are burned or damaged (Coad, 1997). In Gaza, most of the containers are produced locally, and can be designed to be strong enough to handle waste that is much denser than European waste, and to resist the greater corrosion potential resulting from the higher moisture and vegetable contents.

The containers used by the SWMC in central Gaza - and elsewhere in Gaza with trucks funded by the Japanese Government - were specially designed for the local conditions. Since the storage bins are mostly located on sandy ground, it was considered that wheeled containers would not be suitable, being too difficult to move when full. It was specified that the containers should be capable of being lifted from their resting places by a truck-mounted crane (El-Hawi, 1997). Coad (1997) argues that communal containers often prove inappropriate for the Gaza Strip because the lids are difficult or inconvenient to open, or they are dirty, and so residents are reluctant to open them. Consequently, the waste is either placed beside the container or the lids are left open so that the containers serve no purpose. However, awareness workers in central Gaza believe that lids would be used properly in some residential areas, and in the West Bank some cases have been observed where residents do open the lids to deposit their waste, and close them afterwards. It may be appropriate to systematically study the behavior and attitudes of the public towards lids, in order to determine whether it is worthwhile to fit lids to communal containers.

Litterbins of various designs have been installed in the commercial districts of several Palestinian cities, including Gaza City, Deir El-Balah, Khan Yunis and Jericho. Experience has shown the importance of evaluating the designs on a pilot basis before they are implemented on a large scale. In general they are being used well, though there is a need to combine their introduction with an awareness campaign to encourage the public to use them for litter and to ask shopkeepers not to use them for their solid waste (Coad, 1997).

4.2.3 Collection and Transportation

The level of service for waste collection also varies markedly. In most industrialized countries services have expanded to the extent that over 90 per cent of the population (and 100 per cent of the urban population) have access to waste collection. This is not the case in developing countries (UNEP, 1991). The failure to provide adequate collection services poses a serious threat to human health in many developing countries (WHO, 1992). Yet, it should be noted that municipal services in developing countries are handicapped by limited finances and an ever-increasing demand on urban services.

Studies show that in many developed countries, burial in controlled landfills continues to be the most prevalent means of disposing of solid waste including hazardous waste – about 70 per cent of urban solid waste is disposed of in this way in the United States and most European countries. Incineration and recycling also play a key role in the management of urban and industrial waste (UNEP, 1994). It is worth noting that these options are particularly popular in very densely populated countries such as Japan and the Netherlands. In contrast, in developing countries the prevalent method of solid waste disposal is through uncontrolled dumping or burning on open ground or city streets (UNEP, 1994; Cointreau-Levin, 1997). This often results in more pollution and loss of salvageable economic value (Bartone, et. al., 1990; UNEP, 1994; Beede and Bloom, 1995).

Waste collection is the process of transferring refuse from the communal or separate storage receptacles to the collection vehicle. It may involve direct transportation to the ultimate disposal site and so transportation and collection can be regarded as interchangeable processes. However, when transfer stations are used a clear division exits between collection and transportation (UNRWA, 1996).

In the developing countries, refuse collection is generally a labor-intensive process where about 10-50 workers are needed for a population of 10,000 (Bhide and Sundareasan 1980). Large crews are used in some cities, rendering the productivity in tones per crew worker per day as low as 0.2 in the Suez Canal region, Egypt, and 0.8 in Labor, Pakistan. It becomes clear that this productivity level is low when it is compared to the situation in the USA, where 3.8 tones per crew worker per day is typical. The general, observable pattern is that labor intensive systems are used in poorer countries because of the relatively smaller quantities of waste generated per dwelling. These systems – and the preference for manual street sweeping – make the collection processes time consuming. The higher number of workers in the low-income countries can also be attributed to the low level of containerization employed by the population. The variations in employment patterns for waste collection in different parts of the world are due therefore to the different frequencies of waste collection, the differences in vehicle types, the times between pickup, and the length of haul to the disposal or transfer point. In contrast, the more productive and lower numbers of workers employed in the developed countries within the collection process can be attributed mainly to the high degree of mechanization in collection and transportation and also to the better working conditions in such places.

Coad, (1997) argues that, selection of equipment for collecting solid waste is often made quickly and with insufficient consideration for local conditions and practices. It often appears that donors regard refuse collection vehicles as the most convenient from of bilateral assistance, and they seem to think that any type of vehicle will do, therefore they provide vehicles of the type used in their own country. Often the result is that the vehicles supplied in this way are unsuitable for the duty expected of them - they are overloaded because of the high density of the waste and difficulties are experienced in repairing them because they are of a type that is not common in the receiving country and so spare parts and repair skills are not widely available.

An example of the SWMC where these mistakes were not made is in the middle area of Gaza. The vehicles were specified by a German expert and supplied by a Japanese grant and were neither German nor Japanese, but were designed according to the local conditions and practices and were produced as far as possible in Palestine (El-Hawi, 1997).

It is important to co-ordinate the type of collection vehicle with the systems that are currently being operated, with local conditions – such as road width and slope, and the extent of paving (in the case of containers with wheels) – and with the density of the waste. Some proposals for compactor trucks recommend bodies that are much too large for the type of waste that may be loaded, with the result that, when full, the trucks will be seriously overloaded and likely to require frequent repair. The needs of each locality should be determined before vehicles are specified. In fact, the whole of the solid waste management system – storage, collection and disposal – should be considered when specifying any equipment (Coad, 1997).

A wide range of collection systems are found within Palestine. Some residents have waste collected from their doors by street sweepers with wheelbarrows. In some areas of Gaza City – where donkeys are commonly used for pulling carts – a house-to-house collection service is provided using donkey carts, from which the waste is transferred to a skip container. Most cities are served by rear-loading compactor trucks which empty wheeled bins with a capacity of about 1m^3. Hook-lift (also called *arm-roll* or *roll off*) containers are also found in most cities. Many of the truck bodies were produced in Israel, although some donors have shipped complete trucks from Europe. Some villages are served by agricultural tractors pulling trailers.

Crane-tippers are found in many parts of the Gaza Strip. Most were designed as part of the GTZ/SWMC project; each truck has a hydraulically-operated truck-mounted crane which lifts and empties containers into a large body which can be closed at the top by pivoted flaps, and is emptied by tipping. The bodies of these trucks, like the containers they use, were produced in Gaza. A new system, which is used in conjunction with crane-tipper trucks, is a house-to-house collection using a small agricultural tractor, which has an attachment at the rear to enable it to carry one $1m^3$ container. When full, the container can be left at the roadside for a crane tipper to pick up and empty (Coad, 1997).

The current haulage distances are relatively small - waste is transported from cities to convenient dumpsites. Some of these cities and dumpsites may be located in groundwater recharge areas where the underground water resources are likely to be contaminated by these disposal sites. In such cases the waste may need to be transported some distance to an environmentally acceptable sanitary landfill and so more vehicles may be needed, or vehicles of different types. For example, tractors with trailers may be suitable for carrying waste to a dumping area, which is just outside the village, but much too small and too slow for carrying the waste to a sanitary landfill 20 km away. In some cases an economic analysis may indicate that a transfer station is needed, so that waste can be transferred from smaller collection vehicles to larger, long-distance bulk transporters like the case with the Rafah transfer station funded by DFID. The City of Jerusalem operates a small transfer station to the east of the old city, where waste is transferred from small tractors and trailers, that collect waste within the old city, to large hook-lift containers (Coad, 1997).

4.3 Disposal Methods and Options

In the UK, the Consultation Draft for Sustainable Waste Management in 1995, has identified and classified waste disposal methods as a "waste hierarchy." As will be discussed later in this chapter, the objective of establishing this hierarchy is to achieve sustainable waste management (Petts and Eduljee 1994, Gummer 1995). Each of the disposal options will provide a board indication of their relative environmental benefits and drawbacks. The hierarchy of options are: i) waste reduction at source; ii) waste recycling, reuse and recovery; iii) treatment of waste; and iv) disposal of the residue from treatment and other unavoidable waste.

Wilson (1981) acknowledged that waste management technology progressed rapidly between 1970-1980, with new inventions and innovations in waste disposal technology. Today, it is difficult to find a balanced judgment for the best technology for a particular group of waste. An overview of the major disposal options and a summary of each option's advantages and disadvantages is simplified in Table 4.1 and an explanation for other options are detailed below.

Table 4.1: Advantages and Disadvantages of Disposal Options

Source: Wilson 1981

Disposal Options	Advantages	Disadvantages
Landfill	• low cost • body of experience and expertise available • allow reclamation of derelict land.	• availability of suitable void space is declining • potential pollution from landfill gas and leachate if not adequately engineered. Landfill gas is a significant green house effect
Waste Minimization	• reduce quantities of waste requiring disposal • reduces disposal costs for producer • reduces usage of raw materials if waste can be reintroduces into manufacturing process.	• may involve initial capital outlay to invest in new plant
Transfer Stations	• reduces transport costs • reduces traffic movements to landfills sites • allow waste sorting and recycling	• requires suitable sitting, near urban areas but not residential. • Results in double waste handling
Baling	• reduces volumes of waste requiring landfilling • allows easier placing in landfill	• expensive plant/operation costs • high energy demand form plant • slow decomposition rates due to compaction
Pulverization	• produces a more manageable and uniform waste for disposal • reduces volume of waste requiring landfilling	• expensive plant/operation costs • high energy demand form plant • slow decomposition rates due to compaction
Incineration	• reduces volume of waste up to 90% • may be sent to generator power • destroys putrescible component of the waste. • destroys potential hazardous organic waste	• potential air pollution if not adequately engineered/operated • requires expensive plant • difficult to find acceptable location • pollutants concentrated in residue require further disposal
Composting	• removes gas/leachate generating waste from landfill • creates a usable product (compost) reducing reliance on peat based products • biogas generated may be utilized	• costly to instigate and operate schemes • relies on segregation of waste by producer • final product may be difficult to market
Physical Chemical Treatment	• converts hazardous waste into less toxic material • may convert waste into a reusable product	• requires expensive plant • may result in toxic residues requiring further treatment of disposal
Sea Disposal	• simple technology • low cost	• potential to pollute marine environment • to be phased out for industrial waste by 1993 and sewage sludge by 1998
Refuse Derived Fuel	• generates fuel pellets • reduces volume of waste requiring landfill	• high plant/operational costs • limited market for initial product

Coad (1997) argues that disposal to land is a difficult process entailing threats to the environment and to health. Alternatives such as incineration and composting seem attractive. Whilst these methods can reduce the volume of waste requiring landfilling, and whilst they have been used successfully in some parts of the world, they should not be considered as viable on a large scale in the short term.

The burning of waste at disposal sites is a widespread practice. Burning has the advantages that it

- reduces the volume of waste so that a smaller area is required, or a given site lasts for a longer time;
- reduces the fly and rat breeding at the sites;
- reduces the production of leachate or liquor which may pollute the groundwater,
- reduces the decomposition and settlement so that the resulting fill is more stable.

However, burning has the great disadvantage that:

- it causes serious air pollution, which is probably very hazardous to the health of residents who live downwind and to workers who spend part of each day on such sites.
- Low temperature combustion at such sites can produce very harmful products such as dioxins and furans, which are linked to cancer.

4.4 Disposal Options

4.4.1 Landfilling

Disposal requirements affect the whole waste management system. Because of the needs for a higher standard of disposal, it may be necessary to radically modify the institutional arrangements for SWM in Palestine (El-Hawi, 1997).

The closure of existing open dumpsites and the introduction of sanitary landfill is an urgent priority everywhere in the developing world. Even where complementary disposal technologies such as composting or incineration (waste to energy plants) are practiced, a landfill is still required and is the backbone of any sustainable disposal system. Given the essential nature of the landfill for final disposal, and the lack of local experience and financial resources for introducing sanitary landfills, central government support in terms of technical assistance and access to financing is needed in many lower and middle income countries. Matching grants designed to encourage landfill investments and sustainable operations may be an appropriate instrument to consider, primarily because the environmental damage and benefits tend to spill over into neighboring municipalities and regions, or into underlying groundwater resources (World Bank, 2000).

As has already been pointed out, in the process of planning for and siting a disposal facility it will be necessary to anticipate the NIMBY syndrome and plan for public involvement in the location decision. Location decisions also require the conduct of environmental impact assessments (EIAs) and the incorporation of recommended mitigation measures in the final design, construction and operation processes. Finally, when planning for landfills, consideration should also be given to innovative design options like bioreactor landfill design with methane recovery and utilization. The latter point is particularly important given that the methane that escapes from landfills to the atmosphere is a potent greenhouse gas of the facility. In many municipalities there is also a need to improve management of waste from healthcare establishments or parts of waste management system. Healthcare waste management encompasses measures for waste minimization, segregation, storage, collection, treatment and disposal (World Bank, 2000).

Undoubtedly, landfill will continue to be a principle option for the medium term in many countries and in these cases, improvements to landfill management are the key to minimizing the environmental effects. Crawford and Paul (1985) identified the various titles used for this practice as: tips (UK); sanitary landfill (USA); coup (Scotland); controlled tipping (UK); dumps (world-wide). This practice is by far the most commonly used method for waste disposal by both the municipalities and industrial communities. Landfill sites include areas such as wetlands, peat bogs, idle mining and quarrying sites, and low-grade agriculture or farming land.

Typically in the UK, there are about 1000 disposal sites or facilities operated by private companies of which 78 percent are landfills. About 100 sites are licensed to take only asbestos and non-special wastes and 500 sites are able to take special wastes on a co-disposal basis. Co-disposal, where MSW and hazardous waste are disposed of at the same site, can only be operated at specially designed sites. However, there is pressure to substitute the policy of co-disposal with an arrangement where hazardous and no-hazardous wastes are managed separately (ICHEM, 1993).

Today, it is difficult to obtain planning permission for new landfill sites. This is due to increased environmental awareness by the public. The NIMBY syndrome has changed people's attitudes in searching for an ideal living environment. The obstructive power of NIMBY should not be underestimated and public participation is a crucial element in this aspect. Rushbrook & Pugh (1999) have added a similar syndrome NIMTO ("Not In My Term of Office"), which can sometimes stall the decision-making process. Efforts should be made by all concerned to recognize the need for difficult decisions to be taken, not avoided. Politicians must be presented with well-researched and widely supported recommendations.

Ackerson (1990) stated that recent environmental concern over ground water pollution, leaching into waterways, and even air pollution, as well as increasing costs, has resulted in this technology becoming unacceptable in most areas. Few new landfills are being approved, and the average remaining life of operating landfills is only about five years. However, modern designed landfill sites minimise the impact on the environment and local communities.

Coad, (1997) argues that, modern sanitized landfill construction involves extensive civil engineering including the preparation and formation of the site's base and sides. Groundwater protection is provided by natural presynthetic liners. Internal bunds are formed to divide the site into working areas called cells. Drainage and gas collection systems are installed to manage leachate and gas production. Coad added that, landfilling used to be the only disposal option for solid waste in the Gaza Strip. Other alternatives such as incineration, composting and others were never tried except for small scale anaerobic composting at the refugee camps in the fifties and the early sixties.

During the Israeli occupation, sanitary landfilling as a method of disposal has never been used in Gaza. This can be related back to the lack of proper management, absence of awareness on the environmental impacts of handling solid waste, remoteness of dumping sites from the populated areas for the last three decades and lack of financial resources (Coad, 1997).

The main problem associated with landfilling in Gaza is the lack of suitable landfilling sites as land in Gaza is generally scarce. This situation is aggravated by the confiscation and control of land by the Israelis. The use by the Israeli military authority during the occupation rendered about 35% of the land out of bounds for the Palestinians in the Gaza Strip. It is understandable that under such circumstances the price of land will increase far beyond its financial value. Land became a symbol of national identity, pride and preservation. This is possibly the reason why land values are currently extremely high and there's a reluctance to sell land. In the context of SWM it is consequently very expensive and difficult to find suitable and available land on which to establish new sanitary landfills. Land appropriation is also likely to meet steep opposition, regardless of whether this may be for a purpose of common interest or national priority, such as locating landfills in those areas where the risk of groundwater pollution is lowest. It is felt that under the present circumstances, it may be more practical and acceptable to compromise on the environmental factors and to use marginal land where land filling is already on-going, where the owners may be interested in leasing out the land for this purpose in order to increase its usability, and to apply the necessary measures to safeguard against pollution (El-hawi,1997).

As a consequence of the high population density, there is a perception that there is insufficient land for solid waste landfills. In practice, this may not be the case because there are areas of low-grade agricultural land, which would be suitable for sanitary landfills. The problem of siting or locating waste disposal facilities is one of acquiring the land, and not primarily the lack of possible sites. In some areas the land has been divided into small parcels, so that acquiring land for a landfill entails negotiating with many owners, some of who may be abroad. The existing landfills in the Gaza Governorates are all close to the border with Israel, according to the regional plan developed by MoPIC, and so there is a restriction on the height to which the landfills can be constructed, for security reasons. If landfills were to be built further from this border, it should be possible to raise them considerably higher, producing a natural-looking hill, which could become an attractive feature of the landscape at the same time as reducing the area requirement for waste disposal (Coad,1997).

Three central landfills were recommended by the master plan developed by MoPIC in cooperation with MEnA and MoLG. Table 4.2 summarizes these disposal facilities as depicted in Figure 4-1.

Table 4.2: Landfill Existed in the Gaza Strip

Source: MEnA, 2002

No	Name of dump site	Status
1	Rafah Landfill	▪ Area and ownership: 25,000 m2 private land, rented, Proximity to future expansion. ▪ Location from nearest residential area: 8 km ▪ Height of waste: 3 meters ▪ Type of waste: 90% MSW and 10% other waste ▪ Type of soil: Almost clay ▪ Operation, Management responsibility: Rafah Municipality ▪ Expected lifespan: 10 years ▪ Leachate problem: No management, no lining ▪ Possible groundwater contamination: Not documented ▪ Claims of neighbors: Not documented
2	SWMC Landfill	▪ Area and ownership: 45 dunums where 25 dunums are private land and 20 is owned by the SWMC. 13 municipalities and village councils in addition to UNRWA are sharing this facility. Proximity to future expansion. ▪ Location from nearest residential area: 4 km ▪ Height of waste: 25 meters ▪ Type of waste: 95% MSW and 5% other waste ▪ Type of soil: sandy and silty clay ▪ Operation, Management responsibility: SWMC in cooperation with the GTZ ▪ Expected lifespan: 5 years, limited life span ▪ Leachate problem: Proper management through re-circulation at the top of waste, asphalt lining ▪ Possible groundwater contamination: No ground water contamination is documented by monitoring wells. ▪ Claims of neighbors: Not documented
3	Gaza Municipality landfill	▪ Area and ownership: 60 dunums are private land, Beit Hanoun, Beit lahia, Jabalia Gaza and UNRWA are sharing this facility. Proximity to future expansion ▪ Location from nearest residential area: 4 km ▪ Height of waste: 15 meters ▪ Type of waste: 80 % MSW, where 5% Slurry, 5% construction waste, 3 % industrial and 7% medical and hazardous waste. ▪ Type of soil: sandy and silty clay ▪ Operation, Management responsibility: Gaza Municipality with little assistant from the EU. ▪ Expected lifespan: 10 years ▪ Leachate problem: No management, no lining ▪ Possible groundwater contamination: No ground water contamination is documented by monitoring wells. ▪ Claims of neighbors: Little documented

Figure 4-1: Groundwater Quality

Source: MEnA, 2000

4.4.2 Composting

Composting is a cornerstone of sustainable development, yet it is often neglected within integrated municipal SWM programs. However, composting can only be part of municipal solid waste MSW programs if adequate recognition is given to the needs and costs associated with proper waste disposal; nothing is cheaper than not collecting solid waste (Hoornweg, et al., 2000).

Society's concerns about groundwater contamination from landfill leachate, the high cost of incineration as well as its air pollution potential and associated ash disposal problems have made it willing to reconsider MSW composting. If beneficial utilization of MSW-compost is to be successful, the idea of composting as a money making venture must be abandoned and the quality of the product needs to be appropriate for its end use. Then MSW composting might become the alternative to landfills and incinerators (Hoitink et al, 1993).

The following are some definitions of composting from different perspectives:

Composting is the biological decomposition of organic waste under controlled conditions to a state where a storage, handling and land application can be achieved without adversely affecting the environment (Golueke, 1997).

Composting is a managed system that uses microbial activity to degrade raw organic materials, such as yard trimmings, so that the end product is relatively stable, reduced in quantity - when compared to the initial amount of waste - and free from offensive odours (EPA, 1993).

The technical definition of composting can be summarized in three words: "controlled biological decomposition" and these words become extremely important as we talk about communities starting composting programs.

Composting is simply a processing technology, and not a magical process of disposal of MSW as shown in Figure 4-2. It must be recognized that the MSW-product must be safely placed in the environment. Beneficial use of MSW-compost in agriculture or horticulture may add further value to the effort of society to separate waste components and recycle where possible (Zurburgg, 1999).

Although compost doesn't contain enough nutrients to be a substitute for fertilizer, it has the ability to release its nutrients more slowly to plants and it can help in plant disease suppression and water retention, very valuable features in a water scarce environment like the Gaza Strip (El-Hawi et al, 2002). The typical process of composting as an end product is illustrated in Figure 4-2.

Composting of selected organic materials can become a valuable component within the integrated waste management system. It is a process as natural and as technologically advanced as recycling. There is no question of the importance of composting in the future; the more significant questions are how and to what degree composting will become integrated for maximum value recovery. Some of the questions on compost were raised to municipal officials, solid waste specialists, farmers and decision-makers. Responses and interpretations have shown great support with compost as an end product, also as a strategic disposal alternative to landfilling (El-Hawi et al, 2002).

Transfer of solid waste technology, including processes and equipment, is usually from industrialized countries to less developed countries. Often the technology is not directly applicable, as it fails to adequately consider local factors such as the waste characteristics, seasonal variations in climate, lack of technical education and training, cultural attitudes towards solid waste, and the status of waste management in political institutions (Hoornweg, 1999). Table 4.3 shows some relative figures for the composition of urban waste in different countries. The figures seem to indicate that poorer people generate a higher proportion of compostable matter than the rich do.

Table 4.3: Urban Refuse In Low, Middle And High Income Countries

Source: Cointreau, 1982

Percentage Composition by Weight	Low-Income Countries	Middle Income Countries	Industrialized Countries
Per Capita Waste Generation Kg/day	0.4-0.6	0.5-0.9	0.7-1.8
Paper	1-10	15-40	15-40
Glass/ceramics	1-10	15-40	15-40
Metals	1-5	1-5	3-13
Plastics	1-5	2-6	2-10
Vegetables / puterscibles	40-80	20-65	20-50

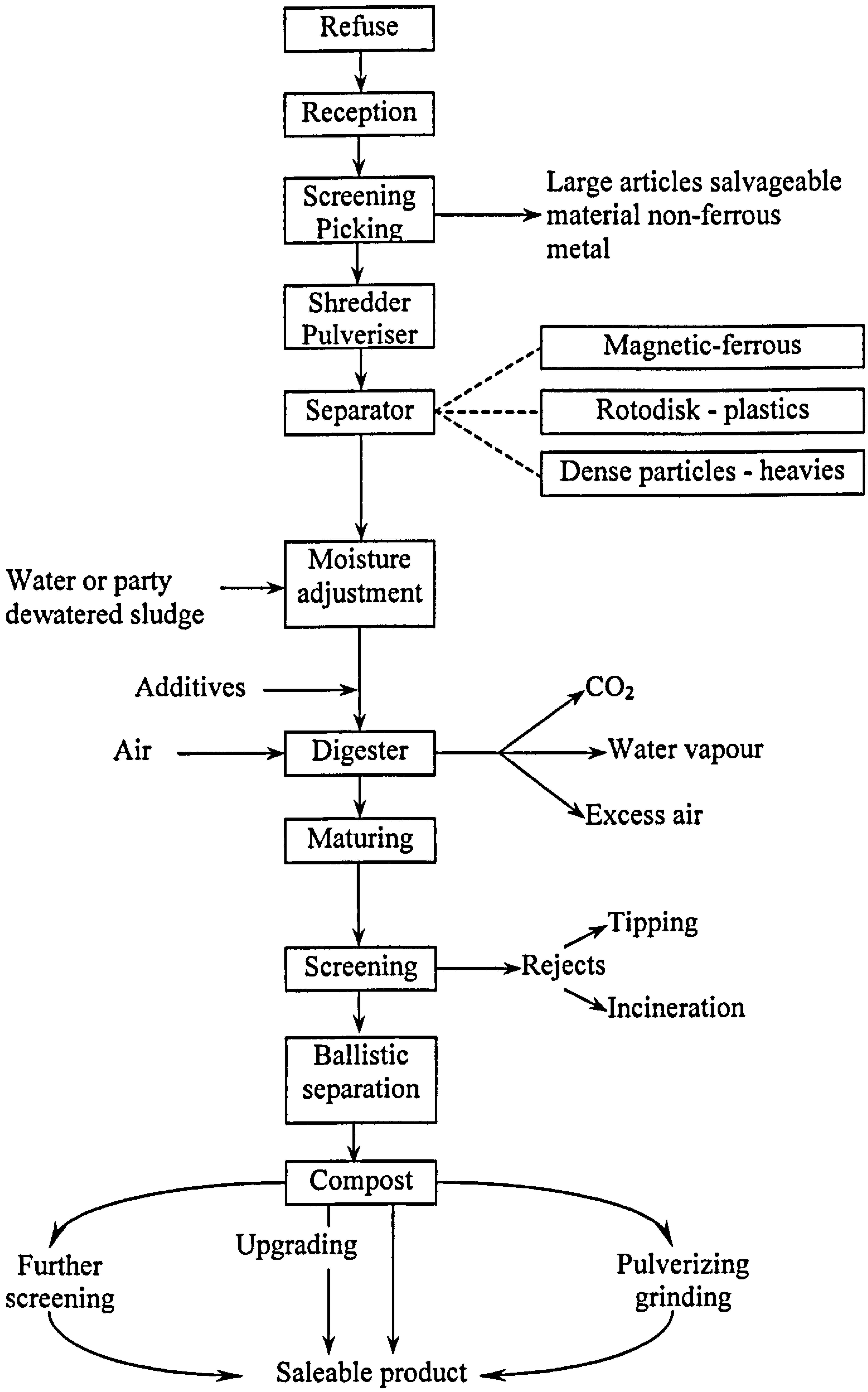


Figure 4-2: Typical Process Flow Diagram For Composting

Source: (After Ambrose, 1983)

Over 50 percent of an average city's MSW stream in a developing country could be readily composted. Composting is a relatively simple process; the compost operator helps nature take its natural course. Optimization efforts increase the rate of decomposition (thereby reducing costs), minimize nuisance potential, and promote a clean and readily marketable finished product (Hoornweg, 1999).

Composting is highly compatible with other types of recycling. Diverting organic material helps to increase the recovery rate of recyclable materials, while at the same time, recycling programs for glass and plastics, which are common MSW compost contaminants, improve the quality of the finished compost. Household source separation of recyclable paper, metal and glass is already common in many developing countries (Hoornweg, 1999).

Vermicomposting

Two known agents of vermicomposting are worms and flies. Worms have relatively widespread use among urban gardeners in Europe and the United Kingdom (Anon, 1995; Linpac, 1995). Vermicomposting is invariably carried out on a small scale in bins.

Vermicomposting can be a successful method of processing organic waste in densely populated, low-income neighbourhoods in the Gaza Strip. In 2001, Khuza'ah Parmaculture Association (a local NGO) working with a pilot group of about 40 Palestinian families used 30 small bins with 0.5kg of worms to compost household organic material. After one to two months, the bins can produce 20 kilograms of vermicompost, which is used by the family or distributed freely to local farmers (personal interview with the NGO, 2003).

4.4.3 Compost Quality

The high organic content in the MSW stream of developing countries is ideal for composting. However, the municipal waste stream also contains increasing quantities of glass, plastics, metals and hazardous materials, which can contaminate the finished compost. Separating contaminants from the raw material at the compost site is inefficient since it requires additional effort, space and time, and it is likely that much of the contamination has already affected the organic fraction. Separating the waste at source before collection is usually an environmentally and technically better way to improve the quality of the final compost. In addition to ensuring a safe product, compost standards provide a valuable marketing tool. The consumer can be satisfied with the knowledge that the product quality is consistent and suitable for the desired application. This is important for commercial and agricultural operations where a relationship exists between predictable results and repeated sales. The supply of compost must also be reliable since the inability to meet market commitments affects customer relations and reflects poorly upon the credibility of the program (Albrecht, 1989).

Chapter seven presents a case study of composting on the community scale as initiated by a local NGO as an environmentally friendly disposal option parallel to landfilling.

Benefits and Constraints of Composting

According to the World Bank (2000), the use of compost as a soil amendment (soil conditioner in agriculture, horticulture and open space management) has the following significant benefits:

- Increases overall waste diversion from final disposal, especially since as much as 80% of the waste stream in low- and middle-income countries is compostable
- Enhances recycling and incineration operations by removing organic matter from the waste stream
- Produces a valuable soil amendment—integral to sustainable agriculture
- Promotes environmentally sound practices, such as the reduction of methane generation at landfills
- Enhances the effectiveness of fertilizer application
- Can reduce waste transportation requirements
- Flexible for implementation at different levels, from household efforts to large-scale centralized facilities
- Can be started with very little capital and operating costs
- The climate of many developing countries is optimum for composting

- Addresses significant health effects resulting from organic waste, such as reducing Dengue Fever
- Provides an excellent opportunity to improve a city's overall waste collection program
- Accommodates seasonal waste fluctuations, such as leaves and crop residue, and can integrate existing informal sectors involved in the collection, separation and recycling of wastes.

Constraints on Composting

Despite these advantages, a composting system creates several problems that will have to be resolved. These problems revolve around the central mechanical issues of the cost of constructing or implementing a system to separate out non-compostable materials from the waste stream in addition to the cost recovery issues (World Bank, 2000).

- Inadequate attention to the biological process requirements
- Over-emphasis placed on mechanized processes rather than labour intensive operations
- Lack of vision and marketing plans for the final compost product
- Poor feed stock which yields poor quality finished compost, for example heavy metal contamination
- Poor accounting practices which neglect the fact that the economics of composting rely on externalities, such as reduced soil erosion, water contamination, climate change, and they try to avoid disposal costs
- Difficulties in securing finances since the revenue generated from the sale of compost will rarely cover processing, transportation and application costs
- Sensible preoccupation by municipal authorities to first concentrate on providing adequate waste collection
- Inadequate pathogen and weed seed suppression

- Nuisance potential, such as odours and rats
- Poor marketing experiences
- Poor integration with the agricultural community
- Perverse incentives such as fertilizer subsidies or over-emphasis on capital intensive projects
- Land requirements are often minimal, but can be a constraint

4.5 Review of Composting Programs in Developing Countries

Previous experiences from developing countries have proved the simplicity of composting, its suitability to local conditions, and the compelling economic and environmental benefits. Some composting operating plants have been successfully operating as illustrated in the following examples:

Box 4-1: Example I: Source Separation And Composting in Cairo Egypt

Efforts are underway to convince Cairo residents of the benefits of separating their waste into organic and non-organic fractions. In an experimental project, 600 households are separating their residential wastes into two streams before collection. The health and efficiency of the waste collectors and the quality of the compost are being monitored. The collectors and processors realize numerous benefits from source separation: reduced incidence of worker injuries and waste related diseases, higher selling prices of cleaner recyclable materials, less time required to sort the incoming waste materials, and improved compost quality. Municipal waste management authorities also benefit from household source separation because less waste has to be collected resulting in lower transportation and disposal costs. The final compost is sold to local farmers to improve the quality of existing agricultural soils. (Lardinois and van der Klundert, 1993).

Box 4-2: Example II: Community Composting in Jakarta, Indonesia

Cipinang Besar, a neighbourhood in East Jakarta, decided to implement a community-composting program to properly dispose of household wastes being dumped into the Cipinang River. Indiscriminate dumping clogged the river and canal and caused flooding during the rainy season. Financial assistance from the United Nations Development Program (UNDP) and the government of New Zealand helped the community to establish its own composting business in 1992. It currently employs 12 people and produces 3 tons of compost per month. Control of the composting business empowers the community and addresses their specific social and environmental needs (Perla, 1997).

Box 4-3: Example III: Community Composting in Brazil

In Olinda, two neighbourhoods have set up composting units on plots of land of about 250m². Incoming waste is dumped into a shallow, lined pit and lifted into a sloped sorting table where rejects and recyclable materials are removed. A team of six individuals can sort one trailer load of waste, weighing approximately 600kg, in about 45 minutes. The remaining organic matter is weighed and formed into windrows. The composting process is controlled by measuring the temperature on a daily basis and the windrows are turned when the temperature drops or when it rises above 650 degree centigrade. Pieces of plastic and other rejected materials that were missed using pre-sorting are removed when the windrows are turned. Stabilized compost is sieved before it is transformed to stockpiles for future use. Regular supervision of the composting process is necessary to ensure proper control (Lardions and van Klundert, 1993).

Composting in the Gaza Strip

In the Gaza Strip, decision-makers are becoming increasingly aware of the need to develop a long-term strategy to deal with SWM problems for today and the future. Although information for such a strategy is generally available, tools to use this information in a systematic and transparent way are lacking (Coad, 1997). Composting units treating MSW have an influence on the expenditure of the institution responsible for SWM service delivery. The solid waste characteristics in the Gaza Strip have a high proportion of organic matter as shown in Figure 4-3 (UNRWA, 2000).

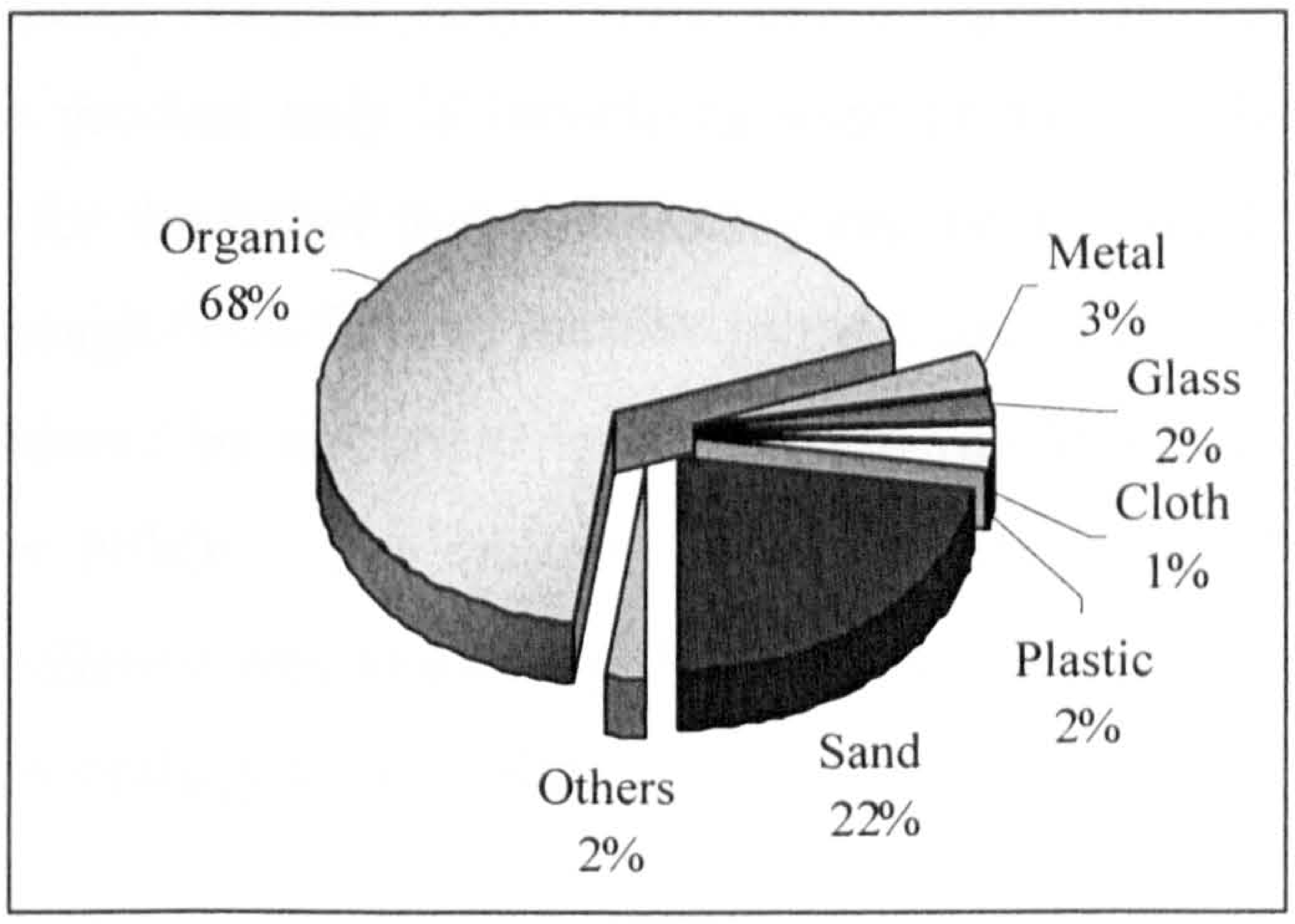


Figure 4-3: The Solid Waste Characteristics in the Gaza Strip

Source: UNRWA, 2000

The high percentage of organic materials and the lack of landfill space in the Gaza Strip make composting of MSW a potentially attractive option, if it is affordable

(UNRWA, 2000). The potential for composting in the Gaza Strip should be good as about two thirds of the domestic waste in urban areas consists of organic material.

The amount of solid waste that needs to be landfilled can be reduced by as much as 50% with the introduction of a composting system. An estimated 65%-75% of the solid waste stream in the Gaza Strip is made up of compostable materials (UNRWA, 2000). Successful composting programmes can double the life cycle of the sanitary landfills. The scarcity of land available for landfilling and the limitations on securing extra land for the existing landfills both provide support for a composting program within an environmentally sound disposal strategy. A composting programme can produce a significant supply of compost that is sold for agricultural use. Such a product can be very valuable in a semi-arid environment like the Gaza Strip (El-Hawi, 1997).

A paper presented by El-Hawi et al (2002) highlighted the potential and constraints of a number of composting issues including: composting as an end product; familiarity of farmers; willingness to use a compost product; the market for, and social acceptability of composting; and composting as an environmentally sound disposal strategy for municipal solid waste as an alternative to landfilling in the Gaza Strip. Municipal officials, farmers, NGOs, the private sector and other decision-makers from the Gaza Strip filled out a questionnaire and were interviewed. Results have shown great support for the composting of MSW. 60% of farmers responded positively when asked whether they would use compost products and 30% were willing to use the product only if incentives were provided. These results provide sufficient support for the belief that composting can be an excellent soil conditioner and fertilizer. Although 65%-75% of the SW in the Gaza Strip is organic, composting is not being considered by any municipality on the whole, but just on a very small scale within a few NGOs. The majority of this focus group (70%) believed that composting is an efficient way to prolong the lifespan of a landfill and that it provides a parallel long-term strategy to landfilling.

According to the UNRWA report (1993), composting is being highlighted as an environmentally sound disposal option parallel to landfilling for the Gaza Strip as shown in Table 4.4.

Table 4.4: Rating of Alternative Methodologies of SWD

Source: UNRWA, 1993

Technology	Technical Merit	Ease of Operation	Capital cost	Recurrent cost	Environmental acceptability
Incineration	A	C	C	C*	B
Landfilling	B	A	B	B	B
Composting	B	B	B	B	A

* Does not include benefits from energy recovery
A = Most favourable, B = Intermediate, C = Favourable.

Experiments by Afifi (1997) have been undertaken to determine the value of decomposed waste. Preliminary investigations suggest that the decomposed waste, after sieving, could be added to soil to improve its organic content. It would also be a useful cover material for the landfill itself. The reuse of the decomposed material in this way frees capacity in the landfill site for more waste. The heavy metal content of the samples was within European limits for compost. If a market could be established for this material, it could be distributed to customers by the trucks that normally return empty from the disposal site (Coad, 1997).

In Khuza'a village close to Rafah, a small permaculture plant collects the organic waste from a few hundred households and farms, and supplies these waste generators with compost. This is not done on a commercial basis (MA'AN, 1997).

Composting also requires a fair amount of water. The actual amount varies depending on the compost operation technology. Water is a scarce commodity in the Gaza Strip. Islamic University examined other options for water supplies for composting. Research by a local environmental NGO (MA'AN, 1997) has indicated that grey water, sewage sludge, or untreated wastewater can be used in the composting process. This creates a potential win-win situation that can solve two major problems: the safe and environmentally sound disposal of both municipal solid waste and wastewater.

In 1998, the European Union and Gaza Municipality constructed a pilot plant aiming to compost 8 tonnes of organic (market) waste per day. The project has been frozen due to the current political situation and unavailability of a budget to cover the necessary running costs.

Try to Kill Two Birds with One Stone

There is a saying; "killing two birds with one stone". In this case, the two "birds" are:

- To assist the municipalities, village councils and UNRWA to save the transportation and disposal costs in the belief that the product will reduce the cost of the SWM operations, enhance and promote the use of composting as an end product and protect water resources from being contaminated by possible leachate percolation.

- To extend the life span of landfills through composting of MSW (65-75%), which will contribute to a saving of 50% in landfill capacities. At the same time, it's desirable to promote organic agriculture, reduce subsidies on chemical fertilizers and convince farmers to use the compost as an end product (El-Hawi et al., 2002) as shown in Figure 4-4.

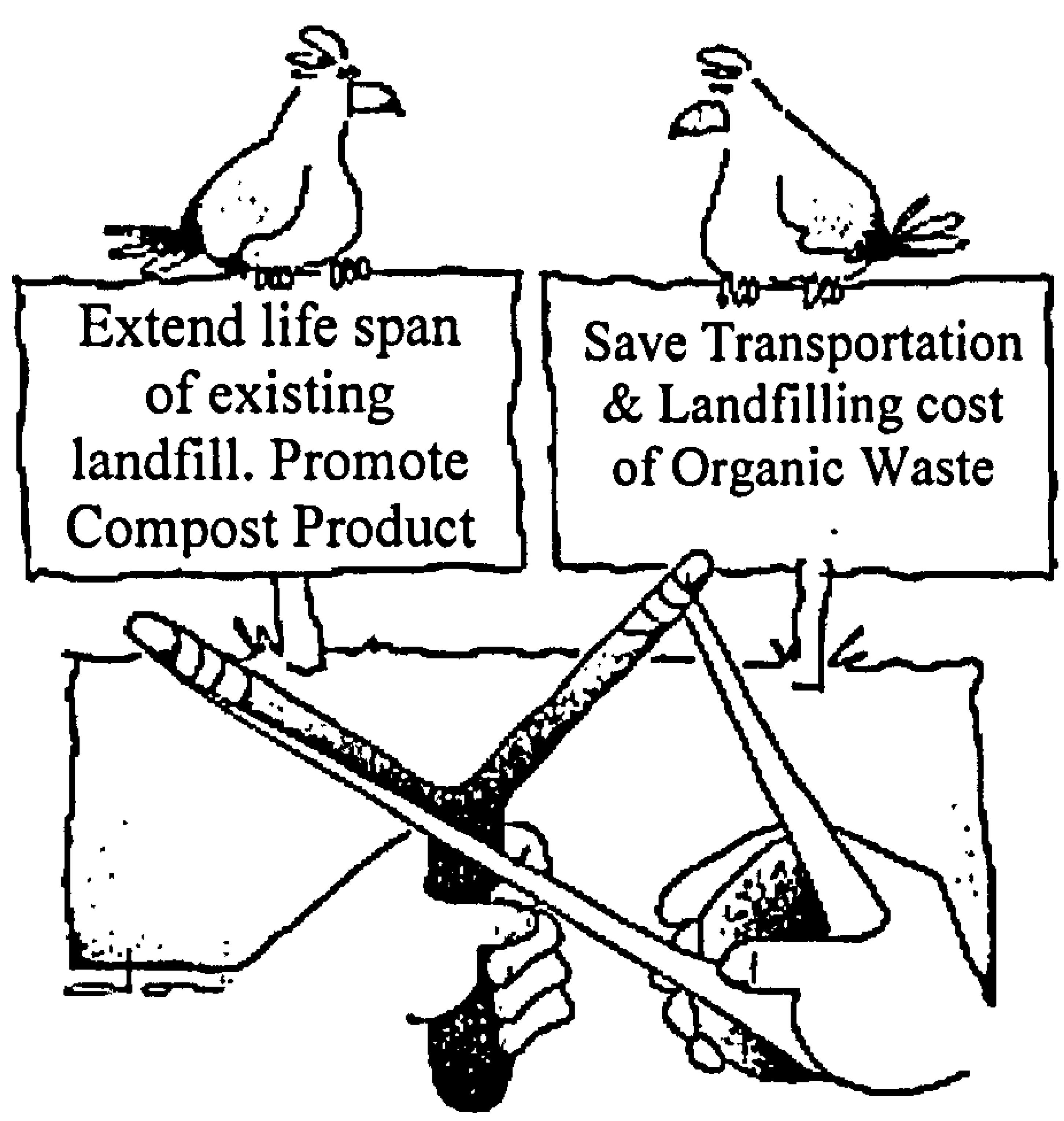


Figure 4-4: Two Birds With One Stone

Source: After Coad, 2000

Composting and Market Issues

Composting of green waste is a viable alternative to landfilling. In 1997, there were a total of 39 fully operational composting sites in the UK, with a further 12 being partly operational, under construction or planned (DETRF, 2000).

Most previous composting pilot projects which were initiated by many different institutions, either focused on the technological or social aspects of composting. Much less attention was given to a detailed assessment of the market for compost.

In many previous cases a detailed market study could have recognized the main challenges facing composting projects, therefore giving the project a chance to concentrate efforts on these. These should be analysed in detail for the city in question and always take the economical implications of these issues into account.

Composting of green waste is not as widely used in the UK as it might be for two reasons in particular:

- The low cost of landfill relative to composting: until recently, it has not been cost effective for waste management companies to select composting over landfill.
- The lack of a market for the product: the principle barrier to more widespread use is the negative perception of composted waste as a product, and the problem of the absence of accepted standards for waste derived compost (DETR, 2000).

Some difficulties have arisen in the implementation of the composting projects in Tunisia, Morocco and Bennin, especially because of political manoeuvring, miscalculation and misunderstandings. The assessment of the projects revealed much confusion in administrative responsibilities and interventions on the part of different government departments that should be cooperating to support composting. The Morocco project is industrial in scale and to process 250 tonnes of solid waste per day. In Tunisia, the pilot composting was a failure because of lack of understanding of the nature of waste.

Apparently Israeli compost suppliers have already threatened that they will market their compost under the pilot plant's price to drive this plant out of business. In Israel, composting is heavily subsidized and the compost firms seemingly do not want to lose their monopoly in Gaza (Coad, 1997).

Labour-intensive aerobic composting facilities may be more appropriate in developing countries than the highly automated aerobic or anaerobic facilities typical of industrial countries. In the most extreme cases, workers may use only simple hand tools to hand sort non-recyclable biodegradable materials from non-compostable materials, to build and turn windrows, and to screen and bag finished compost. Capital-intensive composting projects in developing countries often fail, as in Lagos (Cointreau-Levine 1994, p:29), or they may be converted to relatively more labour-intensive facilities, as in Jakarta and number of cities in India.

Composting will be economically feasible to the extent that economic factors related to the landfills, markets and materials recovery approximate to real financial and environmental costs (Dulac, 2001).

Composting should not be seen as waste disposal but as the manufacture of an agricultural product. An important way of improving the quality of the product is to improve the purity of the incoming raw material, and this is best done by keeping the compostable materials - such as food waste, vegetation and paper - separate from other waste materials that contaminate the final product. This is normally done by promoting separate storage and collection of compostable wastes in the home - and this is a time-consuming task because it is not easy to change the behavior of the public as a whole. Alternatively, a composting operation may only use waste that comes from certain sources, such as vegetable markets and gardening operations. In Gaza considerable progress has been made modifying public behavior by campaigns encouraging citizens to use containers correctly, but it is a much harder task to achieve a separate collection system, which is respected by the majority of the community. It would be good to make a start, but quick results cannot be expected. In the meantime farmers are importing compost from Israel, so there would be some economic benefits to developing composting within Palestine as much as possible (Coad, 1997).

The Gaza Municipality was planning to start a pilot scale composting operation in the second half of 1997, initially using waste from markets and restaurants. This is a commendable step and should provide useful information about quality, costs and demand. The project has been frozen due to the political situation.

4.5.1 Waste Reduction at Source and Minimization

This is a scheme introduced by industrial sectors as a strategy to reduce the amount of waste produced in all the industries' activities. Waste minimization does not simply mean attempting to reduce the output of solid wastes but rather reducing pollution to all environmental media: air, water, and land, and by an approached defined as integrated pollution control (IPC) (Croner's 1995).

It is a target that is consistent with economic sustainability. Priority should be given to minimizing the hazardous components of waste, and certain hazardous materials may need to be eliminated entirely from the waste stream (Gummer, 1995). By having this option, companies may reduce the cost of off-site disposal or the cost of on-site treatment.

A recent piece of work from Woods (1998) entitled "Waste Minimization: where it is going" emphasises the cost of waste and the benefits of implanting a waste minimization policy. The work evaluated the state of the art of waste minimization in industry, and highlights the cost of waste in production and manufacturing processes. It also demonstrates the financial economies that result from implanting waste prevention and minimization policies.

The Organization of Economic, Cooperation and Development (OECD), has also demonstrated its concern to prioritize the implementation of waste reduction policies with a special seminar held in Washington, USA in 1996 (OECD, 1996a). This seminar, under the theme "Waste Minimization," brought together experts from the (OECD) countries in a debate of the state of the art of some priority waste streams.

4.5.2 Waste Recycling, Reuse and Recovery

In recent years there has been a surge of interest in waste recovery and recycling in both the developing and developed world. Among the industrialized countries recycling activities are on the increase. This is due primarily to the political pressure of public opposition to disposal sites – the unwillingness on the public's part to have landfills located in "their backyards", and stringent regulatory standards of waste disposal (Cointreau and de Kadt, 1991; Hooper and Neilson, 1991; UNEP, 1994) – and the economic pressures of the high cost of waste disposal attributable to land shortage, increasing costs of sanitary landfills. In developing countries, on the other hand, which are still grappling with the basic task of collecting garbage, recycling of waste is carried out in direct response to industrial demand for materials to use as raw materials; ie, what is being recycled has some commercial re-sale value (Cointreau and de Kadt, 1991).

An important feature of waste recovery and recycling in low income, developing countries is the involvement of the informal sector. Studies reveal that this sector is mainly engaged in the recovery and re-sale of most of the recyclables and is highly labor intensive (Bromley, et al., 1979; Aziz, 1984; Cointreau, 1987; Furedy, 1989, 1990 and 1994; Cointreau and de Kadt, 1991; Huysman and Baud, 1994). But notwithstanding their significant contribution to waste recovery and recycling processes, their role in urban waste management is not recognized and their earnings continue to be meager (Cointreau and de Kadt, 1991; Furedy, 1990 and 1992).

The studies indicate that waste recovery and recycling processes in poorer developing countries are based on market considerations, in the sense that it helps to create economic value out of waste. In the resource poor developing countries, this has a positive impact on the economy. There is also the added benefit of providing a source of livelihood to many economically deprived persons who would otherwise be unemployed.

4.5.2.1 Recycling

Recycling is an alternative to disposing of waste in landfills, thereby reducing the pressure on space in landfills. Recycling may also reduce the amount of land, air and water pollution as well as reduce pressure on natural resources (El-Hawi et al, 2002). Recycling is also a means of job creation and generation of income, especially among low-income groups (Muller, 2002). Recycling of selected materials can be a valuable component in an integrated waste management system. There is no question that recycling will be important in the future. The significant question is rather how and to what degree recycling will be integrated for maximum recovery value.

The collection of waste and its recovery from different waste generation points is carried out by many agents, formal and informal, which represent a variety of organizational structures and relationships (Cointreau, 1987).

According to Tchobanoglous et al. (1993) recycling refers to the separation of a given waste material (e.g. glass) from the waste stream and processing it so that it may be used again as useful material, which may or may not be similar to the original. In the waste management stage we try to add so much value to the waste, that it becomes an asset again. When asset status has been reached recycling has been completed and the production-consumption-depreciation-disposal cycle starts again. Lund (1993) defined recycling as the act of extracting materials from the waste stream and reusing them, and that recycling generally includes collection, separation, processing, marketing and the creation of new products or materials from used products or materials.

Recycling involves three major agents: consumer/generator, processor, and re-manufacturer. These three agents are what Southerland (1993) identified as the key recycling entities as illustrated in Figure 4-5.

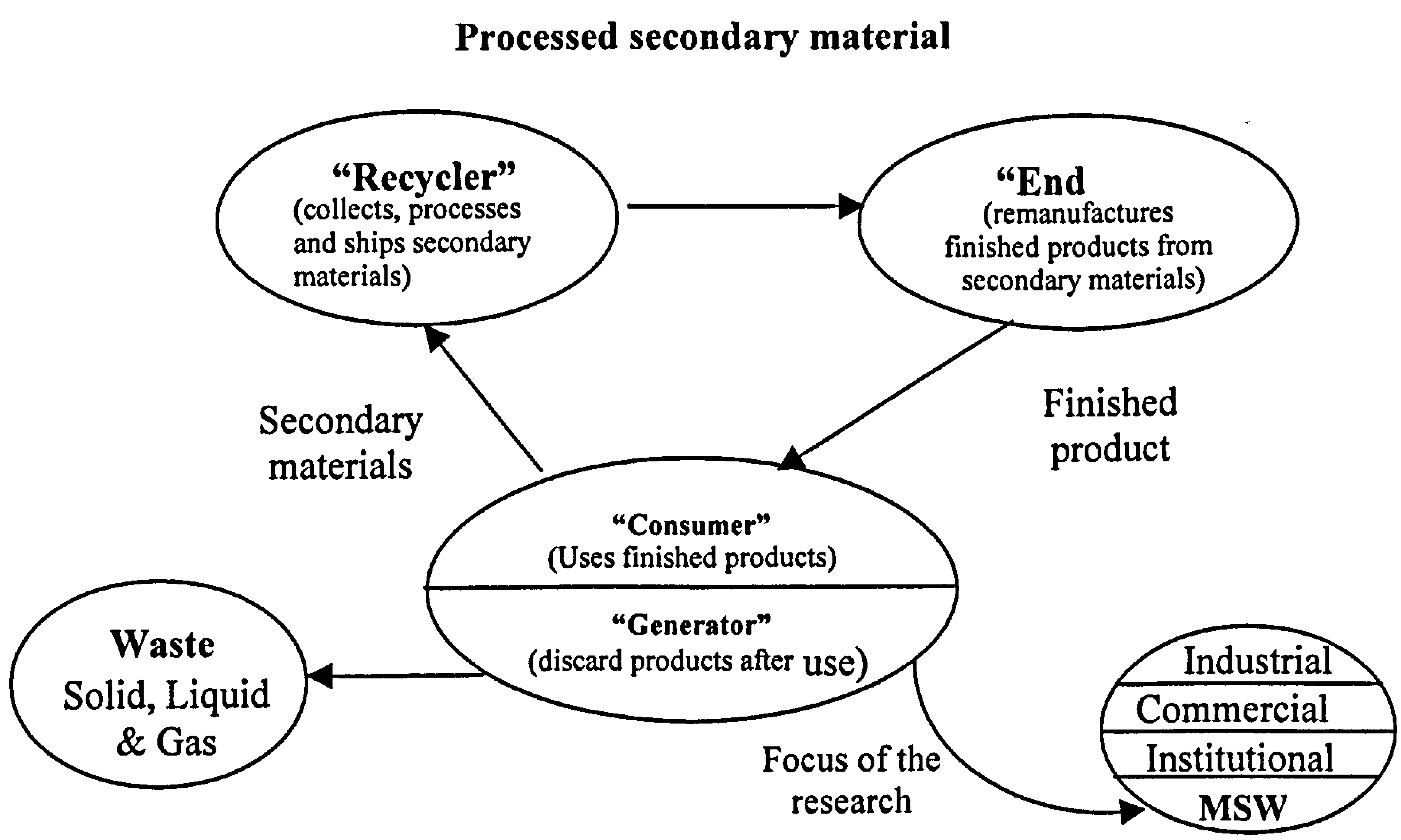


Figure 4-5: Recycling Entities

Source: Southerland (1993)

According to Aquino (1995), the preference for recycling is due to a concern about the environment, about conserving our resources and about the lack of landfill space in at least some of the United States and many other countries. In recycling something new is made out of something old. It is not thrown, it is reused. British government policy will increase pressure and incentives to recycle (Waste management paper No 28, 1991). The Government is promoting measures to encourage local authorities to undertake more recycling (including recycling credits, recycling plans, and the availability of supplementary credit approvals (in England) for recycling investment).

In the UK, the Environmental Protection Act 1990 provides important pressure to recycle in the form of the duty of care and higher landfill standards. The Act introduces a strict environmental regime for disposing of waste. One effect of this is that the landfill operator will be responsible for managing the site not only while it is being used but also for as long as is necessary after the site is closed. The operator will also face legislation requiring higher engineering standards in the licensing system. As a result, landfilling costs are expected to rise significantly in many areas. The result of increasing landfill costs is that recycling becomes more economically attractive, especially when the cost of landfill is reflected in a recycling credit paid by the waste disposal authority to a waste collection authority. Public pressure and concern provides an incentive to recycle. Environmental pressure groups have raised the public's consciousness about environmental issues and in turn the public are applying pressures to central and local government. The introduction of recycling schemes is one way in which an authority can demonstrate its sensitivity to environmental issues.

Informal collectors retrieve recyclables prior to the disposal of the refuse they pick up, for example in Cairo some 30,000 Zabaleen make up a network of garbage collectors. A pair of Zabaleen working with donkey drawn carts can collect garbage from 350 households in a day (Meyer, 1987; Furedy, 1984b).

4.5.2.2 Review of Recycling in the Gaza Strip

Coad (1997) argues that recycling is sometimes an expensive business. Many recycling schemes in Europe make heavy demands on public expenditures. On the other hand, the informal recycling schemes in low-income countries such as Egypt, India and the Philippines support large numbers of families. Palestine is somewhere in the middle - the cost of living is too high to enable waste pickers to make a living in large numbers, and yet there is not a sufficient revenue base nor the public demand for the type of recycling that is found in Europe. The recycling sector in Palestine will probably grow quite slowly because there is no established pattern to follow. Waste pickers are found in small numbers on most sites, although their numbers are greater where Israeli waste is being disposed of. Before recycling can make a significant impact on quantities of waste, it will be necessary to develop reprocessing facilities and markets for recyclable materials, and to develop public awareness to motivate the public to consume less and separate recyclable materials. At present it is not helpful to provide machinery for recycling, as the situation is not yet ready for large-scale operations. In the early stages of the development of recycling in Palestine, it is likely that recyclable material will be sent for re-processing in Israel.

Some of the small micro-enterprises working in the Gaza Strip as middlemen collect scrap to be sold to Israel for $30/ton. Paper and cartons are collected and reprocessed locally as egg pots and boxes. Opportunities for recycling in Gaza City have been the subject of a special study, and considerable work has been done to try to identify ways of reusing the slurry waste from the tile industry (El-Hawi, et al 2002). According to El-Hawi et al (2002), a very small fraction of solid waste is recycled, mainly steel scrap and a small amount of organic. The total MSW recycled is 9,068 of 215,000 tonnes/year (a recycling rate of 4.21 percent). Of this total, 5830 tonnes are metals, 1419 tonnes organic, 1080 tonnes paper and card, 432 tonnes plastics, 200 tonnes glass and 197 tonnes cloth. The qualitative details are discussed in chapter five. In the paper, El-Hawi et al, (2002) found the following results:

- 68% were willing to use recycled products and the health aspect was the main concern of respondents followed by religious and cultural aspects. There was high demand for recycled products among low and middle-income communities in the belief that recycled products are cheaper than new ones.

- 32% were willing to start source separation. This result is explained by a lack of awareness about source separation, and no incentives from municipalities are provided to encourage the public to start source separation.

- 73% do believe that recycling should be adopted as an environmentally sound disposal strategy parallel to landfilling since it saves collection and control of waste related diseases.

4.5.3 Incineration

Incineration is currently being used for disposal of about 10% of waste generated in the USA and this percentage will likely increase as land disposal declines (Watts et al. 1992).

The level of waste quantity reduction in incineration is as large as 1/5 to 1/20. Incineration is highly valued for its ability to stabilize and eliminate hazardous material. It turns perishable organic matter into inorganic matter and kills pathogenic organisms through high ambient temperature (Tanaka, et al. 1992).

The basic principle of incineration is to burn things at high temperature, causing oxidation. Furthermore, since the combustion reaction generates great amounts of energy at the time of oxidation, the ambient temperature becomes higher during the reaction process and kills pathogenic bacteria. The incombustible residue becomes ash, which is stabilized inorganic matter and is discharged from the incinerator. In large incinerators, the caloric energy obtained from the waste combustion process is used to generate steam to assist in electric power generation (Tanaka, et al. 1992).

Incineration often seems to be the best solution - it is modern, apparently clean, and expensive (there is a common feeling that more money is spent to solve a problem, the solution is better - simply because more money is spent). It also seems to be the best solution when land is expensive or difficult to acquire. It must also be emphasized that incinerators are very expensive to buy and to operate (Coad, 1997).

Joudah, (1993) indicated that experiences in a number of places, including Beirut, have shown that incinerators cannot be used for all types of waste. Incineration should not even be considered an option until a very thorough sampling program has demonstrated that the calorific value of the waste is always well above the minimum needed for sustainable combustion.

Most modern incinerators are equipped to extract energy from the burning waste, but it may be very much more economical to generate this energy in another way – it must not be considered as free energy.

Even when a large incinerator is used, a landfill is still required in order to accept the residues from the incinerator and all the wastes when the incinerator is not operational. In the USA incinerator ash is regarded as hazardous waste because it may contain soluble substances that are toxic, but many people regard this ruling as unnecessarily harsh (UNRWA, 1993).

Although incineration is to be recommended as the most appropriate method of disposing of many categories of clinical wastes, especially infectious and pathological wastes, it must be emphasized that municipal incinerators are NOT necessarily suitable for these types of waste. Ideally, hospital and other health care wastes should be incinerated in units specifically designed for the purpose.

Incineration should be employed for the disposal of:

i) human tissue, limbs, placentae, infected carcasses and dialysis waste,

ii) sharps (except mercury-bearing wastes),

iii) all pathology wastes,

iv) small amounts of drugs, medicines and injectables,

v) solid surgical dressings, swabs and other contaminated wastes.

The term incinerator is used to mean the use of waste directly in stoves and burners designed to handle mixed waste or any range of similar fuels. It may be carried out on scales ranging from a domestic cook stove up to the level of institutional or massive municipal incinerators.

Buekens and Patrick (1985) observed that the combustion of solid waste can proceed without supplementary fuel when the heat value exceeds approximately 1200 kilocalories per kg, and under certain limiting conditions of carbon, ash and moisture content. Due to the vagaries of waste composition and incinerator operations, some engineers felt more comfortable with a threshold heat value in excess of 1500 kilocalories per kg. Typical of many middle and lower-income cities, the waste of Istanbul, Turkey, Surabaya and Indonesia have heat values less than 1200 kilocalories per kg, making incineration at least questionable. Buekens and Patrick (1985) also reported that Western European municipal waste typically exhibited a gross heat value of approximately 2150 kilocalories per kg. This is in the range where engineers would be uncomfortable with the prospect of incineration, but also with the economics of electrical generation, at least from the bigger municipal incinerators.

A major constraint for less prosperous cities is likely to be the capital cost of modern incinerators that are not only efficient but also meet the air quality emission standards now found internationally acceptable. For a unit capable of incinerating 1000 tonnes of waste daily, the capital cost is likely to lie in the range of US$110-150 million, with an average of US$ 130 million. Estimates of the costs of incineration – including capital and operations but exclusive of any sales of heat or electricity – currently lie in Asia in the range of US$ 8-120 per tonne of waste (Buekens and Patrick, 1985).

Incineration is the age-old process of burning waste as means of disposal and bulk reduction by eliminating the combustible fraction through combustion. The energy produced may be recovered and used for process heat or heating water. Incineration with energy is more worthwhile when carried out on sorted waste. Operating temperatures are variable and depend on the technological level. Higher temperatures are desirable for destroying noxious gaseous and particular emissions.

Incineration refers to burning unsorted waste and is used mainly for bulk reduction. When used for fuel recovery, incineration has several disadvantages:

- Unsorted waste is heterogeneous and therefore its fuel characteristics are highly variable unreliable,
- The fuel is "dilute" and therefore has a low calorific value

Uneven burning due to non-uniform quality reduces the effective temperature, which then results in noxious residues and emissions. The combustion products and residues may be of mixed toxic levels and will need to be re-addressed. The gases are especially notorious for containing noxious organo-halogenated compounds such as dioxins, furnace and PCB's as well as acidic oxides.

As explained in chapter six, incineration should not even be considered an option until a very thorough sampling program has demonstrated that the calorific value of the waste is always well above the minimum needed for sustainable combustion.

Table 4.5 shows the difference in flue emissions between traditional and modern incinerators. Pollution regulatory bodies like the Environmental Protection Agency (EPA) of the United States of America require extremely high levels of emissions control (Donnelly, 1993). However, in less developed countries without the technology, or in countries where anti-pollution legislation is slack, incinerators continue to be a health hazard and environmental burden to the neighborhoods.

Although the bulk of materials for final disposal is greatly reduced, in the case of mass-burn the remaining solids still need to be sorted to remove any hazardous materials that may not be admissible in certain landfills or that may require special containment.

Incineration is very costly, both in terms of capital cost and operating cost. The importance of such costs should not be underrated, but a more important factor opposing the use of incineration is the nature of the wastes, particularly the content of water and inert material. Experiences in a number of places, including Beirut, have shown that incinerators cannot be used for all types of waste (Tanaka, et al. 1992).

Coad, (1997) argues that, large incineration plants have sophisticated equipment to maintain the necessary combustion temperatures and clean the exhaust gases, and they have proved to be effective and reliable in many industrialized countries. However, in many other countries they have been very expensive mistakes. A key factor to consider is the composition of the waste and the amount of heat that it generates when it burns. If the waste has a high moisture content (as is the case when the waste has a high proportion of food waste), then the waste does not burn satisfactorily in normal incinerators. The result is that large quantities of fuel are used to keep the fire burning or the resulting air pollution is high because the waste is not burned at a high enough temperature. It must also be emphasized that incinerators are very expensive to buy and to operate.

Incineration with energy recovery has other problems and disadvantages: The cost of an incineration plant can be very high especially when tough emission limits have to be met (Wallis & Watson, 1994). It is vastly more expensive to remove the last 5% of noxious emissions than the first 50%. Table 4.5 compares some characteristics of incinerators emissions.

Table 4.5: Some Typical Emission Values from Incinerators

Source: Adapted from Donnelly, 1993

Pollutant	Traditional Incinerators	Modern Incinerators	%Pollution Reduction	EPA Efficiencies (as at 1993)
Particulate Matter (gr/dscf)	0.5-4.0	0.002-0.015	99.5+	99+
(HCI ppmdv)	400-100	10-50	90-90+	-
SO_2	15--600	5-50	65-90+	-
HF	10-20	1-2	90-95	-
Nox	120-130	60-80	30-65*	-
Arsenic	<0.1-1	<0.01-0.1	90-90+	95
Cadmium	1-5	<0.01-0.5	90-99+	95
Lead	20-100	<0.1-1	90-99+	95
Mercury	0.1-1	<0.1-0.7	10-90+	85-90

* Reference conditions-dry gas 20°C and 12% carbon monoxide

For incineration to be an acceptable option, rigorous pollution limits have to be set and met. Old incineration plants have to be closed when new emissions limits come into force. On the other hand, landfill legislation requirements seem to imply the need for some refuse to be incinerated. This is the case when combustible refuse is unacceptable for landfilling. The imposition of tougher emission limits for incinerators in the UK in December 1996, for instance, had some undesirable immediate results (Surveyor, 1996): 14 incinerators had to be closed and millions of tones of waste re-directed to landfills. Ironically, this was just two months after the imposition of a landfill tax designed to discourage landfilling. As a result, there were only five operating incinerators in England. The high cost of up-to-date incinerators will obviously delay the process of replacing the old ones. Alternative ways of reducing landfill materials are therefore necessary.

Bernard, (2000) points out some of the disadvantages of the incineration of PVC as a part of MSW in a brief report published by the European Commission in April 2000:

- Incineration of 1 kg of PVC in the EU creates on average between 0.8 kg and 1.4 kg of hazardous waste in incinerators with non-wet flue gas treatment, and between 0.4 and 0.9 kg of residues of liquid effluence in incinerators with wet flue gas treatment

- Incineration of PVC creates additional costs of between 20-335 Euros/ton
- PVC contributes 10% to the cadmium concentrations in municipal solid waste
- A higher chlorine content in waste has negative effects on the transfer of heavy metals from bottom ash to gas treatment residues
- Incineration of PVC significantly increases the amount of leachate from, and leachable salts in, the resulting residues

Incineration is a method of treating combustible waste to reduce volume and weight and it is normally followed by tipping of the resulting innocuous residues. Considering the relative merits and disadvantages of incineration, it is possible to appreciate why incineration is not recommended for the type of wastes generated in Gaza Strip as depicted in Table 4.6.

Table 4.6: Advantages and Disadvantages of Incineration

Source: MoPIC, 1998

Incineration advantages	Incineration disadvantages
▪ The energy produced can be recovered for several uses.	▪ It leads to air pollution if air pollution if improperly operated, hence installation of prevention equipment is necessary.
▪ Reduction in volume can be achieved to the tenth of the original wastes volume.	▪ It needs skilled labor for operation and maintenance.
▪ Less land area is required for operation than any other method.	▪ High capital and operational costs.
▪ It is possible to perform incineration close to the place creating the wastes thus achieving reductions in transportation costs.	▪ Residues require further disposal; incineration is not a final disposal option.
▪ Complete destruction of combustible and organic matter and the ability to operate under hygienic conditions.	▪ Residues are of negligible value for agriculture.
▪ Free from interfaces of weather conditions which could affect other methods of waste disposal.	▪ Incineration requires a continuous feed of combustible refuse or fuel.

The primary advantage of incineration as a technique for managing MSW is its ability to reduce the volumes requiring disposal. Given the high organic content of solid waste, efficient combustion can accomplish up to an order-of-magnitude reduction in the volume of material introduced into an incinerator. The degree of volume reduction depends on two factors – the technology employed and the nature of waste received.

Degree of volume reduction is best evaluated by comparing the physical volume of the incoming waste against the physical volume of the ash residue.

Evaluating volume reduction estimates for incineration should take into account two additional factors (R.W, et al 1987):

1. The amount of non-proccessible waste (e.g., white goods), which can't be processed in the incinerator.

2. The amount of bypass waste (i.e., waste that must be turned away during scheduled or unscheduled downtimes at the incinerator), which typically accounts for 10-15% or more of incinerator capacity.

Ash resulting from incineration includes several types of waste. Bottom ash typically accounts for 75 to 95 percent (by weight) of the total ash residue. Fly ash and/or scrubber residues account for the remaining 5 to 25 percent.

The relative amount of fly and bottom ash varies considerably, and depends on combustion-chamber turbulence, the nature of the waste burned, and the types of air pollution control used.

Most recently, new factors have entered into the debate. Factors restraining the development of the incinerators include intense public opposition, unresolved risk issues surrounding air emissions and ash residues, major long-term economic risks, and growing concern over the effects that a long-term commitment to incineration may have on more preferred management approaches such as recycling.

These factors are having the effect of reducing the rate at which new incinerators are being built or planned, so numerous proposals have been cancelled or put on hold.

Waste incineration is not common in the developing countries, due to the specific refuse characteristics of low calorific value, high moisture content and the high quantity of non-combustible matter of refuse. In rural and semi-urban communities where waste mainly consists of combustible materials, small, simple and locally built incinerators at the rate of one incinerator per 200-300 people are very efficient. In this system, waste is spread near the incinerator to be dried by the sun before it is placed in it for combustion in the evening of each working day. It has been found that this system is adequate for semi-urban communities with populations up to 50,000 (Oluwande, 1984). Some developing countries have a small proportion of refuse which can be burnt without auxiliary fuel: a refuse incinerator was erected in 1963 Calcutta, India (Feachem, et al, 1977) but upon operation this caused a considerable smoke nuisance.

In Jeddah, Saudi Arabia, part of the collected refuse was burnt in the open, but recently in 1980, three controlled combustion mechanical incinerators (refuse incineration rate of 4.4 tone h^{-1}) were constructed (Farsi and Hamouda, 1984). These incinerators are capable of dealing with 300 tonnes out of a total of 1250 tonnes refuse generated daily in Jeddah. The rest is being disposed of by means of landfilling.

However, in recent year some developing countries have started to consider incineration as a disposal option to use the calorific value of their refuse specifically for energy production. These attitudes were mainly as a result of the vast increase in the cost of energy that has taken place in recent years. For example, in Korea incineration plants are under consideration because of the reduction of the refuse volume to be handled, pollution abatement and resource recovery. However, the heat content of the refuse in Korea is 200-300 kcal kg^{-1}, which is not enough for self-combustion. Hence, the heat content can only be raised to the range of 700-900 kcal kg^{-1} – the level of possible self-combustion – if separation or separate collection is adopted (Choi, 1982).

On the other hand, incineration of house and trade solid waste has been adopted by Local Authorities in the UK for nearly a century. Until 1965, incineration in the UK had been based on separation/incineration plants where dust, cinder, rags, paper, bottles, non-ferrous metals, etc. were separated before incineration of the remaining refuse (Clennell, 1983). In recent years in the UK, separation/incineration plants have become less suitable due to substantial changes in refuse characteristics – higher calorific value – and the higher costs of labor required for salvage recovery and for manual stocking of the incinerator. Hence, direct incineration of refuse without preliminary separation arose as a viable alternative.

In fact, incineration was increasingly used as a method of disposal by the urban authorities in the UK up to the time of the Local Government re-organization in 1974 because of the shortage of tipping facilities within their boundaries (Clennel, 1983). Thus, refuse dealt with by incineration in the UK amounted to 8.3% of the total amount of refuse disposed of by local authorities in the year 1966-67 (D.O.E., 1971).

Finally, the risk to public health caused by the old incinerators is not likely to arise from refuse disposed of by the present incineration methods employed in the UK. This is mainly due to the significant measures which have now been adopted in new incinerators to minimize air pollution by particulate matter. Incineration has become more fashionable in recent years and in such cases the evaluation of incineration should be related to cost.

4.5.3.1 Incineration with heat recovery

This requires the use of a boiler or furnace walls made of closely spaced tubes welded together with water, or steam circulated in the tubes to extract the heat generated during combustion of refuse. A reduction in the air stream is necessary to achieve higher temperatures thus reducing the size of air pollution control equipment. Where high-pressure steam is produced. As the name implies, it does not include heat extraction equipment, and excessive temperatures are avoided by using a quantity of air in excess of that theoretically required for combustion where the excess air serves as a cooling medium.

Finally, in the developing countries it is recommended not to adopt incineration except when a feasibility study is carried out before implementation. Incineration is considered the most costly option, especially the direct incineration of crude refuse.

Therefore, due to the cost effective characteristics of incineration which include very high capital costs, high maintenance costs and a poor availability compared with other methods such as landfilling or composting, incineration should not be considered in developing countries (especially the poorer countries) if landfilling or composting are viable.

4.6 Health Impact and Environmental Effects of Different Disposal Methods

Improper SWM causes all types of pollution: air, soil and water. Indiscriminate dumping of wastes contaminates surface and ground water supplies. In urban areas, solid waste clogs drains, creating stagnant water for insect breeding and floods during rainy seasons.

Rushbrook, et al. (1999) state that rats were implicated in the spread of the bubonic plague in medieval times in Europe, as well as leptospirosis, salmonellosis, and ice-born typhus. He added that some arboviral infections are associated with waste too, as well as habitat formation for breeding insects and mosquitoes. In tropical climates some flying insects are directly associated with the transmission of endemic disease. Uncontrolled burning of wastes and improper incineration contributes significantly to urban air pollution.

Greenhouse gases are generated from the decomposition of organic wastes in landfills, and untreated leachate pollutes surrounding soil and water bodies. These negative environmental impacts are only a result of solid waste disposal; they do not include the substantial environmental degradation resulting from the extraction and processing of materials at the beginning of the product life cycle. In fact, as much as 95 percent of an item's environmental impact occurs before it is discarded as MSW.

Health and safety issues also arise from improper SWM. Human fecal matter is commonly found in municipal waste. Insect and rodent vectors are attracted to the waste and can spread diseases such as cholera and dengue fever. Using water polluted by solid waste for bathing, food irrigation, and drinking can also expose individuals to disease organisms and other contaminants. The U.S. Public Health Service identified 22 human diseases that are linked to improper SWM (Tchobanoglous et al., 1993).

The organic content of refuse is normally the main source of public health concern due to its ability to undergo several decomposition reactions resulting in odor nuisance, the provision of ideal breading sites and rodents. The problem becomes worse when the waste contains faecal matter or urine, which may cause the spread of diseases. Several adverse impacts may result from uncontrolled waste disposal systems, which are reviewed in the following sections:

A. Landfill

Crude waste dumping represents different aspects of adverse health and environmental effects such as those in the form of water pollution through leachate formation by rainfall on dumping sites, especially when these sites are improperly located, drained and managed. Contamination of surface and ground water is likely to occur with the possibility of the pathogens being carried some distance and causing the spread of diseases.

It is inevitable that the chemical and biological contaminants in wastes will find their way back to humans to affect health, quality of life, and working activities. Contamination may then directly affect the drinking water supplies and/or the aquatic food chain. Grazing animals on dumps can pass on diseases via the terrestrial food chain, as well as by pests through infestation (Rushbrook, et al. 1999).

Uncontrolled tipping, with high voids in the disposed matter, can provide an optimum number of proliferation sites for rodents. The presence of food wastes enables rodents to persist in the site and even to migrate to dwellings. This is dangerous as rats may be a reservoir of several disease vectors. In countries whose waste has significant proportions of plastic and paper content, airborne litter is often considered a major nuisance.

Other hazards associated with uncontrolled tipping may be:

1. Fire hazards due to presence of hot ashes in vehicles delivering waste, cigarettes thrown down by workers, or rays of sun magnified through fragments of glass. Such tip fires normally cause clouds of black smoke contributing to atmospheric pollution. A deep-seated tip fire may cause a collapse of waste in the landfill site especially in large dump fires. These fires may last for many years causing delay in land restoration and increasing reclamation costs.

2. Birds attracted to the site may pose a risk to aircraft if there is an airport in the area like the situation with the old dumpsite near Tel Aviv airport in Israel.

3. Unpleasant working conditions for the workers and excessive wear of vehicles by the dust surfaces of landfills especially in arid regions.

4. Provision of optimum breeding sites for flies and other insects, especially in hot climates where waste decomposition is rapid.

Careful selection and proper management of the site can eliminate most of the above-mentioned effects.

B. Composting

Crude waste, which is collected and applied to the land as fertilizers by farmers without any pretreatment, can cause significant adverse health effects as organic waste will usually contain some fly eggs and larvae before they come to the composting site. This can be avoided by turning the compost frequently, which ensures the replacement of the surface material and the hot core each time. This will enable fly eggs, larvae and pathogens to be destroyed if present in the compost. Occasional offensive odors, resulting from composting, are difficult to control properly and therefore careful site selection may be the answer. Pathogens also may be present in the soil and on the crops after spray or application of compost containing human excreta (WASTE, 1999).

Hoornweg et al. (2000) argued that there are two classifications of pathogens – primary and secondary. Primary pathogens can infect healthy individuals, whereas secondary pathogens usually infect individuals with weakened immune systems. Bacteria, protozoan, helminths and viruses are primary pathogens, and fungi and actinomycetes are secondary pathogens.

C. Recycling

Since salvaging is mainly manual work carried out by scavengers and sometimes by refuse collectors in the third world, they are often more susceptible to infection by different types of diseases. But in well-designed and managed plants no evidence of adverse health effects has been recorded (Flintoff, 1976).

Those living on or near a dump are also at risk from direct hand-to-mouth transfer of contamination and from inhalation of volatile compounds and aerosols (WHO, 1995).

In a study in India of school specimens from a group of refuse workers, 84% of this group was infected with selected parasites. This compared with a 2.9% infection rate in other groups of workers (Bhide and Sundaresan, 1980).

Physical injury to people coming into close proximity, scavenger, recyclers or even children play with sharp recycled items.

Risks to public health may arise if the subsequent use of the salvaged materials is not carefully controlled.

D. Incineration

According to a WHO report (WHO, 1999), incineration may reduce the infectious hazards of medical waste, but at the same time give rise to other health and environmental hazards like respiratory and chronic diseases.

Uncontrolled incineration of waste normally results in several adverse environmental and health effects due to the production of a number of atmospheric pollutants, such as particulate matter, sulphur dioxide, oxides of nitrogen, various hydrocarbons and other noxious gases. Hence, well-designed incinerators equipped with gas cleaning instruments are an essential prerequisite (EPA, 1990).

4.7 Influential Aspects Affecting Disposal Alternatives

The sustainable disposal technologies of MSW are the backbone of any waste management process. A number of technical, institutional, financial, socio-economic, environmental and policy/legal factors contribute to the success or failure of the disposal of MSW. These influential aspects are explained explicitly in Chapter Seven.

The lack of adequate institutional arrangements, sound organizational structure, clarity of accountability of staff and the low financial and technical sustainability of existing SWM systems are the main reasons why this kind of situation prevails in developing countries. The waste generated by the fast growing cities is increasingly beyond the management capacity and financial limitations of most municipal administrations. Each influential aspect is discussed in relation to the disposal of MSW.

- ***Technical and performance aspects*** concern the observable practical implementation and maintenance of all of the waste elements: what equipment and facilities are in use or planned; how they are designed; what they are designed to do; whether they work in practice; and how clean the city is on a consistent basis (Klundert, 2001).

  Ogawa (1996) argues that the lack of knowledge and experience in SWM situations in developing countries leads to a tendency to support and provide the available technologies in the donor country regardless of their applicability to the developing country's situation. In some cases, the SWM equipment and facilities, which are obsolete and outdated in the donor country, are provided as a foreign aid to the recipient country like the case with the incinerator to be placed in Gaza and Jericho hospitals and the compacting and sorting unit which was donated by the Spanish Government to the Palestinian Authority. For more details please refer to chapter 8, the incineration case study.

- ***Institutional and organizational aspects*** relate to the political and social structures, which control and implement waste management: the distribution of functions and responsibilities; the organizational structures, procedures and methods implicated; the available institutional capacities; and the actors such as the private sector who could become involved. Planning is often considered the principal activity in relation to institutional and organizational aspects (Klundert, 2001).

  In the Gaza Strip there are professionals whose major or exclusive responsibility is SWM, and they have been trained through working closely with other experts and by attending courses, largely held outside Palestine. However, in Gaza there are often no clear roles/functions defined for the various national agencies in relation to SWM. The lack of coordination among the relevant agencies often results in different agencies becoming the national counterpart to different external support agencies for different SWM collaborative projects without being aware of what other national agencies are doing. This leads to duplication of effort, wasting of resources, and unsustainability of overall SWM programs. For more details see chapter six.

- ***Financial-economic aspects*** pertain to budgeting and cost accounting within the waste management system and in relation to the local, regional, national and international economy. Some specific issues are: privatization; cost recovery and cost reduction; the impact of environmental services on economic activities; the commodities marketplace and how the recycling infrastructures connect to it; efficiency of municipal SWM systems; macroeconomic dimensions of resource use and conservation; and income generation (Klundert, 2001).

  Schertenleib, et al. (1992) argue that adequate fees do not cover the operation and management costs of SWM services, and the available funds from the central budget are insufficient to finance adequate levels of service to all segments of the population. In a situation where resources are scarce, priority is usually given, mainly for political reasons, to middle and high-income areas.

  Financing this part of the SWM cycle is made even more difficult as most people are willing to pay for the removal of the refuse from their immediate environment, but are generally not concerned with its ultimate disposal and act according to the motto "out of sight, out of mind"! (Rushbrook, *et al.* 1999).

- ***Social-cultural aspects*** include the influence of culture on waste generation and management in the household and in businesses and institutions; the community and its involvement in waste management; the relations between groups and communities, between people varying in age, sex, ethnicity, and the social conditions of waste workers.

  Waste management cuts across all socio-economic levels – household, neighborhood, city, region and nation. While at some time, the most important level of waste management system is the city scale, but this does not necessarily mean that the system must be uniform. The "dominant" system may not work in low-income areas or on hillsides, so that uniformity means these areas tend to be marginalized and receive little or no waste collection. In contrast to this, an ISWM approach promotes a variable, customized, decentralized and neighborhood-oriented approach, looking at specific requirements and conditions as the basis for providing service to the various neighborhoods and communities.

Coad, (1997) argues that many existing disposal sites were gradually surrounded by settlements and housing estates. Since the environmental degradation associated with these dumps directly affects the population, disposal sites are subject to growing public opposition.

- ***Environmental aspects*** focus on the effects of waste management on land, water and air; on the need for conservation of non-renewable resources; pollution control and public health concerns (Klundert, 2001).

  Many governments now acknowledge the environmental and public health risks associated with uncontrolled waste dumping.

- ***Policy/Political/legal aspects*** address the boundary conditions in which the waste management system exists: setting goals and priorities; determination of roles and jurisdiction; the existing or planned legal and regulatory framework; and the basic decision-making processes (Klundert, 2001).

  Ogawa, (1996) added that the lack of effective legislation for SWM, which is a norm in most developing countries, is partially responsible for the roles/functions of the relevant national agencies not being clearly defined and the lack of coordination among them. Legislation related to SWM in developing countries is usually fragmented and several laws (e.g., Public Health Act, Local Government Act, Environmental Protection Act, etc.) include some clauses on rules/regulations regarding SWM. The rules and regulations are enforced by the different agencies. However, there are often duplication of responsibilities of the agencies involved and gaps or missing elements in the regulatory provisions for the development of effective SWM systems. He stressed that legislation is only effective if it is enforced. Therefore comprehensive legislation, which avoids the duplication of responsibilities, fills in the gaps of important regulatory functions and is enforceable, is required for sustainable SWM systems.

In the Gaza Strip, enforcement is undertaken by municipal officials, and the degree of enforcement varies greatly from one city to another. In addition to municipal inspectors there are also Ministry of Health inspectors, who may have had very little training in SWM. Courts are not always used to ensure compliance - if reasoning fails the case may be passed on to the governor, or the municipality may refuse to provide any service to the offender until the matter is put right, particularly in the case of debts (El-Hawi, 1997).

4.8 Conclusion

This chapter has dealt with methods of collection and disposal of MSW. It has presented a quantitative and qualitative characterization of the MSW stream. As demonstrated in this survey planning and MSW disposal in developing countries particularly in the Gaza Strip is neither institutionalized nor legislated.

Among the disposal alternatives, composting seems to be acknowledged as the most efficient and sustainable SWM in parallel to the landfilling due to the scarce of suitable land for landfilling. However, the landfilling option will continue to be a principle option for the medium term in many countries. So improvements to landfill management are the key to minimizing the environmental effects. As the PNA took over part of the Gaza Strip and West Bank, considerable improvements in landfill facilities have been observed. Also centralization of disposal facilities at the eastern part of the Gaza Strip close to the boarder with Israel has provided considerable efficiency in collection and transportation. However, most of these landfills have reached near capacity and the PNA still have no clear disposal policy or strategy to deal with this problem.

Waste minimization strategies have been introduced by the industrial sector to reduce the amount of waste produced. However, experiences from developing countries have stressed the financial benefits as a major challenge. Recycling has remained largely informal with scavengers at the community level or dump sites. Despite the high concentration of organics in the MSW stream, composting is not being considered by any municipality in the Gaza Strip. It is concluded that compost is not only a possibility but it is an urgent necessity for all of the Gaza Strip. The recycling sector in Palestine will probably grow quite slowly because there is no pattern to follow. However, recycling and composting should be adopted as an environmentally sound integrated sustainable disposal strategy parallel to landfilling (El-Hawi & Hamilton, 2002).

Although incineration is being used widely by developed countries, surveys developing countries have concluded that incineration is not an effective, reliable or sustainable disposal option due to the capital and operating costs, ash disposal requirements and new environmental standards that developing countries should consider. Some of the health problems were associated with the disposal options so special considerations have to be taken in selecting these options. The main influential aspects – political, legal, institutional, social, economical/financial, technical, environmental – affecting disposal options were covered in this chapter. It concludes by considering the economic influence in addressing the disposal option of MSW.

Poor coordination, cooperation, facilitation and overlapping of responsibilities among institutions concerned with SWM have resulted in the un-sustainability of the disposal strategy on MSW in the Gaza Strip.

CHAPTER 5

PART III: METHODOLOGICAL PART

CHAPTER FIVE: RESEARCH METHODOLOGY

PART III: METHODOLOGICAL PART

CHAPTER 5: RESEARCH METHODOLOGY

5.1 Introduction

In this chapter, research methodologies, their characteristics and application to the research question will be discussed.

The initial decisions concern the focus of the research and the title of the study. Once established, there is a need to select the appropriate design for the study (Edwards and Talbot, 1996). It is clear that researchers have individual approaches to research questions. The individuality creates different foci on different aspects of the research subject and the use of different research methods to approach research questions (Barnes, 1992).

Section 1 addresses the strategy and methodologies for developing research design. This is a combination of various research methods to explore the research question and discusses approaches to reach design, the components and criteria for judging the quality of the research design.

Section 2 discusses the qualitative, quantitative and triangulation methodologies and focuses on case study methodology, system thinking and soft system methodology (SSM).

Section 3, this section will be focusing on SSM and it's applications in the research.

Section 4 is focusing on the development of the practical case studies from the Palestinian real life.

Section 5 is focusing on data collection and data analysis.

Section 6, the last one concerns the use of research methods

These sections are representing research approaches adopted at the inception of the research and when a certain level of understanding of the subject was developed.

Such an approach was useful since the basic knowledge about the topic was not explicitly clear. The sections in this chapter reflect the various techniques of data collection and analysis, which were combined as appropriate to the research question.

This chapter is to understand the sequence process of disposal options for MSW in the Gaza Strip from the strategic context. The research design has been adopted in the study (quantitative, qualitative, and triangulation) with various tools for data gathering like questionnaire, interview, and observation in order to apply the principles of solid waste through the four case studies. SSM was applied to analyze, evaluate research problems and as a result answer the research question as explained in chapter eight.

Most of the data has been collected from the Gaza Strip, Palestine because of the familiarity of the author with the Gaza Governorates and cities, fluency in the language and previous research background as director of Infrastructure Department at the Ministry of Planning and International Cooperation (MoPIC) in Gaza.

5.2 The Research Question

This research is focusing on understanding the main influential aspects affecting Solid waste management (SWM) addressing the disposal options and alternatives suiting the Gaza Strip case. The information will provide decision support for the development of a Palestinian strategy for the sustainable management of the municipal solid waste (MSW) disposal for the Gaza Strip. The five main research questions at the beginning of this investigation were very broad and put in a tentative and speculative way:

- How can MSW disposal contribute to the development of sustainable disposal strategy objectives?
- Are there any Palestinian strategies and policies of waste disposal?
- What is happening in the process of SWM and the institutions concerned with the service delivery within the Palestinian system, these questions could be divided into the following:

- ✓ To what extent SSM can be applicable tool for the analysis of solid waste management in the Gaza Strip?
- ✓ Can solid waste indicators be developed for disposal options represented by the case studies?

5.3 Research Design

Research has been defined as a process of seeking, by way of methodological enquiry, solutions to problems and to add one's own body of knowledge and that of others through the discovery of significant insights (Herbert, 1993).

The process is described as a cycle loop and generalization at one stage may be the beginning of the next cycle. However, most of the research process assumes that some form of the basic knowledge is already a variable on the subject. Such basic data is normally a variable in most of the established research topics (Bulmer and Warwick, 1983). The Oxford dictionary (1995) defines research as the act of searching, closely or carefully for a specific thing or person. An investigator discovers some fact by the careful study of a subject, a course of scientific inquiry. Omar and Stevans, (1995) have a wider definition, which leads to designing of maps of research territory, highlighting the essential aspects of the research process in particular taking the "before", "during", and "after" activities into account.

Whilst there are many definitions of research the common thread is that research is essentially an investigation, a recording and an analysis of evidence for the purpose of advancing knowledge. Philosophically, a basis human desire has been to add to human knowledge. As (Ross, 1974:3) put it " ..... man is by nature a question asker and an answer seeker". Sometimes the research for answers, is motivated by the sheer necessity of solving an immediate problem, at other times it is motivated by a higher, philosophical, need to understand human existence and meaning in the world.

Smith, Thorpe and Lowe, (1995) present three main classifications for research: Pure, applied and action research. The key feature of pure research is that it is intended to lead to theoretical developments, in one of the three forms: as discovery, invention or reflection.

Applied research is the intended to lead to the solution of scientific problems. Action research could be seen as the view that research should lead to change, and therefore that change should be incorporate into the research process itself. As (Herbert 1993:1) observed, there are many types of research, including field research, which contribute to knowledge and it is important to define the purpose and reasons for conducting the research at the beginning of the project. This research is considered as action research since it leads to change the current SWM system. The author has been responsible for solid waste strategies in the Gaza Strip since 1994. During this time, the author has personally managed various solid waste projects, which have changed the nature of SWM operations.

According to (Hakim, 1987) design addresses primarily the aims, purposes, intentions and plans within the context of the practical constraints of location, time, money and availability of staff. (Yin, 1994:18) points out that a research design is the logic that links the data to the collected (and the conclusions to be drawn) to the initial questions of a study. (Yin, 1994:18) also states that every empirical study has an implicit, if not explicit, research design. Yin's observation supports (Barnes, 1992) position that each individual researcher approaches question in a different way. Barnes argues that each research focuses on different aspects of the research subject and use different methods from their research method "tool box" in order to answer their questions.

5.4 Research Questions, Strategy and Methodologies

This section considers the research questions and the strategy and methodologies to be used in order to get data from the real world process it and understand the results so that the findings can be applied to resolve the problems addressed. This study will adopt a combined methodology using both a qualitative and quantitative approach to fulfill the purpose of the research.

The initial research question (How can MSW disposal contribute to the development of sustainable disposal strategy objectives?) conditioned the scope of the literature review. The detailed research questions emerged from that review and as suggested by Yin, (1994) they determined the research design. The methodology is the study of the logical basis of the research, of the collecting data and of interpreting and analyzing the findings (McNeil, 1994). It will form structure of conceptual framework.

In this research the first question clearly defines the focus. The subsidiary questions deal with detail necessary to address the first question. Those details concern the nature disposal of MSW process and the relationship with estimating and assessment of alternative disposal options in the municipal waste stream. The methodologies studied and used create a conceptual framework and form the logical structure for the research, data collection, interpretation and analysis of the findings. The first thing to address was a comprehensive search and review of texts that address the subject. The literature review focused on Disposal Strategy of MSW in the context of the wider issues of sustainable development. It established where the boundaries of knowledge were in the subject area and highlights the key areas where more knowledge and research was required.

Case study is the most suitable strategy to be adopted, because " case study is a strategy of doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple source of evidence." (Robson, 1993:52). In this research, four case studies from the real life representing disposal option of MSW were selected from the Gaza Strip in order to analyse, assess and evaluate the disposal situation.

There are four fundamental advantage of using case study for this research. The first one is " the ability to retain holistic and meaningful view of real life events. The second one is the possibility of in-depth analysis looking at multiplicity of casual link. Thirdly, they are particularly relevant to "how" and "why" type questions, explanatory investigations and research into operation [al] links, which need to be traced over time. Fourthly, a more sympathetic approach [is offered] getting inside the process, or the minds of actors or individuals, as " discovering" "explanations". (Larkham, 1996:167).

Yin, (1994) argues that, research strategy should be chosen as a function of the research situation. Each research strategy has its own specific approach to collect and analyze empirical data, and therefore each strategy has its own advantages and disadvantages. Although each strategy has its own characteristics, there are overlapping areas which bring complexity to the process of strategy selection in order to avoid gross misfits between the desired outcome and the chosen strategy, Yin (1994) stresses that the type of question posed; the control over actual behavioral elements; and the degree of focus on historical or contemporary events are the conditions which should provide the grounds for strategy choice.

Quantitative data can help with the qualitative side of a study during design by finding a representative sample and locating deviant samples while qualitative data can help the quantitative side of the study during design by aiding with conceptual development and instrumentation. The crucial aspect in justifying a mixed methodology research design in the built environment is that both single methodology approaches (Quantitative only and qualitative only) have strength and weaknesses. The combination of methodologies, on the other hand, can focus on their relevant strengths. The researcher should aim to achieve a situation where "blending qualitative and quantitative methods of research can produce a final product which can highlight the significant contributions of both" (Nau, 1994), where "qualitative data can support explicitly the meaning of quantitative research" (Jayaratne, 1993). By adopting the following assumptions, the researcher should ensure that the final product maximizes the strengths of a mixed method approach: (Adopted from Jones, 1978). Qualitative methods, especially observation or unstructured interviews, allow the researcher to develop an overall "picture" of the investigation;

Quantitative analysis, such as capabilities of employers, may allow a representative sample to be drawn for the qualitative analysis. Marsh et al (1978) note that quantitative research may confirm or deny the representativeness of a sample group for such qualitative research. Thus the mixed methodology will guide the researcher, who is carrying out qualitative research, that his sample has some representativeness of the overall population;

Built environment research involves effective characteristics, as well as overall behavioral aspects. Thus a qualitative "core" is appropriate to investigate such aspects by examining the informant's point of view. Much built environment research is still largely exploratory. The use of qualitative methods allows for unexpected developments that may arise as part of such research; Quantitative analysis may complement the findings of qualitative methods by indicating their extent within aspects of the built environment; Quantitative analysis may confirm or reject any apparently significant data and the relationships that may emerge from research. Quantitative methods can be used to enable statistical testing of strengths of such relationships; if such relationships are determined, then quantitative methods are weaker in providing explanations. Qualitative methods may assist in understanding the underlying explanations of significance.

5.5 Evaluation Criteria

Any review of research methods will be incomplete without considering the fundamental issues related to evaluation of the value of any research outcomes. In many respects an evaluation is often focused on measures to counteract the weaknesses inherent in the particular research strategy chosen to carry out a particular piece of research (Them, 1996). The technical language of such research evaluation includes terms such as validity, reliability and generalisability. The debate is rooted in philosophical differences about the nature of reality and takes the form of qualitative versus quantitative methods, as described earlier. In general, the value of any research stems from the validity of its result and extent of its contribution to the body of knowledge. Research into the built environmental is no exception. These results are the outcomes from the collection, interpretation analysis and evaluation of data.

The basic difference between reliability and internal validity is that reliability deals with the data collection process to ensure consistency of results while internal validity focuses more on the way such results support conclusions (Then, 1996). It should also be noted that the above deliberation reverse very much to the traditional evaluation criteria of validity and reliability that are governed by convention of the quantitative research paradigm. Although early qualitative researchers felt compelled to relate to traditional notions of validity and reliability to procedures in qualitative research, later writers (Miles and Huberman, 1994; Yin, 1994; Easterby-Smith et al, 1991) developed their own language to describe the quality criteria in a qualitative research paradigm. Miles and Huberman, (1994) concentrate on improved and rigorous techniques for data gathering and analysis as the best way to enhance credibility and acceptance. Yin (1994) identifies the following to establish validity and reliability in qualitative research:

- Establish a chain of evidence;
- Have the draft study report review by the key informants;
- Use of single research exploratory design by: establishing a casual relationship; use of a single case explanatory design; and specification of the unit of analysis;
- Develop formal research study framework, which typically has the following sections: an overview of the study project (objective, issues, topics being investigated); field procedures (credentials and access to sites, sources of information); research study questions (specific questions that the investigator must keep in mind during data collection); and a guide for research report (outline, format of the narrative).

The research falls within the last of Hebert's (1993) categories. It aims to explain or clarify and achieve a better understanding by waste minimization. It is focused on SSM, which tackled real world problem like the situation with the SWM. The detailed focus is on solid waste process and their disposal strategy.

A fundamental question is how the nature of MSW process influences reuse and recycle and how that can be increased in order to move towards integrated sustainable disposal option of SWM. It includes understanding the role of the actors and external conditions of recycling plants. Morgan and Argus (1995: part 3 – recommendations: 31) highlighted the necessity of cooperation by stating: Waste collection authorities, scavengers and recycling plants should cooperate in the setting up of separate storage and collections for different items of MSW. The Palestinian National Authority (PNA) should encourage this and inform all cities and villages on the actions they have taken; and the system set up. Recycling of certain items can be a surviving strategy of some communities in the Gaza Strip due to the declined economical situation. This study has carried out on the disposal strategy of MSW in the waste stream including influential aspects affecting SWM process and disposal options. Besides the necessity of collecting of data, it will be necessary to develop and evaluate a methodology that gives insights into the relationship of the quality and quantity of MSW stream and the basic characteristics of SWM process. The approach to collecting the data was via triple holistic case studies, because they were a significant source of real data from this research.

Yin (1994:44) points out that each intervention in "real world" might be the subject of an individual case study and a number of case studies combined into a multiple case study design. No broad distinction is made between the so-called classic, that is single, case study and multiple case-studies. The choice is considered one of research design, with both being included under the case study strategy (Yin, 1994:45). Soft system methodologies (SSM), system thinking and system practice (Checkland, 1991) is the most appropriate methodology to achieve understanding of the qualitative and quantitative characteristics of the research. (Wolstenholme, 1990) defines the approach as a "....rigorous method for qualitative description, exploration and analysis of complex systems in terms of their process, information, organization boundaries and strategies; which facilitate qualitative simulation modeling and analysis for the design of system structure and control". It has been argued that the best way to define a problem is by drawing on its behavior through time. This was when the use of the SSM was proposed (Cover, 1996).

(Forrester, 1980:9) points out that the case study method is the best approach to understanding the qualitative issues. This is, he argues, "By virtue of its tremendously large database, the case study approach has a great advantage over the more mathematical, statistical, and analytical approaches, which often dominate operation research economic and management sciences."

SSM uses a particular set of ideas, aimed at giving insight into the world's complexity. It's a process of tackling the "real world" problems, trying to manage situations with an organized set of principles or methodologies, which quid the actions. " System Thinking" develops and compares models in the thinking world and returns the "real world" to compare solutions, to select feasible and desirable changes and finally to improve actions towards the problem solution (Checkland and Scholes, 1990:276). The combination of these two methodologies, case study and soft system methodologies illuminate the links between the characteristics of the MSW, the disposal strategy and other alternative options.

The need to identify and unpack the MSW more clearly is a real world problem. Knowledge is a prelude to understanding rather than for action. It is a prerequisite to pursue the new sustainable waste management process. It is necessary to develop the work and obtain more accurate data from holistic case studies. The goal will be to minimize the consumption of natural resources, energy and costs while changing the general attitude towards the environment (Morgan and Argus, 1995: Part 3-Recommendation). The first requirement to select the case studies in the Gaza Strip was to define the principal structure features of the solid waste sources generation, which were the unit of analysis of this research. An initial survey of the solid waste being generated from the Gaza Strip as well as its characteristics according to its source of generation has been carried out.

A pilot study was undertaken to test the strategy (Procesl, 1997: 86-87). The pilot study had the specific objective of exposing the boundary of knowledge and the state of art in dealing with waste and SW process in the Gaza Strip. The technology and the decision-process that lead to the use of the technology was established through observation and interviews which the Palestinian people are famous with. SSM was used as supporting tool with qualitative and quantitative methods. It was also used to analyse, understand the SW problems in the Gaza Strip and as a result recommend some actions in order to improve disposal situation. SSM was used to highlight the human activity systems associated with SWM: thus so it leads to certain actions that help in solving the problem. The understanding of importance and interrelationship between qualitative, quantitative and SSM is fundamental to approach the research problem. The next section discusses these three traditions in research.

Triangulation methodology emerges from combination between quantitative and qualitative in order to cover weaknesses of both. SSM focuses more on learning the problem situation, understanding the richness activities in reality and conceptualizing the specific problems in a global (holistic) context.

5.6 The Qualitative And Quantitative Methodologies Approach

The fundamental determinant of the methodological approach to be adopted is the nature of problem under investigation (Robinson, 1998). The research question under investigation is exploratory. It is non-experimental and aims at identifying the individual's perception of the world around him. Therefore, this research adopts various approaches qualitative, quantitative, triangulation and SSM.

A qualitative research as stated by Casel and Symon (1994:4) "is less driven by very specific hypothesis and categorical frameworks and more concerned with emergent themes". Qualitative research allows flexibility in the research process. Actually, a great part of this research has dealt with framing the issue in order to create a framework based on theoretical concepts and empirical work, which could help in approaching it meaningfully. However, quite recently, increasing recognition of the value and appropriateness of qualitative studies has emerged. This may perhaps in acknowledgement of the potential for such methodologies to get beneath the manifestations of problems and issues which are the subject of qualitative studies, and thereby, to facilitate appreciation and understanding of basic causes and principles, notably, behaviors (Fellows and Richard, 1997).

Qualitative methods are the more appropriate since they "seek to understand phenomena in their entirely in order to develop a complete understanding of a person, program or situation. This is contrast to the experimental paradigm, which aims to isolate and measure narrowly defined variables and where understanding is tantamount to prediction and control" (Rudestam and Newton, 1992:32).

Qualitative research is not about measuring attitudes, behavior and making statistical comparisons, but it is about exploring, understanding and explaining the range and diversity in attitudes. Thus, qualitative research involves:

- seeing through the eyes or taking the subject's perspective;
- describing the detail of a setting from the perspective of participants;
- understanding actions and meanings of their social context;
- emphasizing time and processes;
- favoring open and relatively unstructured research designs;

- an approach in which the formulation and testing of concepts and theories proceeds in conjunction with data collection. (Hakim, 1987:26)

The particular reasons of favoring qualitative methods in this research can be summarized as:

- scarcity of information available as to the generalities of the subject area;
- the need to understand waste management process focusing on strategy of disposal options and public participation in SWM decision-making.
- the need to find factual evidence for the general consensus that the policy and realities of practice are at odds as a result of the different perceptions of the different players.

Qualitative data, with their emphasis on people's "lived experience" are fundamentally well suited for locating the *meaning* people place on the events, processes, and structures of their lives: "their perceptions, assumptions, prejudgments, presuppositions" (van Manen, 1977) and for connecting these meanings to the *social world* around them" (Miles and Huberman, 1994:10).

Considerable research in the built environment involves asking and obtaining answers to question through conducting surveys of people by using questionnaire and interviews. Often, responses are compared to "hard data", such as total cost of construction project. Survey techniques, such as questionnaires, interviews etc., are highly labor intensive on the part of respondents and particularly on the part of the researcher, whilst a further consequence is the low response rate (Fellows and Liu, 1997). Given the early stages of quantitative methods to arrive at the field-work stage of the research, there is the requirement of a considerable amount of pre-conception in deciding what data to be collected, how they will be collected and what analyses will be done (Fellows and Liu, 1997).

Quantitative investigations look for "distinguishing characteristics, elemental properties and empirical boundaries" and tend to measure "how much" or " how often" (Nau, 1995). They are appropriate to examine the behavioral component of the built environment.

Both qualitative and quantitative approaches have strengthens and weaknesses. Quantitative data are recognized by their reliability and representative samples allow very broad generalizations. Interpretation of quantitative data through statistics is considered faster and economical. However, quantitative methods are considered inflexible and artificial, less helpful in generating theories and effective in understanding processes and significance propel attach to actions. (Miles and Huberman, 1994:266). Table 5.1 provides a pragmatic view of a summary of some of the strengths and weaknesses of the two research paradigms (Adopted from Easter by-Smith *et al*, 1991).

Table 5.1: Comparison of Strengths and Weaknesses

Source: (Easter by-Smith et al, 1991).

Theme	Strengths	Weaknesses
(Quantitative Paradigm)	▪ They can provide wide coverage of the range of situations. ▪ They can be fast and economical. ▪ Where statistics are aggregated from large samples, they may be of considerable relevance to policy decision	▪ The methods used tend to be rather inflexible and artificial. ▪ They are not very effective in understanding process or the significance that people attached to actions. ▪ They are not very helpful in generating theories. ▪ Because they focus on what is or what has been recently they make it hard for policy-makers to infer what changes and actions should take place in the future.
(Qualitative Paradigm)	▪ Data gathering methods seen as more natural rather than artificial. ▪ Ability to look at change process over time. ▪ Ability to understand people's meaning. ▪ Ability to adjust to new issues and ideas as they emerge. ▪ Contribute to theory generation.	▪ Data collection can be tedious and require more resources. ▪ Analysis and interpretation of data may be more difficult. ▪ Harder to control the pace, progress and end-points of research process. ▪ Policy-makers may give low credibility to results from qualitative approach.

There is a strong suggestion within the research community that both quantitative and qualitative research are best thought of as complementary and should therefore be mixed in research of many kinds. (Das, 1983) states that, " qualitative and quantitative methodologies are not antithetic or divergent, rather, they focus on the different dimensions of the same phenomenon. Sometimes, these dimensions may appear to be confluent: but even in these instances where they apparently diverge, the underlying unity may become visible on deeper penetration....The situation contingencies and objectives of the researcher would seem to play a decisive role in the design and execution of the study". This emphasis has developed with the growing attention focused upon "Triangulation" in research (Yin, 1994). Triangulation is the combination of methodologies in the study of the same phenomenon. The assumption in triangulation is that the effectiveness of triangulation rests on the premise that the weaknesses in each single method (only quantitative or qualitative) will be compensated by the counter-balancing strengths of another. This term is occasionally taken to refer to a broad approach, which combines "multiple observers, theoretical perspectives, and methodologies" and is frequently used interchangeably to describe research strategies that incorporate a combination of a quantitative and qualitative research methods in the study of the same phenomenon. It generally denotes a reference to a combination of research methods-thus the use of qualitative and quantitative techniques together to study the topic-which is very powerful it gain insights and results and to assess in making inferences and drawing conclusions, as illustrated in Figure 5-1 (Fellows and Liu, 1997).

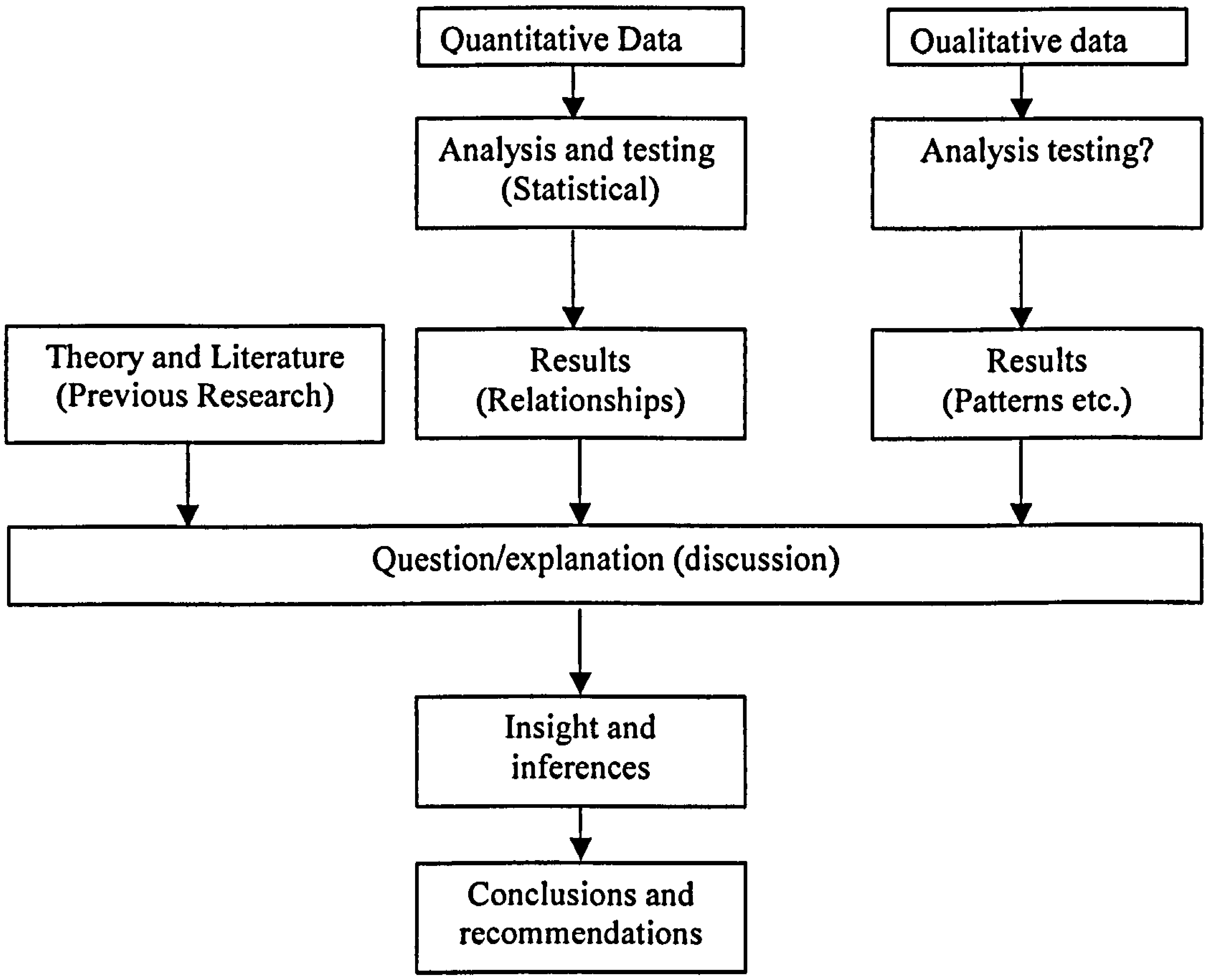


Figure 5-1: Triangulation of Qualitative Data

Source: (Fellows and Liu, 1997)

Rossman & Wilson (1991) answer the question of why link qualitative and quantitative data and consider it to be:

- to enable confirmation or coordination of each other via triangulation;
- to elaborate or develop analysis, providing richer details and;
- to initiate new lines of thinking through attention to surprise of paradoxes, " turning ideas around", providing fresh insights;
- Links to section on how research applied

5.7 The Case Study Methodology

The case study is a research strategy, which focuses on understanding the dynamics present within single settings (Amaratunga & Baldry, 2000) and usually refers to relatively intensive analysis of a single instance of a phenomenon being investigated.

Yin, (1994) defines case study as an empirical investigation into contemporary phenomenon operating in a real-life context. It is a particularly valuable when there is not a clear definition between the phenomenon and the context itself. It involves the use of multiple methods of data collection and aims to examine the world qualitatively. (Harley, 1994) defines case study research as a heterogeneous activity covering a range of research methods and techniques, a range of coverage, differing lengths and levels of involvement in organizational functioning and a range of different types of data.

Case study is one of several methodologies for undertaking and understanding research. Initially it was applied mainly to the social and humanistic science but has increasingly been applied to the engineering field like the case with the SWM. Each case study strategy has peculiar advantages and disadvantages Yin (1994), depending upon three main conditions:

- The type of the research question posed
- The degree of control of investigator has over actual behavioral events"
- The degree of focus on contemporary as opposed to historical phenomena

Case studies are tailor made for exploring new process or behaviors on ones, which are little understood. In this sense, case studies have an important function in generating hypothesis and building theory in built environment research. They have a high likelihood of generating new theory, and further more, the emergent theory is likely to be testable with construct that can be measures and hypothesis that can be falsified. Detailed case studies may be essential in comparative research, where an intimate understanding of what concepts mean to people, the meaning attached to particular behaviors and how behaviors are linked.

Case studies may be used for specific function of the research. Appropriately they can be used at the exploratory phase of an investigation. They can be used descriptively recording surveys and histories and for thirdly for explanatory or casual inquiries. The way in which the case study is used derives from the distinctive characteristics of each situation Yin (1994:1). In this research the case studies are used to describe the waste management process in the "real world" as well as disposal options and alternatives pertaining MSW as explained in the case study of Chapter Six.

Four case studies representing disposal options were selected from real world in order to highlight how these options/technologies can be integrated to develop disposal strategy of MSW suiting the Gaza Strip case. The author of this thesis took the advantages of case study methodology over other methodologies into consideration at the initial stages of the research. A case study methodology is adopted in this research, as it will give an accurate profile of the waste management process including Palestinian institutions involved in SWM service delivery. The data was collected in this research using the case study method has been collected through the use of participant observation as explained in Chapter Six. Site visits to the SWMC, PEF, Gaza municipality and Shifa hospital were arranged, several meetings with the heads of these departments were conducted and information on the influential aspects from each case study was gathered as illustrated in Chapter Six. Indicators and selection criteria (technologies) were used for the assessment and evaluation of disposal options as explained in appendix.

5.8 Multiple Case Studies

The key feature of the case study approach is not method or data but the emphasis on understanding process as they occur in their context. The investigator interviews individuals or studies life history documents to gain an insight into behavior and attempts to discover unique features and common traits shared by all persons in a given classification. Much case study research, because of the opportunity for open-ended inquiry, is able to draw on inductive methods of research, which aim to build theory and generate hypothesis rather than primarily to test them

Often, case studies employ a variety of data collection techniques. Unlike questionnaires and interviews when the case researched is the responded and so a possibly large number of cases are researched for statistical significance, in a case study the case is the particular occurrence of the topic of research. It may be, for instance, a legal case hearing, a building in use over a time, or the procurement of a construction project. Interviews may be used as accompanied by collection of "hard" documentary data. Questionnaires are less usual although they may be employed to gain an understanding of the general situation of which the case being studied is particular instance. A case study yields deep but narrow results. Commonly, it will employ triangulation both in the case study itself and to facilitate generalization of findings. However, it is essential to be aware of the validity of generalizing the findings of a case study research project. (Fellows and Liu, 1997).

Robson (1993) perceives survey methodology as " the collection of standardized information from a specific population" (Robson, 1993 P.49). This approach usually encompasses methods such as questionnaires and structured interviews, and involves the sampling of a large portion of a population to achieve quantifiable results.

In the context of a study on SWM it was more useful using this in combination with other research strategies. As an isolated research technique issues of reliability are of crucial importance. For example, respondents of questionnaires/interviews could be economical with the truth and mislead the researcher. Therefore, it was important supplementing these techniques with other approaches, such as observational techniques.

5.9 Soft System Methodology

5.9.1 Introduction

Soft System Methodology (SSM) was developed by Checkland (Checkland 1980) to tackle problems that hard to define, known as soft problems. Such problems cannot be solved by the same techniques that are used to solve the hard problems. The main difference between the hard system and the soft system thinking is lying in what types of questions are needed to be answered (El-Hawi and Hamilton, 2001).

The real world problems are different to the problems that researchers study in a laboratory environment. In a laboratory setting the researcher can define the problem and control the environment (Checkland 1981:150). A real world-problem is not well defined like the situation with the SWM case and, because of its complex relation to the environment, cannot be studied in isolation. Furthermore, because of the complexity, one real-world problem is not identical to another and therefore is not reasonable to work out techniques that are problem-related.

Soft System Methodologies use a particular set of ideas to illuminate world complexity. It is a process of addressing "real world" problems to enable the management of a situation using an organized set of principles or methodologies to guide the actions. The basic shape of the methodology is to formulate a model, which it is hoped will be a near match to the real world situation. Then, by a process of comparison of the real world, refine the match (Checkland and Scholes, 1990:6).

SSM started from the experienced inadequacy of the epistemology of systems engineering (SE) and its ontological assumptions when used in management problem situations. SE makes the same assumptions that we make in everyday language when we casually refer to the "*legal System*", "the education system", health care system, or "solid waste system". The unexamined monolithic assumption there is that systems exist in the world and that way may be engineered to achieve objectives, which can be unequivocally defined (El-Hawi and Hamilton, 2001). SSM began to make progress when it was realized that all real-world problem situations were characterized by people trying to take purposeful action. A set of activities, linked together so that the set was purposeful, was treated as a new kind of system concept (a human activity system). But it was realized that the way in which the purposefulness was defined had to be declared, since on observers "*terrorism is another's freedom fighting.* (El-Hawi and Hamilton, 2001).

These any real world situation in which people tried to take would be purposeful action could be expressed by testing it (the perceived situation) against a number of models of "a human activity systems" built on the basis of different Weltanschauungen. The models were thus simply epistemological devices, or to use Koestler's useful word, there were *"holons"* (Checkland, 1988a). The role of the comparison between holons and perceived problem situation was to structure a coherent debate about change, the intent in the debate being to enable the participants to learn their way to the accommodation between conflicting interests, which enable action to be taken to improve the problem situation. Later developments added social and political analysis of the problem situation as an aid both to deciding what models might be relevant and to teasing out what action in the situation might be both desirable and feasible.

SSM was thus itself a learning system, one structured by the use of purposeful holons to explore the complexities of real situations and to take action to improve them. Techniques of model building were developed. SSM can be seen as an approach which took the *"trial-and-error"* principle we are familiar with from our everyday undertakings and established it, with the aid if system ideas, as a methodology for enquiries into problematic situations. Unlike other system analysis methods, which guide the user through a structured process from problem definition to solution implementation, SSM is a set of guidelines that help the analyst in performing the analysis, while allowing a considerable scope of personal interpretation. SSM is a methodology that aims to bring about improvement in areas of social concern by activating in the people involved in the situation learning cycle which is ideally never-ending (Von Bulow, 1989). The overall and the aim of the SSM is to take seriously the subjectivity which is the crucial characteristic of human affairs and to treat this subjectivity, if not exactly scientifically at least in away characterized by intellectual rigor.

In this research, SSM will be used a tool to analyze the four case studies trying to identify weaknesses and strength for the purpose of recommending some actions in order to improve the solid waste disposal situation.

5.9.2 Soft Systems Thinking

The hard system thinking is answering the how questions assuming one problem has definite solution and a number of goals. The soft system thinking is answering what and how questions since soft system recognise that there is not a single problem but several problems to be solved.

Chekland's SSM provides powerful techniques for the analysis of the systems with human and social components. It has a framework for system analysis of seven stages as shown in Figure 5-2.

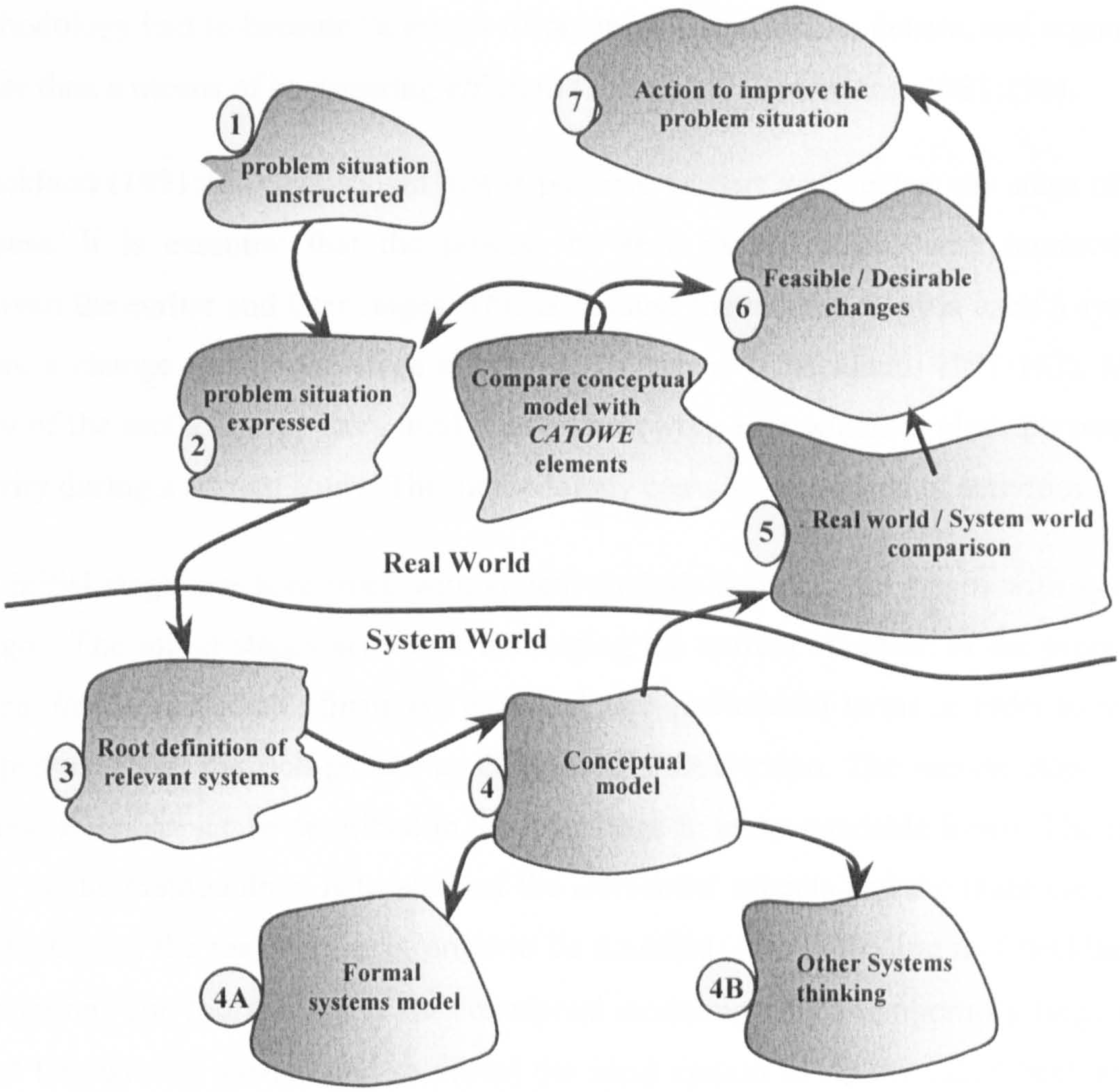


Figure 5-2: The Main Feature of SSM is a 7-Stage Analysis Process Depicted in a Diagram

Source: Checkland and Scholes, 1990

Hence, in soft system thinking the systemicity is no longer assumed to be in the outside world; it is in the methodology for enquiring into the perceived world. The difference between "hard" and "soft" systems thinking is summarized thus the "soft tradition regards system models as models relevant to arguing about the world, not models of the world; this leads to "learning" replacing "optimizing" or satisfying"; this tradition talks the language of "issues" and accommodations rather than "solutions" (Checkland, 1985:765).

In a real world problem many different and interrelated facets are present and therefore numerous definitions of the problem are possible. Once a problem is defined its solution is usually implied. Therefore, the "hard" methodologies had to be adjusted to fit the managerial problems that the Lancaster researchers focused on; the methodology had to become "a means of organizing discussion, debate, and argument rather than a means of engineering efficient "solutions" (Checkland, 1981:191).

Checkland (1991:162) has shown that is possible to start a project at any stage of the process. It is essential that the process be seen as interactive with interactivity between the earlier and later stages. This is because the methodology is itself a system where a change in any one stage affects all the others (Checkland, 1991:163). Most users of the methodology have used it as a framework into which to place purposeful activity during a system study. The methodology contains two kinds of activities.

The initial stages are concerned with system analysis and the later stages with system design. The initial stages start with addressing the current situation of the proposed system in environmental, financial, technical and institutional terms in order to make the picture clear, the rich picture as Checkland's description. The second stage is to express the rich picture described in the later stage in understandable forms. The third stage of the methodology is to abstract the influential aspects and the main elements and factors of the real system in order to be modeled, root definition as Checkland's description. The fourth stage is the conceptual modeling which temporarily forgetting about the existing system and to model the ideal system to do the job. Checkland's methodology prescribes six essential components of a system that must be identified at the conceptual modeling stage. A system is defined through a **transformation** carried out by the **actors** within it. The system affects beneficially or adversely other people who are its **consumer** and there is some agency with power of existence over it who is its **owner**. The system has to exist within outside constraints forming its **environment** and the whole activity of system definition takes place within an ethos or **weltanschauung** that effects our views of it. In order to choose the best, Checkland suggests criteria of five E's, efficacy (will it work at all), efficiency (will it work with minimum resources), effectiveness (does it contribute to the enterprise), ethically (is it moral) and elegance (is it beautiful). (El-Hawi & Hamilton, 2001).

Stages 1,2,3,5,6 and 7 are "real world" activities, necessarily involving people in the problem situation, and depend upon the individual circumstances of the study. Stages 1 and 2 are the "expression phase" during which an attempt is made to build up the richest possible picture of the situation. Stages 3, 4 are "system thinking" activities, which may or may not involve those in the problem situation.

The first and second stages are related to the collection of as many perceptions as possible building the richest possible picture of the problem. Stage 1 deal with unstructured ideas. Stage 2 defines the problem situation more clearly. These two stages belong to the "real world". In this research the design begins in the second stage, as the research ideas are well structured. The third stage is related to the choice of the root definition of a relevant system. The conceptual model has to consider all activities in order to match the system named in the definition of the transformation described in the definition. The fifth stage compares the conceptual model with the reality. The sixth stage focuses on systematically desirable and cultural feasible changes. These could be changes in structure, in procedures and in attitudes. The purpose of the stage is to generate a debate with people concerned with the problem. The outcome of the debate is to define possible changes that simultaneously need to meet two criteria. Those criteria are that the changes are arguably desirable and feasible giving prevailing attitudes and power structures, and having regard to the history of the situation under examination. The last stage involves taking actions to mitigate the problem. This defines a "new problem" and it may now be tackled using the methodology (Checkland and Scholes, 1999). Within this research, the customers are the community in its broad sense. The community is the beneficiary of the environmental and sustainable practice. The actors (A) are the people participating from the design phase, through generation to the final disposal of solid waste phase. The transformation process (T) in this research is the SWM system that provides a healthy sustainable environment at affordable cost like composting, recycling and reuse. The "Weltanschauung" (W) is that the world needs to be resource efficient and this process will contribute to that end in an area, which is manifestly not resource efficient. In this research, the people are entitled to a healthy and clean environment in which to live. The owner (O) is the people as a whole represented by Palestinian Legislative Council (PLC) who has the overall decision-making authority. It also includes those who are responsible for the SWM service delivery. Finally, the environmental constraint (E) are the element outside the system. It also includes the present economic and political situation, the topography, ecology and climate.

5.9.3 Rich Pictures

Checkland and Scholes, (1999) tends to describe their systems with diagrams known as rich picture, it could be any sort of picture, a diagram "without roles". This is exactly the point; through rich pictures do have some distinguishing features. They show the people involved, their stated purposes, and their desires and fears (usually in think bubbles). They show more environmental detail than most diagrams (human activities, like processes, cross organizational boundaries). And they show how interests agree or conflict. In chapter seven, rich picture is developed for SWM in Gaza Governorate as illustrated in Figure 7.2. By considering the CATOWE elements it is possible to produce rich pictures.

5.9.4 Root Definition and CATWOE

According to Checkland and Scholes, (1999) the "root definition" should be a concise description of a human activity system, which captures a particular perspective. It expresses the core purpose of a purposeful activity system. This is always expressed as a transformation process. The transformation process is one in which the inputs of an entity are changed or transformed into some new form, the output of the same entity. In this research "a root definition" was established that led to an activity subject to the transformation process. That activity and transformation process was the nature and form of the SWM process. An objective was the conceptualization of a disposal strategy of MSW and evaluation of the process as an application of SSM to analyze the SWM process in the Gaza Strip as explained in chapter seven.

Root Definition RD: Means naming, in a short statement, a system of purposeful activity. The formal rules for a well-formulated root definition is that it should be contain the elements of the mnemonic word CATWOE (Smyth & Checkland 1976).

RD can be described as the root from which the model grew (Patching, 1990) and as such from the base for the creation of the model (and the connection between stage 3 and 4). RD is a professionally-manned system concerned with the overall management of "intellectual property" so that by this management the system makes the best possible contribution to the businesses success of a science-based company (Checkland, 1980).

The root definition of an appropriate " root definition", which is the core of the purposeful activity, is fundamental in the research development. This study highlights an environmentally sound disposal strategy and alternative options of MSW subsystem, which leads to proper decision support system (DSS). Checkland and Scholes (1990:35) defines the elements CATWOE as follows:

C: stands for the customers, which means the person or persons who would be the beneficiaries or victims of the systems of the system; In this research the population in the Gaza Strip as a whole

A: for actors, that is the person or persons who perform the transformation process; In this research the municipalities, village councils, SWM Councils (SWMC).

T: for the "Transformation process of some input, the core purpose of the chosen system in which some entity is changed to some new form of that same entity; In this research An SWM system that provides a healthy sustainable environment at affordable cost.

W: describes the worldview, which makes the transformation meaningful; people are entitled to a healthy and clean environment in which to live

O: stands for the owner, the person who can stop the transformation; and finally. The people as a whole represented by Palestinian Legislative Council

E: constraints from the environment that is taken as given. The present Economic and political situation. The topography, ecology and climate.

The structure of CATWOE implies that the simplest version of the root definition would be "a system to do X" where X is a particular transformation process (T). The core of the CATWOE is the pairing of transformation process (T) and the worldview, or weltanschauungen, (W) which makes it meaningful. The importance of stating ownership and aspirations in SSM models are illustrated in the term weltanschauungen.

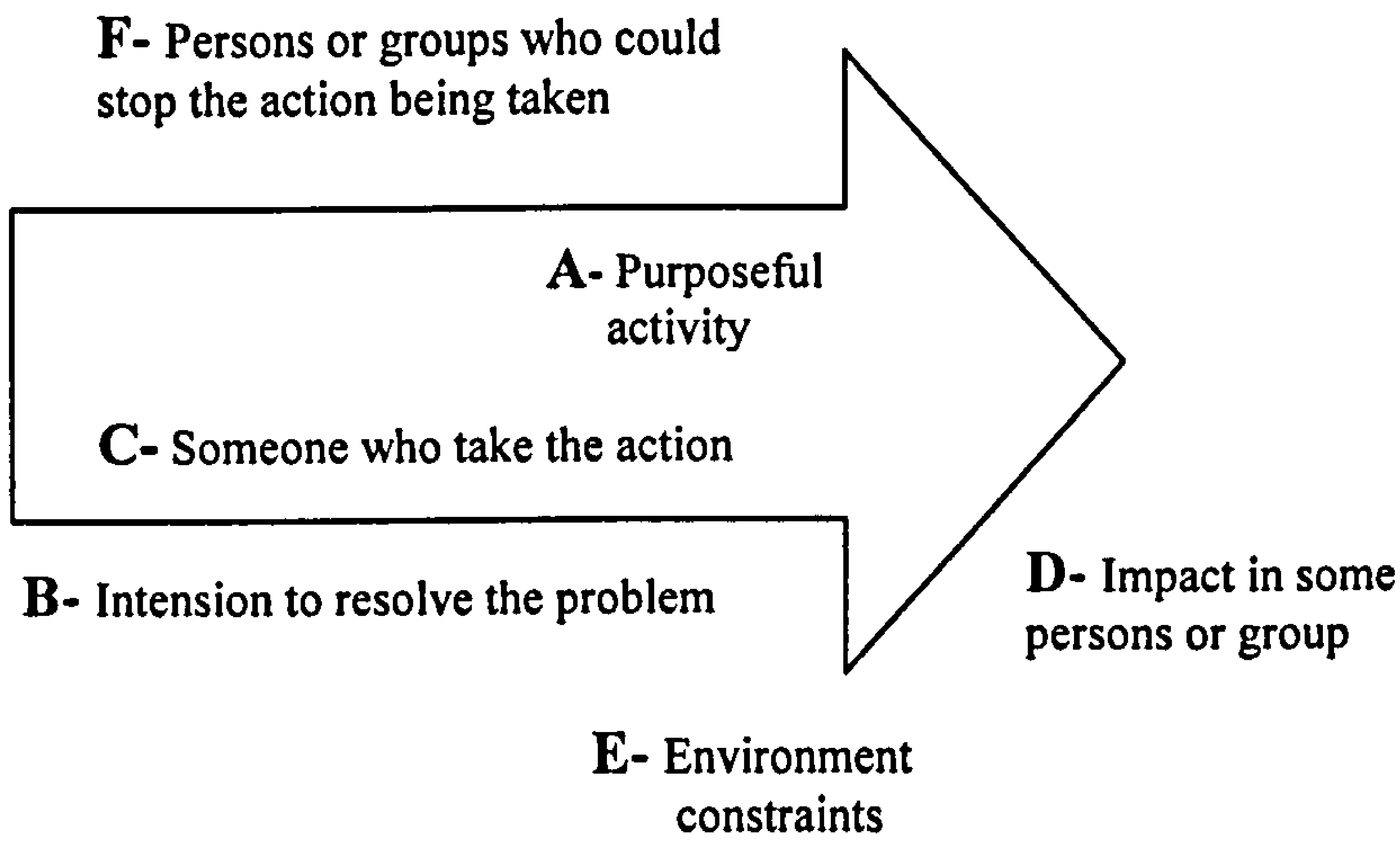
One reason why this is an appropriate moment at which to undertake the task is that there is now a considerable gap between the use of SSM by experienced users (who have internalized it) and the naïve formulations of much of the burgeoning secondary literature on the approach.

5.9.5 Purposeful Holons; Human Activity Systems (HAS)

Human Activity System (HAS) can be defined as sets of purposeful human activities related to each other so that they can be viewed as a whole. Activity, which could in principle, is found in the real world. Such systems are notional in the since that they are not descriptions of actual real-world activity (which is an exceptionally complex phenomenon) but are intellectual constructs; they are ideal types for use in a debate about possible changes which might be introduced into a real-world problem situation. Often the fact that they form an entity is emphasized by the existence of other systems (often designed systems) which are associated with them: the activities which make British Rail a human activity system, for example, associated with the designed physical system which is the rail network, with it's stations, track, engine depots, etc (Checkland and Scholes, 1999). The case is the same with the National Health Care System (NHS) in the UK the activities which make the NHS human activity system is the designed associated physical system and medical equipments and public health facilities.

Another example is the situation with the SWM system, the activities which make local authority a human activity system is the designed associated physical system and equipments used for the collection, transportation routing, disposal practicing and other associated activities might be resulted from the system like composting, reduce, reuse and recycling (3R's) initiatives where some industrial activities are linked to solid waste sector that affects the private sector and other consulting firms (El-Hawi and Hamilton, 2001). Solid waste sector has been engineered, it has a man's language, a toolmakers; communication, coordination and consultation.

The concept human activity system is crucially different from the concepts of natural and designed systems. These latter, once they are manifested, 'could not be other than they are' but human activity systems can be manifest only as perceptions by human actors who are free to attribute meaning to what they perceive. There will thus never be a single (testable) account of a human activity system, only a set of possible accounts all valid according to particular Weltanschauungen (El-Hawi and Hamilton, 2001). Figure 5-3 illuminates an emblematic model of a purposeful; activity adapted to the focus of this research.



INTERVENIENTS:

A- To chose an appropriate environmentally sound disposal strategy for the MSW for the Gaza Strip

B- The public as a whole represented by Palestinian Legislative Council (PLC).

C- Local authorities, municipalities, village councils, SWMC, private sector and donors

D- People/Palestinians are entitled to a healthy and clean environment in which to live.

E- Present economic and political situation. The topography, ecology and climate conditions.

F- Local authority, PLC and Israeli government.

Figure 5-3: An emblematic model of a purposeful activity

Source: Adapted from Checkland and Scholes (1990)

The researcher attempts to approach this overarching purpose will be carried out in three steps. First, SSM is presented. It gives guidelines that support the process of SWM including institutions involved in service delivery, from the initial modeling to taking action. Factors like Weltanschauung (world outlook) and consciously chosen perspectives and theories influence the direction of change. In the second part, disposal alternatives like: sanitary landfilling, composting of organic waste and recycling of recyclable materials will de developed to focus alteration efforts toward sub-system (holon) that affect the environmental performance as explained in chapter six. Directions for practical use of the theoretical perspectives in the SSM conclude this part. In the third part, an attempt will be made to produce a concrete research design for case studies.

In SSM, change is proposed through "relevant systems", and these are modeled as human activity systems. It is self-evident that "relevant systems" will vary with the analyst's interests. For example, a change in perspective from human resources to extended enterprise will heavily influence the "relevant systems" described. Another example, a change in perspective from local authority to private sector will also influence the whole SWM process. So, an environmentally sound disposal strategy of MSW and extended enterprise emphasis interactions between enterprises, and other perspectives are less visible.

5.9.6 Structuring a survey

Checkland, (1999) argues that, there are many problem situations in which the felt need is for understanding rather that action. A survey is called for, rather than action taken. There may of course be a political content in the decision to set up the inquiry or call for the survey, and this is frequently the origin of official reports, their initiation being the minimum possible action in a situation in which, for political reasons, some public action is necessary like the case with the landfill or disposal facility site selection (El-Hawi & Hamilton, 2001).

The process of compiling and publishing reports and surveys is a part of community learning. Whether their investigators intend it or not, such reports will indicate changing concerns and evolving standards of judgment, and many well affect subsequent actions directly or indirectly. There is therefore a place for methodology relevant to the preparation of survey reports. Although the SSM was evolved in situations in which actions was the aim, a method of structuring survey report is useful (El-Hawi & Hamilton, 2001).

5.9.7 Systems Design

Soft System Methodology has raised much interest and attention with the interprevistic strand of information system. It was recognized that SSM models of human activity systems could be used to draw information flows (Checkland, 1984; Checkland, & Griffin 1970). Much research has aimed at using SSM for information requirement analysis, e.g. Checkland & Holwell (1993), Mingers (1995), Wilson (1990) and Winter, Brown & Checkland (1995). Other research has combined SSM with information systems design methodologies, e.g. Avision & Wood-Harper (1990), Gregory (1995), Khlaif, Malbaski & Obradovic (1989), Moll (1986), Savage &

Mingers (1996) and Stowell & West (1994). In addition to this, there is research which point at problems of combining methodologies with different philosophical underpinnings, i.e. the problem of combining interpretivistic and functional methodologies. SSM aims at understanding different interpretations in inquiring and learning about reality and recognising that there is no single, correct interpretation. Functional methodologies, on the other hand, formalize reality into functions and since their aim is to engineer such functions, they are only interested in one single interpretation of that reality.

Conventional information systems design methodologies are usually based on a functionalistic approach and therefore, since SSM's and these latter methodologies' views of reality are different, their combination may cause problems. Finally, in an attempt to view the information systems field as a whole, a process model is developed based on SSM, which links human agents, organization and technology (Checkland & Holwell, 1998).

The basic shape of the SSM in Figure 5-4 can also be applied to distinguish three methodological phases: Finding out, Systems modeling and Taking Action. These are represented by the dotted square boxes. The first phase, finding out, corresponds to activities that explore the "real-world situation of concern" and in which the SSM practitioner is actively involved. The second phase, systems modeling, answers especially to SSM's principles of systems thinking. The third phase, taking action corresponds to the part of the process where comparisons are made, perceptions are accommodated and subsequent "actions to improve the situation" are taken. The way SSM is triangulated in this research with other methods of data collection is studied in section 3 in this chapter.

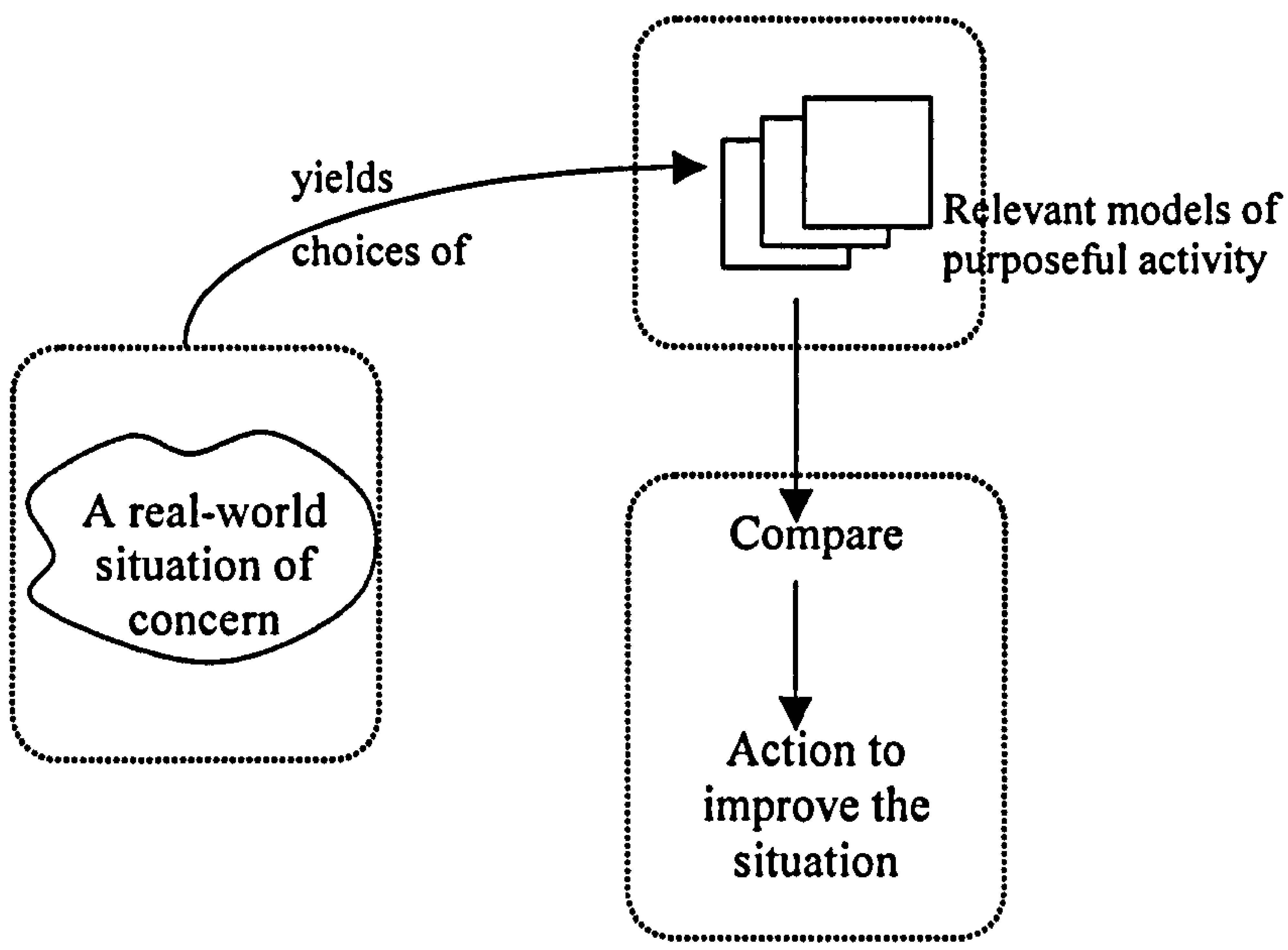


Figure 5-4: Basic Shape of SSM

Source: After Checkland & Scholes, 1990b:7

5.10Data Collection and Techniques

The way SSM is triangulated in this research with other methods of data collection is studied in section 3 of this chapter. Selection of data collection methods depends on the amount of existing knowledge on the generalities of the subject area. Although there are references closely related to solid waste processing, the process itself and the issues involved in decision-making are not well researched.

Few studies on identifying the issues concentrate on different alternative of MSW disposal options. They usually adopt a quantitative approach. This research doesn't follow the route of using the readily identified variables and confirm them. There are two fundamental reasons. The first is the number and specify of these studies. The few number of studies conducted in this field concentrate on the issues involved in the adaptation of WM process and alternative disposal technologies of MSW.

Data collection is at the core of the research. The value of the data can be maximized if the construct validity and the reliability of the data in the case studies are properly established (Yin, 1994). The three processes to establish that construct validity and reliability are:

Use multiple sources of evidence. This enables triangulation and the development of converging lines of inquiry. Patton (1987) suggest four types of triangulation:

- Of data sources-data triangulation.
- Among different evaluators-investigator triangulation could be used for validation.
- Of perspectives on the same data set-theory triangulation.
- Of methods-methodological triangulation like SSM, interview and case studies, see section 3.

In this research, data was collected from several case studies; other sources of evidences were extracted from the proceedings of international, scientific and technical reports, technical guides and other reliable material available from the Palestinian institutions.

The phase one data collection was based on a multiple source of data, interviews, observations and documents. The principle data source being in-depth semi-structured interviews that were recorded on audiotape and later transcribed. Data also gathered in the form of observational notes and minutes from attendance at solid waste coordination meetings which takes place on a monthly base between municipalities, village councils, SWM councils and UNRWA to present latest development on waste management related issues and avoid any duplications.

In this section, data was collected using the following tools:

- Quantitative approach, the tools used for this method are: questionnaire, survey, visual observation, and documents (records, registry, projects).
- Triangulation of qualitative approach, of data sources-data triangulation, the tools used for this method are: a) multiple case study techniques, all the case studies were conducted with the required surveys, interviews, discussions, participatory, and non-participatory observations and other tailor-made which were developed as per requirements.

- SSM triangulated with the case studies were used as analysis tool to describe and assess the SWM current situation.

For example, fifty open-ended interviews to stakeholders, municipal officials, SWM councils, UNRWA, NGO's, street sweepers, scavengers private sector, community leaders/mokhtars and SWM consultants. Were distributed. All interviewee were selected in such away to categories to fulfill:

- Those who are affected by SWM operations like households, stakeholders and general public.
- Those who involved in SW service delivery like municipalities, village councils, SWMC's, NGO's and UNRWA who respond to public claims.
- Those who work in SWM field like ministries, consultants and private sector.

The objectives of the sampling is to provide a practical means of enabling the data collection and processing components of research to be carried out whilst ensuring that the sample provides a good representation of the population; i.e. the sample is representative. Unfortunately, without a survey of the population, the representativeness of any sample is uncertain, but statistical theory can be used to indicate the representativeness. Measurements of characteristics such as the mean, of a sample are called statistics whilst those of a population are called parameters. How to obtain representativeness begins with consideration of the population. Almost invariably, it is necessary to obtain data from only a part of total population with which the research project is concerned; that part of the population is the sample (Fellow and Liu, 1997).

The reason behind selecting these groups like street sweepers, municipal mangers, directors of solid waste departments....etc they involved SWM service delivery, follow up waste management operations, responding to people's claims and coordination with donors regarding financing some SWM projects.

5.11Questionnaire Design and Preparation

It is extremely important that the survey instrument is tested and redefined. Once the questionnaire has been developed, each question and the questionnaire as a whole must be evaluated before implementation. In general, three phases of presenting can be distinguished, i.e question development, questionnaire development, and polishing pretests (Bishop and Heberlin, 1990; De Vaus, 1996).

Some of the questions were deleted as not related like asking about level of income, level of cleanness, level of education and age as sensitive questions and not directly related to the subject. Other questions were redrafted to fit and cope precisely with the aim of the questionnaire; the concept questionnaire will normally be longer than the final version, as unnecessary parts are deleted.

5.11.1 Pilot Testing of the Questionnaire

According to Baarda and De Goede, (1995), the whole questionnaire was evaluated and tested. Imported aspects focusing on the research topic like disposal technologies have been taken into consideration, fluency of questionnaire, and transition from one section to another smooth, huge jumps were avoided. Listening to the interviewee rather than reading the questionnaire. Careful attention on the total time needed for the questionnaire. Respondents were informed on how long the questionnaire will take. Unnecessary parts of the questionnaire were cut out. Finally, the questionnaire has been tested according to the final design and layout, wording of questionnaire were made clear where respondents recognise and understood.

The starting step is not putting or addressing questions or reviewing similar questionnaire but:

- Researcher's wide knowledge and expertise in the field of solid waste as directors to the Infrastructure department at the Ministry of Planning and International Cooperation with access to policy and strategy of SWM papers.
- The precise and concise of selecting the problems as well as research objectives and required tools.

After understanding the research problems, objectives determined and selection of tools, the researcher has put the questions, which cope and contribute to solve the problems suit and considered as main questions, then secondary questions have been divided and conducted to cope with research objectives. The questions of the questionnaire have been focused on the integration of understanding to the disposal strategy of MSW through understanding of cooperation, coordination and facilitation as well as implementation mechanism among institutions involved in SWM service delivery. That's how the questionnaire has been applied in the Gaza Strip with the target group (Ministries, SWMC's UNRWA, Municipalities, village councils, private sector and NGO's) focusing precisely on disposal technologies of MSW. The questionnaire is attached in the appendix.

5.11.2 Implementation of Research Questionnaire

When the questionnaire has been tested, reviewed, revised and proven viable and reliable, the sample size and target group were (50 people) almost all people involved in SWM business. In order to ensure adequate control of the survey, accomplished questionnaires were handed over to a team of supervisors for inspection, to see if all questions have been answered and written down according to the rules.

Before the questionnaire was tested, some problematic concepts used in the survey were discussed locally. Some of the questions were deleted as not related like asking about level of income, level of cleanness, level of education and age as sensitive questions and not directly related to the subject other questions were redrafted to fit and cope precisely with the aim of the questionnaire like cooperation and coordination with municipalities, willingness to be involved and to participate in SWM decision-making process and willingness to pay for better SWM service delivery (El-Hawi and Hamilton, 2003).

Interview

An interview can be defined as a "conversation with a purpose" (Berge 1989). There are three types on interview: structured, semi-structured and unstructured (Berge 1989; Sommer and Sommer, 1991). The structured interview is most closely associated with the quantitative approach. The unstructured interview, on the other hand, is closely associated with the qualitative approach.

Interviews are an investigative method, which provide chiefly three kinds of information (Herbert, 1993):

- Observation of a limited sample of the Behaviour manifested during the interview
- Data about the user's present situation and predicament
- Life history data

What the person has done in the past is a good indicator of what he or she may do in the future, especially when interpreted in the light of concomitant circumstances and of his means to find out not only what happened to the users, but also his or her perception of those events, the meaning ascribed to them and the current evaluation put upon them. In this research semi-structured interviews were used to obtain opinions of the target group.

The researcher depended on the interview as a second tool, which represents the second support towards understanding the solid waste situation and its management in the Gaza Strip through interviews arrangements with institutions involved in SWM service delivery as well as decision-making process. The researcher has selected and adopted the interview as a tool beside the questionnaire in order to enhance weaknesses of each through gradual understanding of problem solution of SWM in the Gaza Strip. The selection of interview by the researcher was too important to explain the mysterious, which the researcher can't predict through the questionnaire, which depends on the following:

- Expressing the subject and involve interviewer as if he/she is part of the solution.
- The common sense that the researcher has to understand the nature of interviewee.
- Special strength of the researcher in adopting research objectives.

The interview was very relevant and valid tool especially in the field of environment in order to know the internal feeling for those who are concerned with environmental protection which has some political dimension in the Palestinian society because environment is part of their life and feelings. Environment is the nature, which is part of human feeling. So conducting such interviews are crucial tool to deeply understand their real feelings and as a result understanding the research problem and contributed to the validity of the hypothesis.

Written comments are not at all adapted to the Palestinian culture. Oral tradition is common among Palestinians, they like to talk to present their feelings/participation. That's why interview on waste management and its disposal has become main part towards the understanding of solid waste problem like the situation of the Gaza Strip.

Observation

One of the most direct ways of measuring behavior is by way of interpersonal interaction. Fortunately, there has been considerable research into the measurements of behavior by direct observation (Herbert, 1993). Observations are made prior to the research intervention and they can be repeated at different times during the program. It is wise to make observations according to some predetermined schedule. This is an important precaution against the bias that could arise if the observer merely recorded whenever something obvious or interesting happened.

In order to gather necessary information from the existing situation including the influential aspects affecting disposal technologies for each case and the observations through participation as described in Chapter seven. A number of visits at varying times to the Solid Waste Management Council (SWMC), Palestinian Environmental Friends (PEF), Gaza Municipality (GM) and Shifa Hospital case studies were made.

Observation has been selected by the researcher as a case study methodology, which depends on behavior determination of target groups and their role in SWM in the Gaza Strip. In addition, observation was taken from documents, diary books that include vital information. These tools have been selected according to methodologies which have been chosen as quantitative, qualitative, triangulation and case study methodology, in order to highlight the SW problem and its solution. Waste Management and its disposal is one of the most vital problems that all parties share.

SWM has been recognized as one of the most immediate and serious problems confronting the Palestinian institutions especially those who are concerned with SW service delivery, planning process and policy formulation especially those who in decision-making positions. So, all parties should work together to plan for a SWM strategy, which leads to develop new basis and tools to deal with short and long-term solution for the MSW in the Gaza Strip.

Data Analysis

The analysis and interpretation of research data forms the major part of the research. The definition of what is the "analytical method" is of paramount importance to any analytical strategy. It is stressed that only when the correct analytical strategy is put together with its correspondent interactions, does it enable the generation of "laws" as the term law is usually employed in science. Different types of methods can be found including examining, categorizing, tabulating, or otherwise recombining the evidence to address the initial propositions of a study. The definition of analytical strategy determines the limits of data collection and dissemination of results.

Analysis of Qualitative And Quantitative Data

The data obtained was both qualitative and quantitative in nature. The qualitative data was obtained from the open-ended interviews, semi-structured interviews, observation, in-depth interviews with the target groups. Most of the interviews were made in person since the Gaza Strip is a small area or some notes were made in the field. The quantitative data was obtained from the waste quantities obtained from municipal records, UNRWA and NGO's, whilst the quantities and prices were obtained from the SWMC, UNRWA, local NGO's and private sector. All the quantitative data and the questionnaire were analyzed using Excel. The chapters describing different case studies are rich in both qualitative and quantitative information. The SSM has been applied as an efficient tool for the situation analysis of the disposal strategy of SWM in the Gaza Strip.

5.12Use of Research Methods

SSM and its applications will be used as a methodology and a tool (7- stages) in order to analyze the SWM current situation with special focus on disposal options. This was an innovative part of the research. SSM is triangulated with other methods (quantitative, qualitative and case study methodology) in order to achieve the research objectives as explained in Figure 5-5.

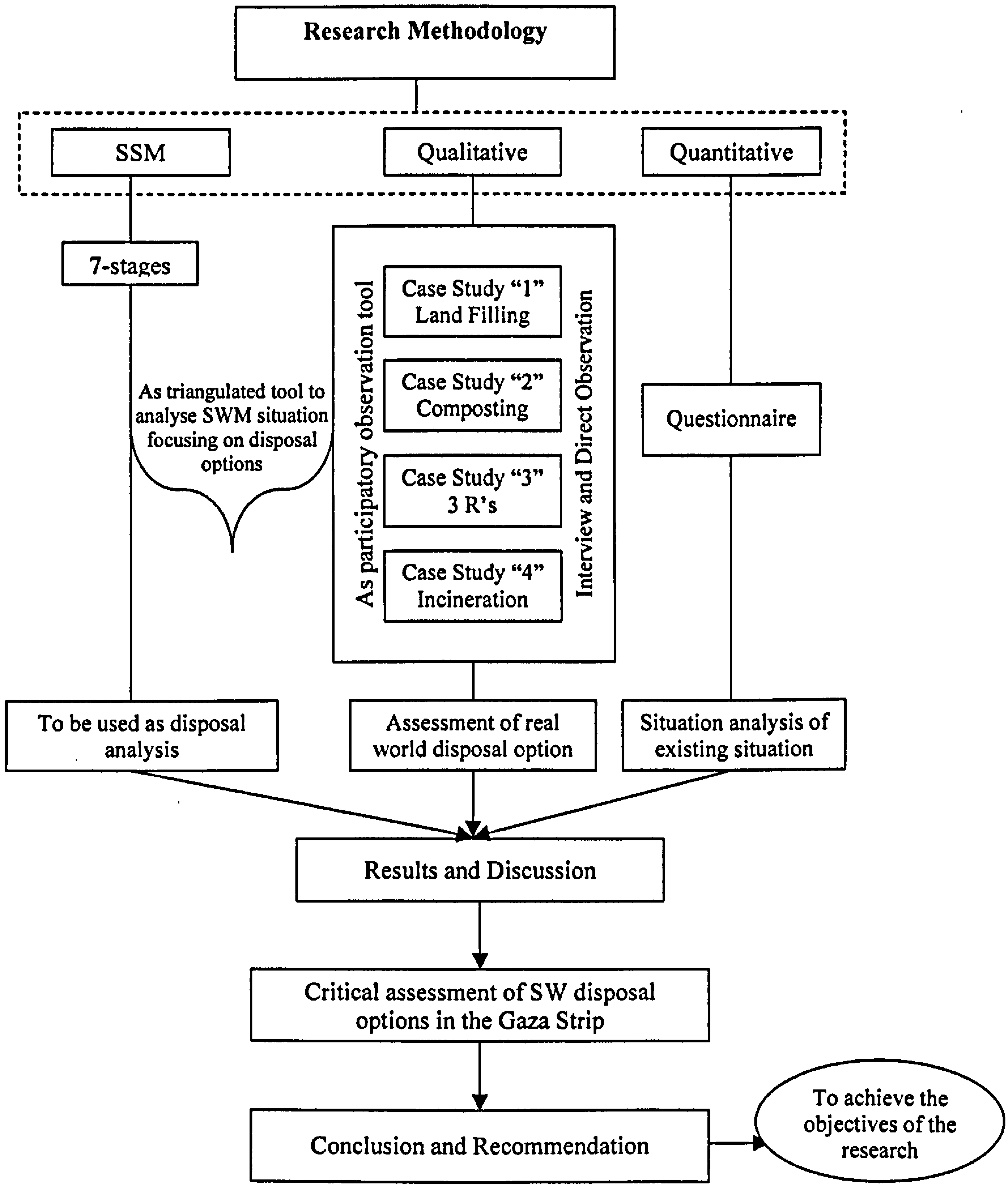


Figure 5-5: Research Methodological Structure

Source: by author

5.13Summary

This chapter has presented the methodologies used during this research development and process, which was overviewed in chapter one. Chapter one represented the research structure, aims and objectives. Following this research flow methodologies are presented, explained and justified in the context of this research. The explanations presented also have the objective to an understanding of how, when and why these different but complementary approaches work together towards a common objective. They contribute to the demonstration of the relationship between the thinking worlds and the real world practice.

Quantitative, qualitative, triangulation and case study methodologies provides the environment for data collection. Questionnaires, interview, direct observation and participatory were responsible for data collection. Data were analysed using Excel. SSM as analysis tool was applied to the research methods as well as on the case studies. Solid waste indicators were developed to help in evaluating and assessing the four disposal options, see appendix II.

SSM provides the framework for developing some actions in order to improve the disposal situation and allowing comparison with the real world. The target group opinion and views will contribute to validate the data collected in the context of the environmentally sound disposal approach. This is a characteristic of every technical and sustainable system. Particular attention was paid to the characteristics and preparation of the four case studies. The methodologies to collect the specific data were designed with a view to their possible application to future research on the disposal strategy of MSW in the Gaza Strip.

CHAPTER 6

PART IV: THE EMPIRICAL PART – DISPOSAL OPTIONS: THE GAZA STRIP CASE

CHAPTER SIX: ANLAYSIS OF DISPOSAL ALTERNATIVES OF SWM IN THE GAZA STRIP USING SSM

PART IV: EMPIRICAL PART

CHAPTER 6: ANLAYSIS OF DISPOSAL ALTERNATIVES OF SWM IN THE GAZA STRIP USING SSM

6.1 Introduction

In the Gaza Strip, acquiring land for disposal of solid waste presents many difficulties due to land availability for landfilling purposes associated with the high population densities, and the Israeli constraints. New problems have arisen, such as the increase in the numbers of high- rise buildings, increases in packaging, new industries, and increased quantities of construction waste and the new Palestinian returnees as a result of the peace process with Israel, more waste is expected to be generated. Integrated sustainable disposal options based on disposal strategy of solid waste is not being developed by the PNA. The research has been conducted since the start of the current Intifada in 2000. During this Intifada, Palestinian municipalities have been experiencing great difficulties reaching dump sites due to their locations in the eastern part of the Gaza Strip as shown in chapter 4 Figure 1.

Coad (1997) argues that, landfilling used to be the only disposal option for MSW in the Gaza Strip. Other alternatives such as incineration, composting and others were never tried except for small scale anaerobic composting with some local NGO's.

One objective of this research is to better illuminate the waste stream and propose Palestinian strategy of MSW for the Gaza Strip. The absence of strategy has lead to inefficient management of raw materials and resources. It has created difficult in the dissemination of information on sustainable disposal option of the MSW including the improve management of natural resources.

This chapter is divided into 2 sections: ***Section one***; is focusing on Gaza profile including demography information, socio-economic, institutional arrangements. ***Section two;*** SSM will be applied as a trial to understand and analyze the SWM problem through the SSM 7-stages.

6.2 Study Area Profile

The Gaza Strip is a small area 365 km^2 according to the (PCBS, 1999) the population is 1.2 million where 65% are refugees living with unhealthy, unhygienic and low level services as explained in chapter 2 earlier. This area used to be managed by the Israeli occupation from 1967 until 1994 when the PNA has took over part of the Gaza Strip and West Bank as a result to Oslo Peace Agreement between Palestine and Israel.

6.3 Demographic information

Gaza Governorates are strongly influenced by political development, which have played a significant role in the growth and population distribution of the Governorates (UNRWA, 1993). These details were explicitly explained in chapter 2. The demographic momentum can be demonstrated and influenced by the following factors:

- The very high birth rate coupled with shortage of resources significantly contributes to the environmental problems. The very constrained space of the Gaza Strip and the rapid population growth has turned this strip into one of the world's most congested areas. This coupled with shortage of resources leads to environmental damage that affects public health and overloads the limited sanitation services (MEnA, 1999).
- Thirty years of lack of attention, deteriorating infrastructure and negligence, which accompanied the Israeli occupation of the Gaza Strip. Over the period 1967-1994, there has been inadequate, investment in the various environmental sectors, particularly water, wastewater sanitation and solid waste. During that period some of the existing infrastructure deteriorated while the population and their needs rapidly increased. This lead to environmental degradation in almost every aspect (MEnA, 1999).
- The presence of the Israeli occupation and shortage of strong central environmental management contributed towards the indifference and lack of awareness of the needs and means of achieving acceptable environmental standards. Municipal services were not only inadequate but are deteriorating as well, with no planning or serious investments. All this lead to a situation that a significant part of the population of the Gaza Strip, particularly inside the refugee

camps, have become accustomed to living with environmental standards that are well below human dignity (MEnA, 1999).

- Over the last many years, the Gaza Strip has become the "dumping ground" for various second hand and obsolete small Israeli factories, appliances expired food and materials. Most of these were inefficient and environmentally unsound. This only contributed towards the deterioration of the environment in the Gaza Strip and resulted in the unacceptable health risks, presence of insects, mosquitoes and flies that spread disease and are a grave nuisance, particularly in the agricultural areas (MEnA, 1999).

6.4 Socio-economic Environment

The socio-economic and cultural background of the Gaza sub-district of Palestine was a distinctive rural society. The primary rural nucleus was the extended family, living together in a close knit collection of houses, the families related by tradition, economic activities and socio-religious links as explained in chapter 2. All such villages of the Gaza sub-district outside the present borders were eradicated after the emergence of Israel in May 1948, which caused the exodus of the Palestinian inhabitants. The distribution of the urban and rural population was changed due to political circumstances. The relative decline of the rural population was mainly due to the movement of the refugees towards different urban areas (PCBS, 1999).

With the urbanization, cost of living became unaffordable to the residents, that 83.2% of the households only are owned, regarding that 32.8% of the population are under the Poverty line, and the average income per family ranges from 55.4 to 97.6 per day. The main activities that contribute to GDP in the Palestinian territories are services, mining and manufacturing 21%, construction19%, agriculture and fishing12%, trade, public administration 9%, transport 9%, financial intermediation 9%, public owned enterprises5%, with percentages 3%, respectively. The literacy rates are high in comparison with other regions in the Arabic world, where about 86.3% of the population are literate, and 13.7 % are illiterate. 85.4% of households have water public network, 37.9% only have sewage public network, so a high percentage of population are living in low health and sanitation environment (PCBS, 1999).Disposal situation includes solid waste quantitative, population, type and location of dump facilities and responsible municipalities are summarized in Table 6-1.

Table 6-1: Disposal Situation in the Gaza Strip

Source: MoPIC, 1998

Governorates	Waste disposal
Northern Governorates Beit Hanoun Beit Lahia Jabalia Total Population 200,000 people	▪ Open random dumpsite locates at the best ground water sources adjacent to the boarder with Israel. ▪ 100 ton of solid waste is being disposed of in this dumpsite. ▪ The three municipalities have got an offer from the GTZ to close this site and go to Gaza sanitary landfill through a proposed SWMC. ▪ Around 25% of municipal expenditure is on solid waste management.
Gaza city & Beach camp Total Population 388,000 people	▪ 200 ton of solid waste is being generated, collected, transported and disposed of in a ▪ Controlled disposal major site established by the EU and 5-6 un-controlled dumpsites. ▪ Palestinian Authority has acquired a 20-dunum site for the extension of Gaza existing landfill. ▪ Northern Governorates will share Gaza municipality landfill.
Middle Area Governorates Deir El Balah Nussierat. Maghazi Bureij Zawaida Total Population 157,000 people	▪ Sanitary landfill of 25 dunums located at the eastern part of Deir El-Balah city funded by GTZ. ▪ 11 municipalities and village councils are sharing this sanitary landfill through SWMC. ▪ The site has been in operation for at least 25 years. ▪ Recently, SWMC has purchased another 25 dunums area of land to extend the life span of the landfill site. ▪ UNRWA is disposing of solid waste generated from refugee camps in this landfill against fees of US$ 5/tonne.
Rafah Governorates Total Population 130,354 people	▪ Uncontrolled landfill of a 20 dunums located at the eastern part of Rafah funded by the EU. ▪ On-going solid waste management Canadian project initiating composting on a small scale.

6.5 Institutional Responsibilities

The absence of Palestinian structure associated with the Israeli occupation has result in no governmental level to take the lead in environmental issues or to formulate legislation and guidelines. The municipalities and village councils had little experience in administering services like SWM. The relatively low performance level of SWM services is strongly related to this lack of experience and lack of strategies or policies. As explained in chapter 2, the Ministry of Local Government (MoLG) has assigned to supervise and operate SWM all over the Gaza Strip including tariff structure while the Ministry of Environmental Affairs (MEnA's) is responsible to develop policy and strategy for environmental issues including SWM. Although clear mandate from the PNA to these ministries is not available.

With the exception of the emerging Solid Wastes Management Council (SWMC) for the Central Area there is no uniform SWM organization, and the administration is structured differently depending on the size of the municipality, Each municipality is too small to be able or to afford to build up an organization with the necessary technical competence. The refuse collection services seem to be carried out on an ad hoc basis, the current organizations have a number of weaknesses which are typical for small municipalities, such as:

1. The Ministry of Local Governments and not the Municipal Council approves all annual investment and recurrent budgets, in addition to regular audits,

2. The SWM functions fall under the Public Health Department, which also is responsible for inspection and control of the cleanliness. It is inherently wrong that one and the same department carries out the control of its own operations. The control functions must be separated from the implementation or operation functions.

3. Accounting is not carried out in such a way that the cost of providing solid waste services can be identified, attributed to these services, and monitored effectively. In other words there is a lack of transparency. Also, a proper management information system is lacking. There is no systematic recording of the performance of equipment and staff in terms of waste collected and disposed and associated costs. Consequently, there is no accountability, and no incentive to operate the system at least cost.

4. The responsibility for vehicle operations and refuse collection is divided into two departments. The mayor alone or together with the accountant decides on

smaller expenditures after consultation with the department heads or those in charge of the Services. Nevertheless, this means that the authority is not delegated to these responsible for managing the service. This invariably leads to poor system control and inefficiency.

5. Finally, the Mayor makes all-important decisions, and this becomes a serious "bottleneck" in the daily operation of municipal services. However, this is the consequence of not delegating authority.

Apart from the refugee camps in the Gaza Strip, where the services are largely provided by UNRWA, the collection and disposal of solid waste is the responsibility of local government – municipalities and village councils. The organizational structures of municipalities show considerable variations among themselves in the numbers of departments and the responsibilities of each. SWM in municipalities is managed by either a health department or an engineering department. In villages the situation is worse in that there is usually no one responsible for SWM; instead a contractor may be hired and made responsible, either by an individual village or by a group of villages, or the head of the village may himself take responsibility for day-to-day operations.

In the middle area of the Gaza Strip (south of Wadi Gaza, excluding Rafah) a Solid Waste Management Council (SWMC) has been formed. It serves eleven communities; the heads of these communities are all members of the Council and participate in decision-making, having voting rights according to the sizes of their communities. The Council has been set up with assistance from GTZ (German Technical Co-operation). The mission of the Council is to provide secondary collection from communal storage points and to dispose of this waste in an acceptable way. The Council has a Director, and also employs two Garage Managers (all with previous experience in solid waste management) and an accountant, and though previously most of the drivers and crew were employees of the municipalities in the area, more and more of them are now employees of the Council. A weighbridge has been installed at the landfill site so that all loads are weighed. In this way reliable data on solid waste generation are now available. Each member community is billed monthly according to the weight of refuse collected from that community, and other sources, such as UNRWA, are also billed according to the weight they bring for disposal. The charges to the communities were initially based only on operating costs, but now, gradually, depreciation of the vehicles is being included in the charges, so that the system becomes sustainable, and not reliant on foreign donor assistance. The work of the Council has included a public awareness campaign to foster community participation. The recycling of decomposed waste is being considered. The SWMC will be fully covered in chapter 7.

Experience in Gaza has shown how important it is for SWM leaders from the different municipalities and projects to meet with each other. (The regular meeting - at intervals of about two months solid waste coordination meetings) in Gaza has been an excellent opportunity for sharing experiences and preventing wasteful duplication. Table 6.1 summarizes the roles and activities of institutions involved in solid waste service delivery.

6.6 Application of SSM to the SWM

Solid Waste Management (SWM) takes into consideration the environmental performance through the entire life cycle of the services and processes. SWM focuses on cooperation between enterprise, local authorities and municipalities in order for by-products/recycling from one actor (a large fraction of which was previously known as waste to serve resources for the others. Environmental management is a sub-system to the general management. Since environmental management is typical "social science for social change", these theories should be developed in a scheme developed complex, ill-defined and multi-purpose systems like enterprise networks. Action research as introduced by Greenwood and Levin (1998), has completed this transformation from decomposition to the diversity of multi-stakeholder systems.

As explained in the research methodology in chapter 5, Checkland found that small or big enterprises, private or public, had one characteristic in common. "They all featured human beings in social roles trying to take purposeful action" (Checkland & Scholes 1990 p: 82). A set of connected activities making a purposeful whole was on this background taken to be a particular kind of holon. The word holon was a response to the need for " a new word for the entities which are wholes at one level of hierarchy while simultaneously being parts of higher level entities" (Checkland &

Scholes 1990 p: 82). The concept Weltanschauung (world outlook) is the (unquestioned) image or model of the world, which makes this particular human activity system (with its particular transformation process) a meaningful one to consider. SSM emphasize the importance of explicitly formulating the Weltanschauung, and possibly changing it if the results are not satisfactory. In practical use it bears resemblance to the four frames; structural, human resources, political and symbolic, deduced from the retrospective view on schools in organizational theory by (Bolman and Deal 1997).

The overall aim of the SSM is to take seriously the subjectivity which is the crucial characteristic of human affairs and to treat this subjectivity, if not exactly scientifically at least in away characterized by intellectual rigor.

1. In the first stage the analyst is learning and understanding the problem situation. The reason for the initiation of the analysis is usually a *general feeling of uneasiness* from the person/body who asked for the analysis (the *problem owner*). The term *problem situation* is used to describe the specific problem and its environment, as the analyst should approach the investigation with an "open mind" and should not limit himself to a limited context. In this stage the analyst reads background material, performs interviews and other activities that are needed in the learning process.

2. The next stage is to express the problem situation. The output of this stage is the *rich picture*. A rich picture is a schematic tool that helps the analyst in describing the problem situation. They are also a communication tool, which the problem owner and other stakeholders when discussing the problem situation can use. The discussion aim is to ensure that the analyst understand the problem.

3. In stages 3 and 4 the analyst detracts himself from the system and analyze it. The first output is the creation of *root definitions*. Root definitions describe what the system is and what it aims to achieve - as each stakeholder sees it. By subscribing the root definition, the different views about the problem and the expected solution are expressed clearly

4. The root definitions form the base for the *conceptual models* - a model that describes how the activity that the root definition describes can be achieved practically - input, output, transformation (the processes that transform input to output), control element and relations between these elements.

5. In stage 5, the conceptual model is compared with the rich picture and discussed with the problem owner. Again, the problem owner should participate and approve the conceptual models that the analyst created.

6. Stages 6 and 7 focus on the implementation of the necessary changes. In stage 6 the analyst and the problem owner deliberate and discuss what changes are feasible and practical. Some changes might be impractical due to political, structural, financial, ethical or other reasons.

7. After clearing out the necessary (and feasible) changes, these changes can be implemented and added to the system.

Stages 1, 2, 5, 6 and 7 are "real world" activities necessarily involving people in the problem situation; stages 3, 4, 4a (sub-systems to 4) are "systems thinking" activities which may or may not involve those in the problem situation, depending upon the individual circumstances of the study (Checkland 1981 p:163).

"The function of stages 1 and 2 is to display the situation so that a range of possible and, hopefully relevant choices can be revealed". A particular system being part of a hierarchy of systems must be chosen and described using "structure", "process" and "the relation between structure and process". Attempts should be made to build up the richest possible picture, not of the "problem" but of the "situation" in which there is perceived to be a problem. Applying this to the MSW case, the structure represents the following aspects:

- Institutional
- Legal, regulatory, policy and political

While process representing theses aspects:

- Technical

- Environmental
- Socio economic and,
- Financial

Stage 3, the root definition, is intended to encapsulate the environmental nature of the systems chosen and naming by the Palestinian National Authority (PNA) that from the analysis phase seem relevant to the disposal of MSW problem. Root definitions have status of hypothesis concerning possible improvement to the MSW system. It is important to view root definitions as "relevant system" which can lead to illumination of the associated problems and hence their solution or alleviation.

6.7 Analysis of Disposal Situation of SWM Using SSM 7-Stages

In this research, SWM problem situation was addressed in order to understand the richness of the problem. Root definitions, CATWOE elements and rich pictures for SWM existing situation in the Gaza Strip were analyzed. Conceptual models were compared with SWM problem in the real world represented by rich pictures and recommends feasible and desirable actions in order to improve the disposal situation. The SWM situation in the Gaza Strip is critically analyzed using the SSM 7-staeges as the following:

6.8 Stage 1: Problem Situation Unstructured

The Gaza Strip suffers from a lack of convenient sites for sanitary landfills, and so any means of reducing waste quantities is to be welcomed (El-Hawi, 1997). The most common disposal practice in the Gaza Strip is dumping at landfill sites located around the city, which are generally uncontrolled dumps. Dumping is also carried out illegally on private farmlands located in the city vicinity. One reason for this is the lack of landfill space in the cities. Often, sitting plans for potential landfills are strongly opposed by surrounding residents that causes complications; the case of the Solid Waste Management Council (SWMC) and the case of Gaza Municipality is a good example of this. Both have faced great problems securing land for extending the existing sites. Various forms of resource recovery activities on a small scale are practiced in the Gaza Strip, such as composting and recycling with NGO's like the case with PEF. The recycling sector in the Gaza Strip will probably grow slowly because there is no established pattern to follow. Currently, a very small fraction of solid wastes is recycled, mainly steel scrap and a small amount of organic. The total MSW recycling is 9.0m tonne/year out of 215,000 tonne/year (a recycling rate 4.21 percent). Metals 5830 tonne, organic 1419 tonne, paper and card 1080 tonne, plastics 432 tonne, glass 200 tonne and cloth 107 as shown in Figure 6-1 (field work by the researcher).

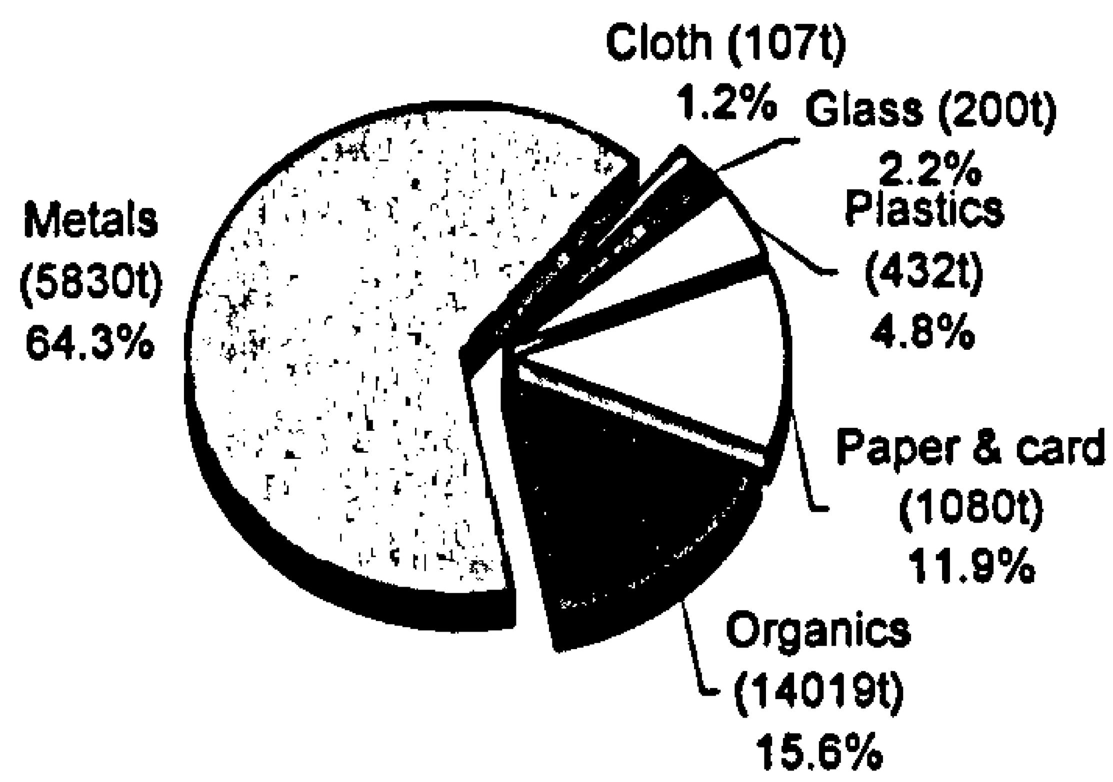


Figure 6-1: Estimated MSW Recycling Rates in the Gaza Strip (Total 9,068 t)
Developed by the Researcher

Some of the small micro-enterprises working in the Gaza Strip as middlemen collecting scrap to be sold to Israel against $ 30/ton. Paper and cartoon are being collected and reprocessed locally as egg pots and boxes (Personnel interview).

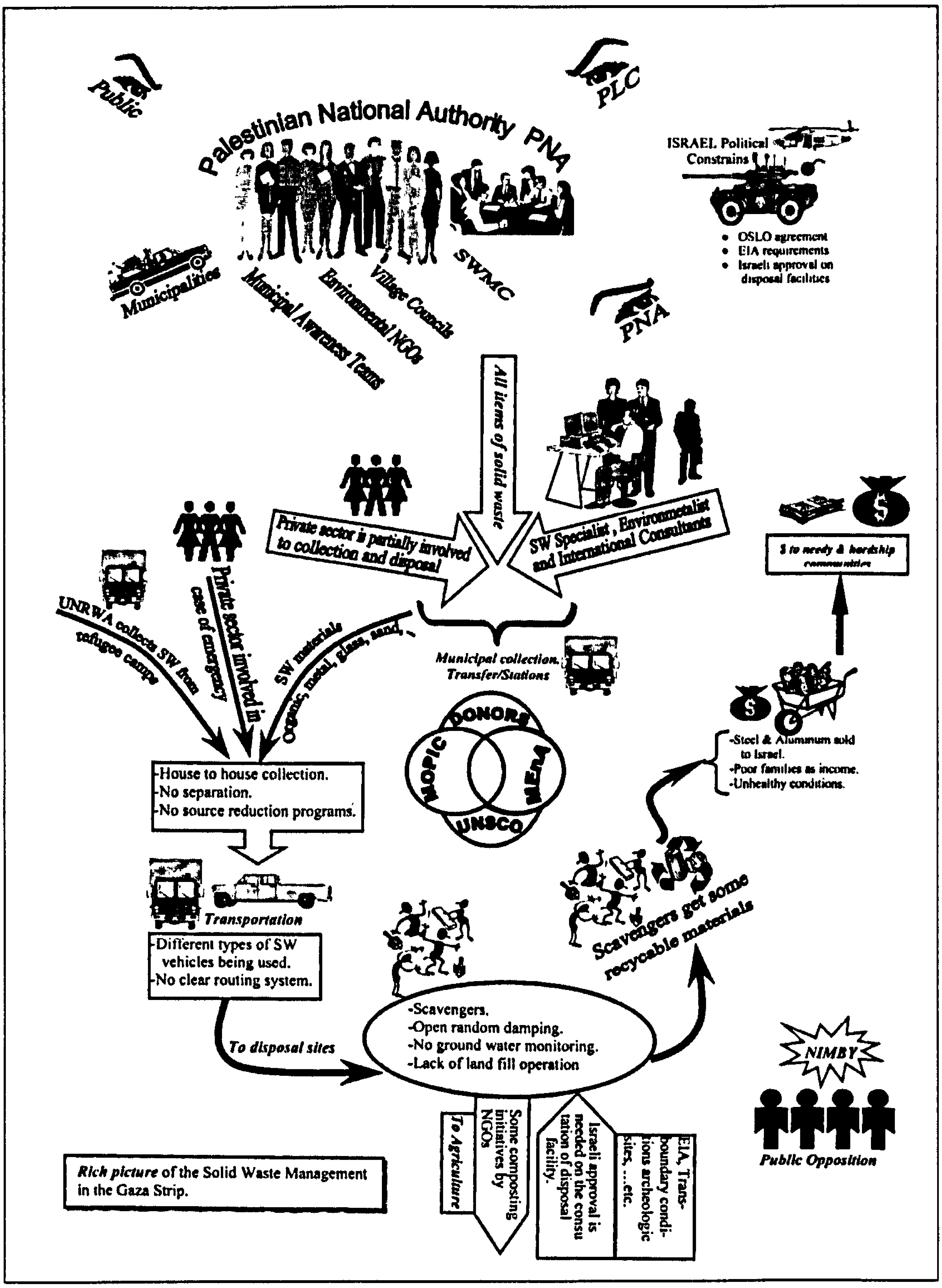
It was estimated in 1992 that, the agricultural sector was generating over 2400 tons of plastic waste each year, most of which was burned in the open Although contaminated with soil, and perhaps with pesticides, this source of plastic waste may be of some interest to the recycling industries (Coad, 1997).

6.9 Stage 2: Problem Situation Expressed

In stage 2, the first tool that characterizes SSM is introduced: the ***rich picture***. The rich picture is a diagrammatic representation of the SWM problem situation. It represents what the human system is "about", and can be considered as a mental map

(Avison and Fitzgerald, 1995) (Figure 6.3) depicts relationship between village councils, municipalities, SWMC, UNRWA and NGO's is limited to collection, transportation and landfilling. Disposal alternatives regarding 3R's, composting and incineration is not available as explained in the rich picture. This rich picture presents the human activity system including institutions concerned with the SWM service delivery.

The RP depicts the main stockholders that are involved or take part in the SWM process and the relation between them. The PNA represented by municipalities, village councils and SWMC is responsible for SWM decision-making including SWM policy and strategy formulation as depicted in Figure 6-2.



Rich picture of the Solid Waste Management in the Gaza Strip.

Figure 6-2: Rich picture of the SWM in the Gaza Strip

Developed by the researcher

All wastes are being collected, transported and dumped together. No source separation is practiced. The SWMC in the middle area is well structured; the board was elected from 13 municipal mayors. The council has set adequate plans to improve the waste management system through necessary equipments unified compacted trucks, weighing bridge, daily cover and daily computerized achieving statistics on quantities of waste being dumped to the site. In addition, the council has developed and adopted incentives schemes of monitoring value to motivate the staff like the case with the overtime policy and problem strategy.

UNRWA and NGO's were providing SW services in partnership with the SWMC. The council has jurisdiction and authority to plan, finance and operate waste management system. In certain occasion, SWMC contacts private sector to do collection, transportation and landfill operation.

Village councils are providing SWM services to villages and remote areas and share municipalities and SWMC with the disposal facilities. Solid waste community initiatives are being submitted to donors for funding through the Ministry of Local Government (MoLG) and municipalities. (as discussed in Chapter 7, case study 2) Cooperation between PEF and Rafah municipality in green waste composting including environmental awareness and cleaning campaigns is a good example.

A possible conflict between Palestinian institutions suppose to develop SW plans, polices and strategies like the case with MoPIC and the MoLG.

The status of the environmental NGO's in the Palestinian planning system is "interesting", as they do not have a role in the legislation, but do have a minor role in SW community initiatives (see Chapter 6 case study 2).

PEF doesn't have any role in the SWM process and transparent of rewards and penalties are not available.

Waste management strategic plans highlighting "composting as an environmentally sound disposal option was addressed.

As the main planning body, MoPIC, MEnA and MoLG is drawn "not to scale" in terms of overall importance in the SW planning process, but according to their mandates which is not clear so far.

The Israeli constraints are prohibiting municipalities, SWMC and UNRWA from reaching the official disposal facilities, which resulted in accumulated SW in random dumpsites close to residential areas like the situation with Gaza municipality.

6.10Stage 3: Constructing Root Definitions

The definition is intended to encapsulate the fundamental nature of the systems chosen by naming national systems that from the analyst seem relevant to the problem. In stage 3 we cross the line to the systems thinking world. The main output of this stage is the ***root definitions (RD)***. As stated above, root definitions describe the system that will be modeled stage 4. Each root definition uses a certain perspective of the system. The RD should include the next elements (usually referred in the mnemonic **CATWOE**).

The structure of CATWOE implies that the simplest version of the root definition would be "a system to do X" where X is a particular transformation process (T).

The core of the CATWOE is the pairing of transformation process (T) and the worldview, or Weltanschauung, (W) which makes it meaningful. The importance of stating ownership and aspirations in SSM models are illustrated in the term Weltanschauung.

Noteworthy is the difference between **primary task** RD and **issue based** RD. Primary task RD are detached and less contentious ("objective") while issue based RD represents specific viewpoints ("subjective").
For the case of MSW disposal option, it will be focused on subscribing primary task root definition "what it aims to achieve" and issue based root definitions for the next stockholders:

- Infrastructure and environmental department in the Ministry of Planning and International Cooperation MoPIC.
- Solid waste department in the Ministry of Environmental Affairs MEnA.
- Central Planning Committee in the Ministry of Local Government MoLG.
- Municipalities, SWMC, UNRWA, NGO's.

The selection of stakeholders is according to their role in the SWM system. The first tow has an active role in SWM planning, policy and strategic formulation and the third is responsible for approving guidelines and coordinate it with concerned institutions. The fourth is responsible for SW service delivery, respond to the public constraints and implement SW plans initiated by the first two bodies.

Primary Task RD

The disposal strategy of MSW is a national and environmental sanitation document, therefore the requirements for planning and processing which can serve the base for the primary task RD Translation of this strategy plan into detailed measures and policies and actions will also require a contacted effort from other authorities, ministries and municipalities.

It will remain the overall task of MEnA to monitor and evaluate the effectiveness these measures and policies from the viewpoint of environmental protection.

To support this approach, the strategy plan has to be arranged in an integrated way around four different disposal alternatives. These are:

- Landfilling
- Composting
- 3R's
- Incineration

However, the first step to formulate the RD is to identify the CATOWE elements:

C: People living in the Gaza Strip.

A: Municipalities, consultants, village councils, SWMC, village Councils.

T: Disposal alternatives of MSW plans and transportation process as initiated by MoPIC, MEnA and MoLG.

W: To assess the disposal alternatives and subscribe means to reduce adverse impacts.

O: PNA and PLC.

E: Palestinian central committee, president cabinet office.

According to this element, the RD is:

(RD1): Solid Waste Management in the Gaza Strip can be defined as:

A Palestinian Local Authority (municipalities, village councils and private sector) owned and manned system to collect, transport, recycle and environmentally sound disposal of solid waste in keeping with the overall concerns parties like municipalities, village councils, Ministry of Environmental Affairs MEnA, Ministry of Health MoH, scheme of the Gaza Strip in order to improve the public health, environmental situation and enhance public participation to SWM sector as depicted in Figure 6-3.

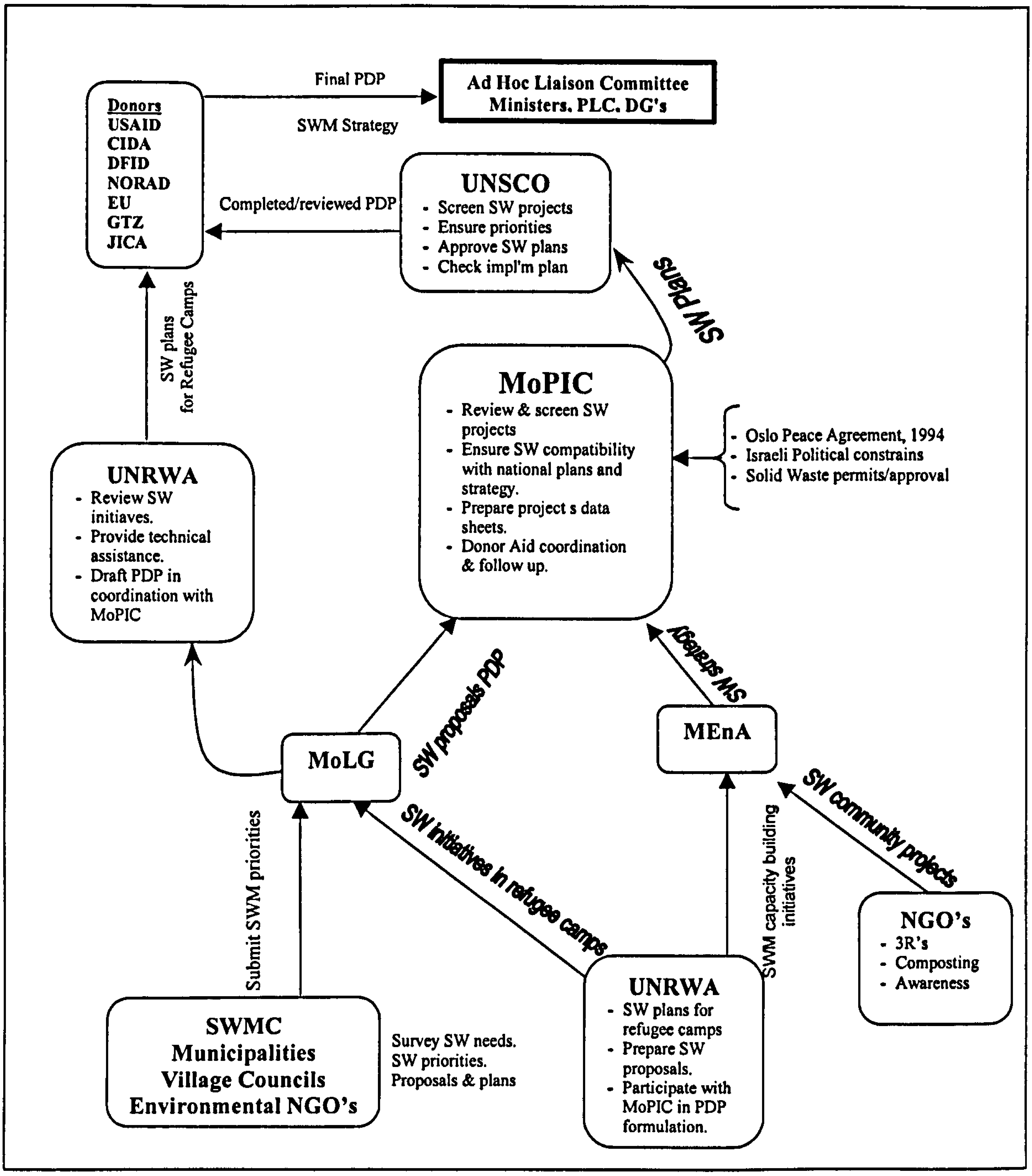


Figure 6-3: Top Influence Level of Solid Waste Management in the Gaza Strip.

Source: El Hawi and Hamilton, 2001

(RD2)

A Local Authority, health environmental engineering and planning system was developed for efficient solid waste management practitioners so that other actors like municipalities, village councils, private sector, public, NGO's, and solid waste consultants could be assisted in the process of selecting the best service delivery proposing a composting plant on a pilot scheme.

(RD3)

An environmentally sound and sustainable service delivery owned by the Ministry of Local Government, operated by municipalities, village councils and SWMC's, that receives solid waste plans and initiatives for efficient and effective solid waste management in the context of the Palestinian National Authority PNA constrained by the orders of the Palestinian Legislative Council PLC.

6.11Stage 4: Conceptual Models

Landfilling is the only disposal option for MSW being considered by the PNA in the Gaza Strip. Other alternatives such as composting, 3R's and incineration to be considered as an integrated sustainable disposal option were not on the agenda for the near future on a national level. In this stage, the minimum activities required for improving the disposal situation will be highlighted and addressed.

After subscribing root definitions, stage 4 focuses on modeling the activities within the system. Figure 2 in Chapter 5 shows, the conceptual model happens in the "system thinking" world, and is an analytical part of understanding the problem situation. Even in this stage, no solution is prescribed (that will happen later - in stage 6).

The root definitions can be described as "the root from which the model grew" (Patching, 1990) and as such form the base for the creation of the model (and the connection between stage 3 and 4). The ***conceptual models*** show the minimum necessary activities that must exist for the described transformations. Therefore, the model is built from the activities (based on the verbs in the RD) and the relations between them. Each activity will be analyzed in what is known as **decomposing.**

It is noteworthy that the models depict the activities without explaining how the activities are accomplished, as the models should focus on the what.

During the creation of the model should be compared with the **formal systems model** (stage 4a). Stated simply, this is an evaluation of the question "is this a model of a system?" (Haklay, 1999).

Primary Task Conceptual Model

The first Conceptual Model (CM) follows the MSW disposal situation exactly. It is noteworthy that this situation does not give any lower level description of the processes. Hence, only this level will be explored. In this case, this model will be compared with formal systems model implicitly:

- The ongoing purpose of this system is to produce a disposal strategy of MSW
- This activity is expected to continue as long as SW disposal policy and strategy formulation including implementation of these activities.
- Measures of performance could be between MEnA and MoLG through developing SW indicators and selection criteria of disposal options.
- The disposal options are controlled by rating matrix and scoring system through SWM Experts Office (SWMEO).
- MoLG, MEnA, MoPIC are systems represent SW planning policy and strategic formulation including SWM decision-making process as depicted in Figure 6-4.
- The CM presents the interaction between the system component that RD described for the four disposal alternatives.
- The SWMC, municipalities, village councils, NGO's and UNRWA will be dedicated to the operation of the system. In addition to the financial contribution from donors can be regarded as a source.
- SWM system is part of the Palestinian regional plan developed by MoPIC.
- The boundary of control includes MEnA, MoPIC, MoLG and SWM Experts Office as depicted in the rich picture (Figure 6-4), which represent the loop cycle.

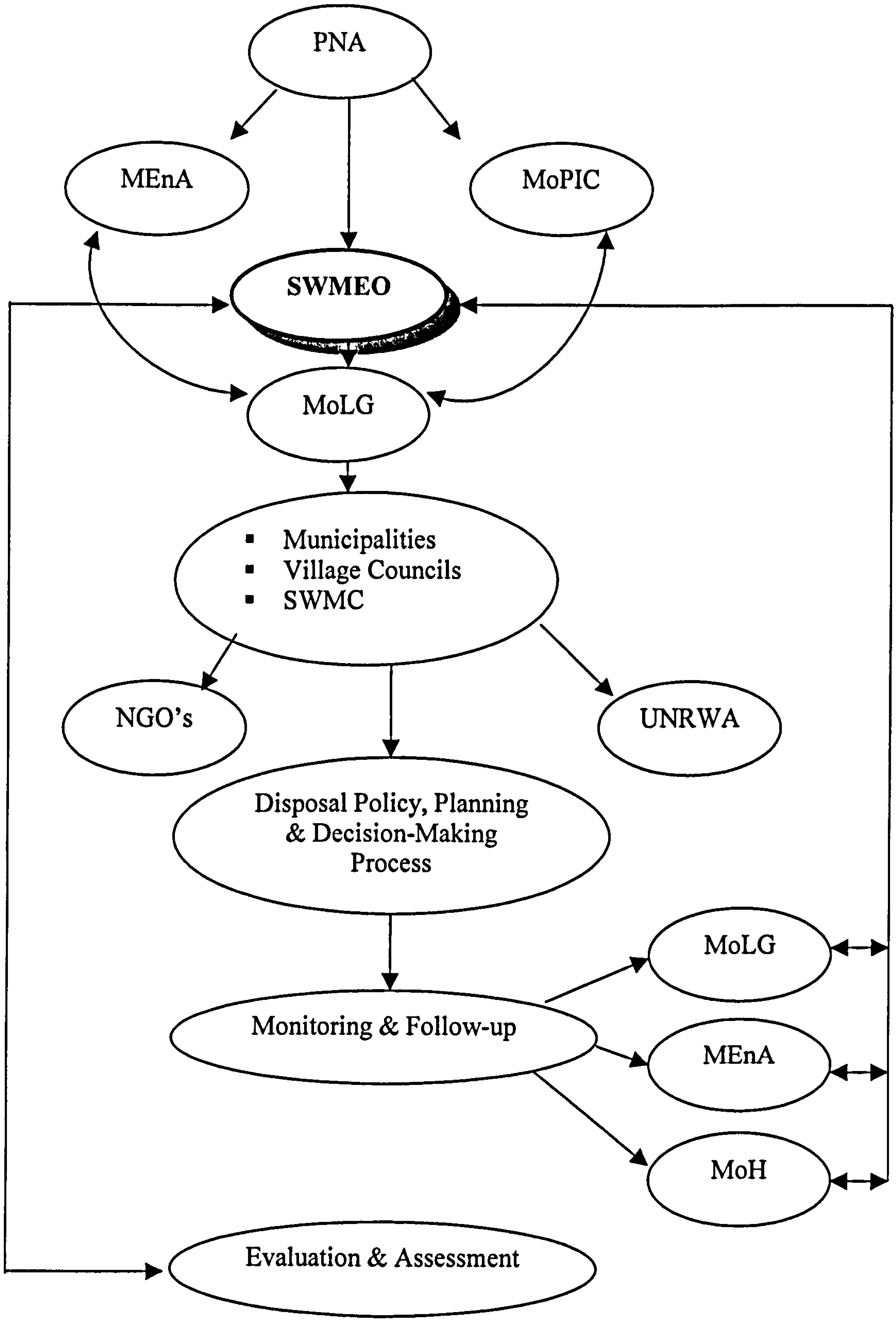


Figure 6-4: Conceptual Model of SWM System

Source: Developed by the Researcher

6.12Stage 5: Comparing The Conceptual Models To The Rich Picture And Reality

After completing the "system thinking" tasks of SSM, "floating back" to the real world and compare the conceptual model(s) and the root definition(s) with the real world situation. Figure 6-5 depicts the SSM – 7 stages and its application to highlight disposal alternatives of MSW.

The comparison is aimed to validate the model and give answer to the question "does the activities that the model/RD depict really exist?". It can be viewed as cross checking the model to ensure that no activity that takes place in reality was missed and is not represented in the model, or that the model depicts an activity that simply doesn't exist. As noted before, this stage is still part of the Problem situation learning.

(Haklay, 1999) argues that, the models and the RD should be discussed deliberately with the problem owner who usually commissions the whole analysis exercise. In case of deficiencies and disagreement about the output from the system thinking stages, the cycle should repeat stage 3 and 4, alter them and return to the problem owner again, until a consensus is reached (or until the situation becomes properly understandable.

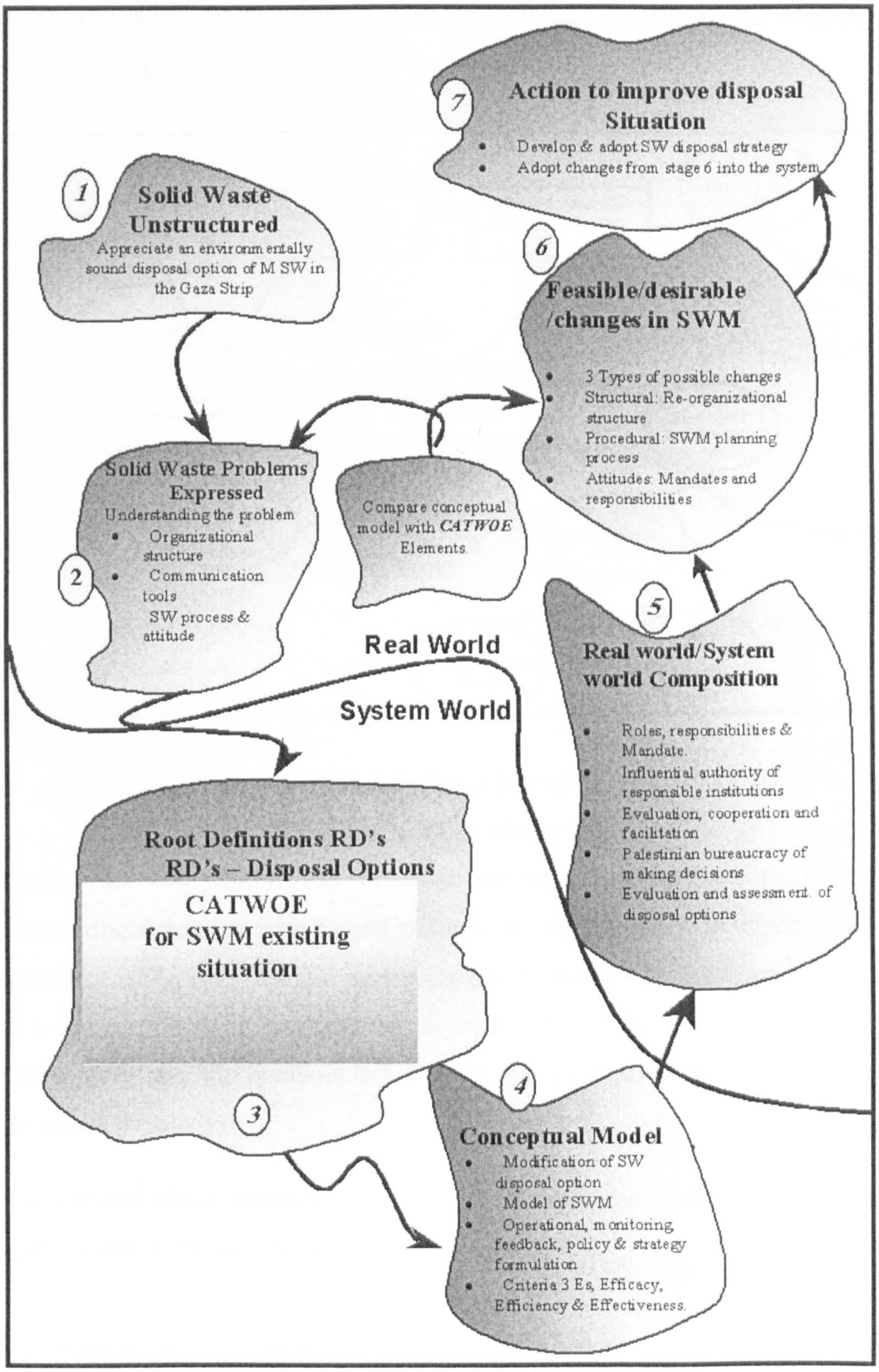


Figure 6-5: Application of SSM 7-stages of the SWM Disposal Options in the Gaza Strip

Source: after Checkland, 1999

Comparing the CMs to the Rich Picture and other information that the analyst has gathered about the problem situation makes the comparison. Figure 6-6 is taken from Patching (1990) and represents stage 5:

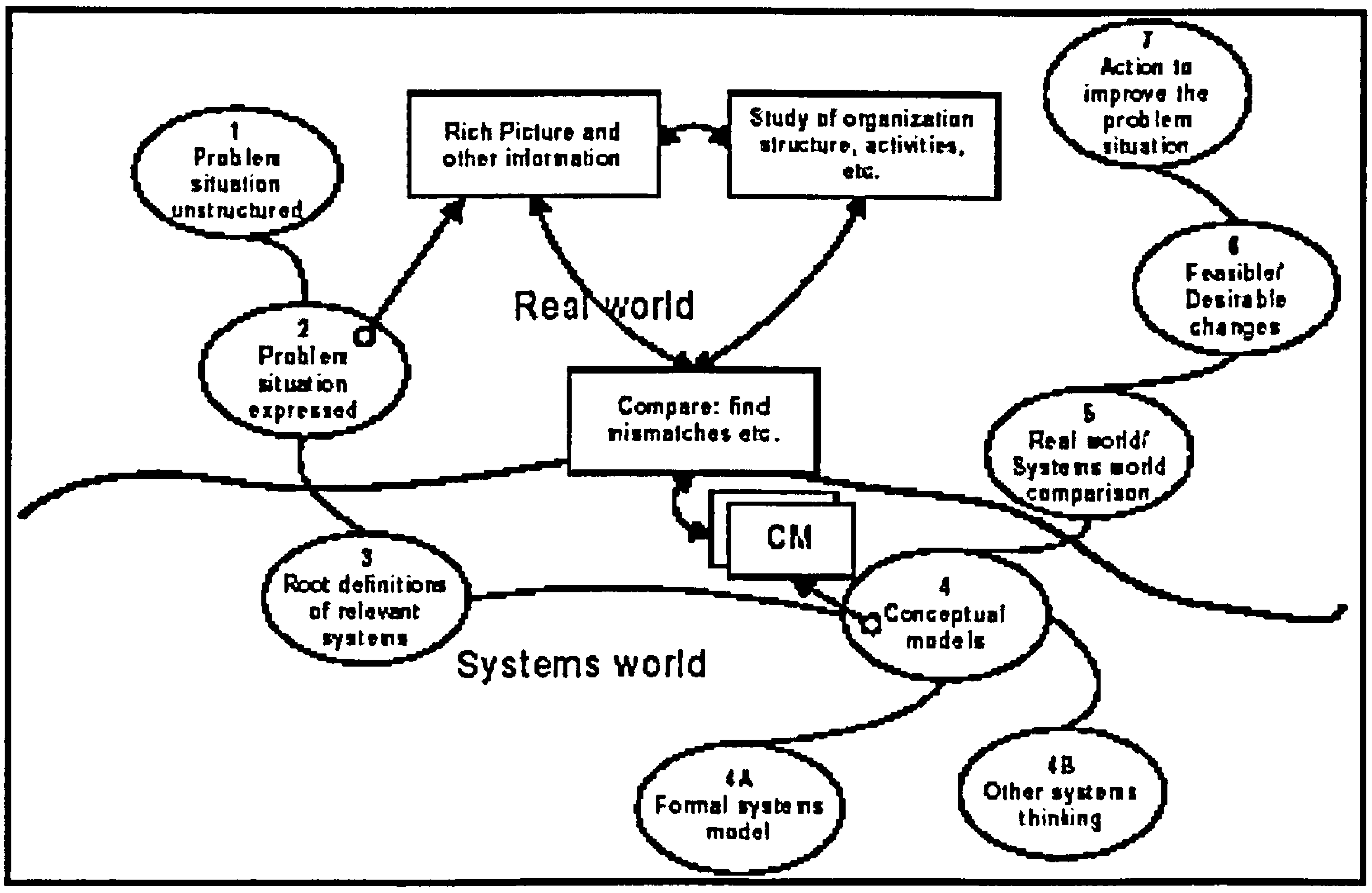


Figure 6-6: Stage 5 of SSM

Source: After Patching, 1990

Practically, the comparison can be done through structured or semi-structured interviews, discussions or with the aid of tools like model-overly in which a model of the current situation is drawn and then compared with the CM. (Haklay, 1999) argues that, it is not surprising to learn that the conceptual model seems to compare well with the rich picture and the documentation about the process, as this information was known before the analysis.

There are several observations that rise from the comparison of the conceptual models to reality and between the CMs themselves.

6.12.1 Different of System Organization/Structure

One of the most striking observations that rise from the CM is the different of roles and responsibilities of institutions involved in the MSW decision-making including disposal policy and strategy formulation.

To some extent, this deficiency was deliberately introduced to the system. The rational behind the system is that no clear mandates of institutions responsible for SWM system. As observed from stage 2, although MEnA has developed environmental bylaws, it lacks influential authority applied to SW in terms of bylaws, regulation and enforcement mechanism.

Gaps were found between MEnA and MoPIC in SW coordination and facilitation as depicted in the rich picture Figure 6-2. The CM suggests that, MoPIC, MEnA should cooperate and work closely to achieve smooth SWM decision-making process. In this regard, the MoLG should be involved in the planning process

6.12.2 Connections and Communication Channels

In the rich picture (Figure 6-2), connection and communication channels for institutions responsible for SW decision-making are not expressed explicitly. However, SW cycle including Israeli constraints has been clearly explained.

Relation between institutions responsible for SWM planning process and decision-making are more informal then formal, even though the SW regulation and policy is not clearly defined. CM (Figure 6-4) suggests an efficient link and coordination between MEnA, MoPIC and MoLG regarding disposal strategy of MSW.

Finally, a comprehensive evaluation and assessment of SWM situation doesn't exist. However, CM recommends creation of SWM experts to be formed from SW specialists from MEnA, MoPIC, MoLG and private consultants in order to achieve tow goals:

- Analysis and assessment of SW planning process including priority projects
- Re-organizational structure and responsibility matrix of institutions responsible for SWM decision-making
- Provide technical assistant to any institutions or key ministries involved in SW services

6.12.3 Time Constraints

As the rich picture portrays, the issue of lack of clear mandates of institutions responsible for SWM planning process and strategy formulation. In addition to the bureaucracy of making decisions and lack of Palestinian experience in dealing with such subjects.

Frequent Israeli siege, curfew and closure on the Gaza Strip and West Bank, Palestinian municipalities and UNRWA have become unable to reach disposal facilities which resulted in environmental adverse and public health problems especially dumpsites located close to residential areas like the situation with Gaza Municipality and the SWMC.

The PNA doesn't have the financial resources to cover SW operation cost due to the bad economic and political situation prevailing in the area during the Intifada.

6.13Stage 6: Feasible / Desirable / Needed Changes

As Haklay, (1999) argues, the sixth stage of SSM is the first stage where a problem is clearly expressed and the effort turns to finding a proper solution. By this stage, the analyst is expected to have a very good knowledge about the system, "what makes it ticks", what are the main issues in it and what are the particular opinions about it - both in the structural level (according to the role/position of the actors) and the personal level.

In this stage, the main problems found in the SWM system should be described and try to prescribe solutions. The solutions should be discussed with the problem owner (municipalities, village councils, UNRWA) to find which are feasible and/or desirable.

According to Checkland, (1999) there are three types of possible changes. The types are:

1. ***Structural*** - changes to the static or factors that don't tend to change in the short term.

2. ***Procedural*** - changes to the activities that relate to achieving the goals of the organization and communication activities.

3. ***Attitudes*** - changes in influence and expectations of individuals.

It is expected to use the proper methods and techniques in accordance to the problems that has been found. For example, if the preferred solution is by introducing a new SWM system taking into account composting of organic and green waste, 3R's as waste minimization strategy supported by SWM Experts Office (SWMEO).

In this stage SSM gives researchers complete freedom in the selection and implementation of the problem solving method.

Since the PNA has taken over the Gaza Strip and West Bank in 1994, donors have put considerable funding into the Palestinian Planning System including SWM. Some ideas on how to improve and change the SWM system have been provided by key ministries, UNRWA and international consultants. The next list represents the main suggestions regarding SWM policy and strategy:

A comprehensive national SWM disposal strategy taking into account close coordination, cooperation and facilitation to fulfill the following:

- MEnA and MoPIC should work closely and cooperatively in SWM planning process

- Donors should consider SW plans developed by MEnA and MoPIC

- MEnA and MoPIC should be responsible for SWM decision-making process

- MEnA and MoPIC will be responsible for monitoring, control and follow up on SWM issues.

- MoLG should create two-way communication channel to improve the disposal process of MSW.

- Proposed SWM Experts Office (SWMEO) will be responsible for prioritizing SW projects, evaluation of organizational structure of Palestinian institutions involved in SWM decision-making.

- Municipalities, SWMC and village councils under the umbrella of the MoLG are the responsible / Implementable body for SW process including responding to public claims.

- Efficient communication with NGO's and UNRWA to achieve integrated disposal options of MSW.

- There is a need to improve public participation throughout the waste management process. This is relatively new to the Palestinian culture and planning process, where public participation happens only at the end of the process.

By comparing these recommendations to the main observations from the SSM analysis, it is possible to suggest some changes to the MSW disposal system.

The most apparent change is structural change. There is a mismatch between key ministries involved in MSW disposal policy and strategy formulation. In certain cases, MEnA contacts donors to fund some SW projects away from MoPIC. Another example, MoLG coordinates with MoPIC in SWM issues away from MEnA.

Furthermore, in the PNA government decision on the creation of SWM Experts Office (SWMEO) where it help in analyzing, evaluating and recommending issues in SWM planning process.

Therefore, the role of MEnA should be recognized in the regulations. This could be done by recognizing the Palestinian Legislative Council (PLC) as the main authority in SWM planning in the Palestinian system; such change can be initiated by MEnA but must go through the legislative process through the government and the PLC.

Several procedural changes can be advised; firstly, adopting the recommendations on the disposal options and alternatives in the creation of a sustainable integrated SWM system. By making the process formal and obligatory.

The stakeholders will have to respond positively and cooperatively to the new SWM procedures and will have to consider their response to the planning process carefully. Secondly, the communication channel between MEnA and MoPIC jointly with SWM Experts Office (SWMEO) should receive formal recognition. It is possible to trust professional judgment of the SWMEO and to believe that they would not be easily influenced by MEnA and MoLG during the SWM planning process. Finally, it is recommended to use computerized system to improve the decision support system (DSS) in SWM applications to help evaluate the local properties of the plan and to exploit the facilities that are already installed in MEnA.

The attitude changes are the most contentious. The main changes of roles and responsibilities of key ministries involved in MSW policy and strategy formulation including decision-making were focused on mandates and job description. This is a major change in positioning of the different bodies and probably will be the main source of obstacle for a change.

After applying SSM to the SWM at the regional level of the Gaza Strip in general, it became possible to apply SSM to the four case studies following the guiding sets. Understanding and analyzing of disposal options for the four case studies have helped in developing CATOWE elements, rood definitions and rich pictures. These elements have helped in expressing the vertical analysis of the disposal situation highlighting the institutional arrangements represented by organizational structures, mandates and responsibilities of concerned parties including coordination and facilitation between them as illustrated in chapter seven for each case study.

6.14Stage 7: Changing the System

The final stage of SSM is the implementation of the needed and agreed changes.

As the case study is hypothetical and based on secondary sources for analysis, it will be quite daring to offer any implementation of the above-mentioned ideas. The conclusions and recommendations should be considered as tentative and relevant. This in fact defines “a new problem” that may now be tackled with the help of the methodology (Haklay, 1999).

Furthermore, proper analyses should not stop with this stage, the whole SWM system should be evaluated to produce coherent conclusions that are structurally viable, procedurally applicable economically feasible, politically acceptable and attitude prescriptive.

6.15Conclusion

1. SSM focuses more on learning the SWM problem situation, understanding the richness of the human activity system in reality and conceptualizing the specific SW disposal problem in a global (or holistic) context.
2. SSM was presented as guidelines that support the process of organizational change.
3. Links and relations created through SSM between structure and process resulted from stage 2 focusing on the SWM problem situation expressed.
4. In SSM, the SW disposal problem solution stages (6 and 7) are open-ended where the problem solving methodology can be adopted.
5. Root definitions describe what the SWM system is and what it aims to achieve as each Palestinian stakeholder sees it. By subscribing the RD is focusing different views about the SWM problem and the expected solution for the MSW disposal option.
6. Conceptual model is the output of the activities presented in the RD.
7. SSM and its application in analyzing SWM in the Gaza Strip is not well known. However, SSM has proved useful tool in pursuit of sustainable management practices and well tested since "environmental management is social science for social change". SSM gives recommendations that support the process of organizational change, from the initial modeling to taking action (El-Hawi and Hamilton, 2001).
8. Root definition, CATWOE elements, rich picture and conceptual models for solid waste still unclear to stakeholders. So, introducing Palestinian institutions to the SSM technique and applications should be investigated (further research).
9. Finally, SSM seems to be a suitable approach for structuring, expressing and modeling the available information and as a result solving the problem of SDWM in the Gaza Strip (El-Hawi and Hamilton, 2001).

CHAPTER 7

CHAPTER SEVEN: THE PALESTINIAN EXPERIENCE OF MSW DISPOSAL OPTIONS THROUGH CASE STUDIES

CHAPTER 7: THE PALESTINIAN EXPERIENCE OF MSW DISPOSAL OPTIONS THROUGH CASE STUDIES

7.1 Introduction

Disposal of MSW is difficult process entailing threats to the environment and health. There is particular concern in the Gaza Strip about the area of land required for landfill disposal of waste, and whether sanitary landfilling is a sustainable option for Gaza as described in chapter 2. The increase of public concern on the environmental and health impact and the appearance of landfills have long been debated. This chapter concerns the Palestinian experience in the way of disposing their MSW and the recent trends in securing disposal facilities through an overall SWM national strategy. It will also focus on the characteristics, data collection and type of MSW being generated in the Gaza Strip area multiple case studies. In this chapter, special focus on SWM and associated disposal alternatives including: institutional arrangements, technical, political and legal aspects. It gives a general description discusses criteria for the selection and other significant issues concerning case studies. The collection, transportation and final disposal of MSW and the data in the Gaza case studies are also discussed. These are subsequently applied to the four case studies of this chapter. This chapter is divided into two sections, ***Section one***; is focusing on the following case studies:

Case Study 1

Is focused on sanitary landfilling, which has been adopted by the Solid Waste Management Council (SWMC) as an environmentally sound disposal option, the structure of the council, operation and functioning of the staff including institutional arrangements were tackled. Root definition, CATOWE elements and rich picture will be developed for this case.

Case Study 2

Is focused on composting of organic waste as an environmentally sound disposal alternative parallel to landfilling as long-term disposal strategy, which has been adopted by the Palestinian Environmental Friends (PEF), local environmental NGO working in Rafah city, south of the Gaza Strip close to the boarder with Egypt. CATOWE elements and rich picture will be developed for this case.

Case Study 3

Is focused on reduce, reuse and recycle (3R's) of MSW, which has been initiated by Gaza Municipality as a necessary step towards waste minimization and public participation, this project is funded by the European Union (EU). CATOWE elements and rich picture will be developed for this case.

Case Study 4

Is focused on the incineration of the health care waste case study taking the incineration donated by Spain Government to Shifa hospital in Gaza city as to get red of the healthcare waste being generated from the hospital. CATOWE elements and rich picture will be developed for this case.

Section two; is focusing on selection and developing SW indicators. Approaches to indicators classifications and use, developing and applying SWM indicators, criteria for selecting indicators and finally rating matrix and indicators to measure effectiveness of disposal options will be tackled. Applications of these technologies were attached to the appendix II.

7.2 CASE STUDY ONE: Solid Waste Management Council - Sanitary Landfilling

7.2.1 Introduction and Background

In the middle area of the Gaza Strip (south of Wadi Gaza, excluding Rafah) a Solid Waste Management Council (SWMC) has been formed. It serves eleven communities; the heads of these communities are all members of the Council and participate in decision-making, having voting rights according to the sizes of their communities. The Council has been set up with assistance from GTZ (German Technical Co-operation) including the rehabilitation of the old dumpsite into a sanitary landfill. The landfill has been constructed in cooperation with the Palestinian-German development aid programme. (The German contribution has been financed through the Federal Ministry of Economic Cooperation and Development). Features include asphalt lining, and leachate collection and re-circulation. The mission of the Council is to provide secondary collection from communal storage points and to dispose of this waste in an acceptable way.

A weighbridge has been installed at the landfill site so that all loads are weighed. In this way reliable data on solid waste generation are now available. Each member community is billed monthly according to the weight of refuse collected from that community, and other sources, such as UNRWA, are also billed according to the weight they bring for disposal. The charges to the communities were initially based only on operating costs, but now, gradually, depreciation of the vehicles is being included in the charges, so that the system becomes sustainable, and not reliant on foreign donor assistance.

7.2.2 Approach

At the start of the GTZ project, soon after the creation of the Palestinian National Authority (PNA), there were a number of uncontrolled open dumpsites in the area under consideration. The first step in improving this situation was to assess the soil and groundwater conditions at several locations. Based on this information, and other factors, the existing dumpsite east of Deir El-Balah was chosen as the most suitable site for a central landfill, to serve the eleven communities in this area. Two boreholes were drilled into the underlying aquifer, to a depth of about 55 meters, to collect information on soil strata, water levels and quality. The subsoil consists of sandy material with a 14 m clay layer located some 15 meters below ground. One of these investigation boreholes was subsequently converted into a monitoring well (Coad, 2001).

The site is located in a natural depression, which drains to a nearby Wadi. There is a natural watershed at its upper end. The design for the landfill will raise the ground surface at the site by up to 29 meters, creating a hill with slopes of up to 1:2.2. Photo 7.1 shows the site being prepared.

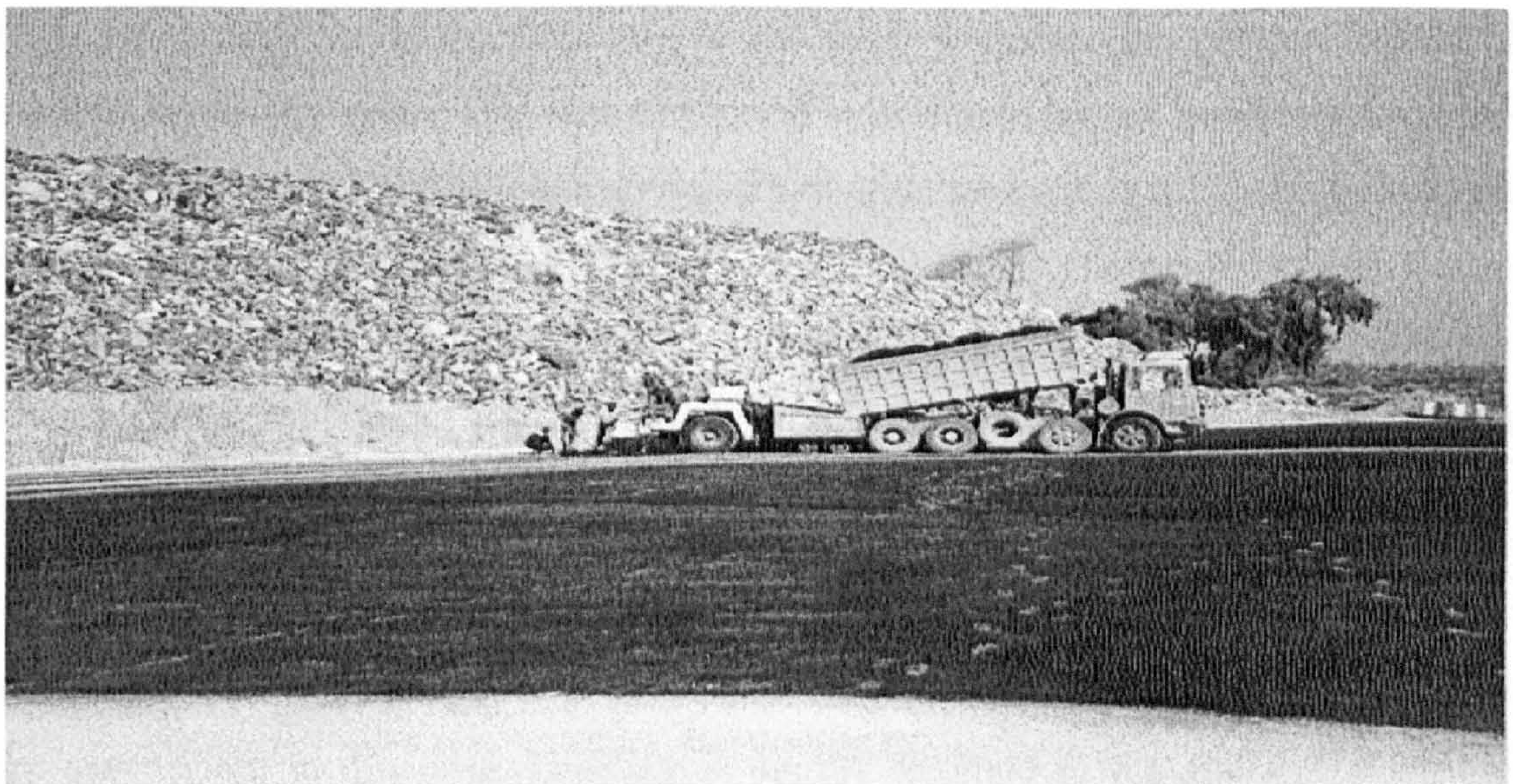


Photo 7.1: Construction of the landfill: Leveling, construction of the boundary dams, Lining with asphalt, and soil compaction.

7.2.3 Technical and Operational

Using a grant contribution provided by the German Government, phase one of the site was constructed by a local contractor and completed by November 1997. By 2000 the second construction phase was under way. Site management facilities such as a weighbridge, offices and stores had been erected and installed. Photo 7.2 shows the site office and weighbridge.

Photo 7.2: Access control. The structure for the site office is based standard shipping containers, and the electricity for the weighbridge and computer is generated by solar panels

High waste densities at the disposal site are likely to reduce the permeability of the mass of landfilled waste. This was confirmed by a simple test: A pond was excavated in a filled section of the site and it was filled with leachate to a depth of about one meter. This was in mid April 1999. It was not until the beginning of October that the pond had dried out. The expected evaporation within this period is around 950 mm. Although this experiment was not set up to provide accurate results, it indicates that the permeability of the landfilled waste is very low indeed.

Both the small variation in leachate flow rate between the dry and the rainy season, and these observations of low permeability suggest that the term "re-circulation" is not appropriate in this case. Leachate is simply returned to the site and distributed uniformly by a set of agricultural sprinklers for evaporation. No doubt, a small proportion will infiltrate, enter the leachate collection pipes to end up once more in the storage pond for re-circulation. However, the amount of leachate, which is actually re-circulated, seems to be almost negligible.

Basic planning parameters are set out below:

- The site serves communities with a total population of about 370,000 (11 towns and villages and 5 refugee camps).
- About 240 tonnes of MSW are disposed of at the site daily. (The total quantity disposed of in 1999 was 87,900 tonnes).
- The lined area is about 60,100 square meters (34,700 m2 for phase 1 and 25,400 m2 for phase 2).
- The total capacity is about 772,500 cubic meters (441,500 m3 for phase 1 and 331,000 m^3 for phase 2).
- Rehabilitation of the existing dumpsite included moving some 152,000 cubic meters of old waste to the lined area of the partially completed landfill site, so that all of the site could be lined.
- Considering this quantity of waste that was already on the site, and a disposal density of 0.90 tonnes/m^3, the remaining life span after construction and rehabilitation work was estimated to be about 6.5 years. As will be discussed

below, waste densities at the site proved to be much higher than expected, and, in the light of experience, the estimate of the actual remaining life span after rehabilitation was doubled to 13 years.

Following implementation of this landfill site all former dumpsites were closed, no longer used for solid waste disposal. As already mentioned, it was expected that the landfilled waste would achieve a density of around 0.9 tonnes/m^3. Considering that a tracked loader is used at the site in Gaza and that waste is placed in layers of 2 meters and more, this value was considered to be quite optimistic In fact it turned out to be grossly underestimated.

7.2.4 Environmental

Some experts believed that no significant leachate should be expected under the climatic conditions in Gaza because:

- The annual precipitation is only between 200 and 450 mm.
- The rainy season is between October and April and there is no rainfall during the rest of the year.
- The annual evaporation is between 1,200 and 1,400 mm.

It was further agreed to delay decisions regarding capping, final cover and post-closure care until reliable estimates of the quantity of leachate had been established.

Since groundwater is the main water source in the Gaza Strip, it was considered desirable to avoid any risk of further groundwater contamination. GTZ therefore decided to line the landfill site. (Experience later showed how wrong conventional wisdom was concerning leachate quantities, and how important it was to provide such a lining.). The design of the site was carried out by international specialists according to the following concepts:

- Lining of the site with two asphalt liners with a bitumen mastic layer between the liners. The reasons for choosing asphalt included that local contractors in Gaza had sufficient experience to lay a good quality asphalt liner, whilst clay and plastic liners would require an international construction company. The use of asphalt for lining of MSW landfill sites is a recognized standard in Switzerland and Germany, where it has been used since the early 1970's as depicted in Photo 7.1.

- Installation of coarse aggregates and drainage pipes to convey leachate to a storage pond.
- Installation of pumps and a sprinkling system for recirculation of leachate. No municipal wastewater treatment works had been continuously operational in Gaza, so there were doubts that it would be wise to expect effective and continuous operation of the more difficult processes of leachate treatment. Therefore recirculation was considered to be the only feasible option. Because of the climatic conditions low quantities of leachate were expected.

The new site is operated by a tracked loader and filled by placing lifts (or layers) that are between 2 and 4 meters deep. Temporary cover (sand) and plastic sheets are applied to the deposited waste before the rainy season. This is to reduce infiltration and to avoid polluted runoff during winter. No daily cover is applied. Sprinklers are installed in filled areas for leachate recirculation and evaporation. (Flat areas without cover proved to be most suitable for leachate evaporation). Leachate recirculation helps to reduce houseflies because they do not breed and feed on the areas that are saturated with leachate. Fences are installed to control wind-blown litter.

The council has improved its capacity to adapt to the newly emerged technology such as leachate collection, treatment and sieving of existing waste to be used as soil conditioner and daily cover. The adoption of this technology would extend the life span of the landfill

Samples of the substrate were analyzed and it was found that:

- Heavy metal and salt contents are below permissible limits for refuse derived compost in Europe
- Nutrient and organic contents are low and only about 1/3 of the values for conventional compost.

However, the humus content in the sandy and loamy soils in Gaza is extremely low. Therefore the substrate recovered from the landfill site is far more suitable than local soils for re-vegetation of the site. The screened material is relatively inexpensive to produce and allows a saving of landfill capacity. It may also oxidize some of the methane as it diffuses through the layer of compost-type material. Marketing of the material may be possible and cost-effective. However, further studies will be conducted to assess the impacts with regard to agricultural application. The collection and treatment of landfill gas were not regarded to be a priority for the time being. Reasons included that the landfill is relatively small and that the utilization of gas would be uneconomical.

7.2.5 Leachate Quantities Are Very High

After lining the first section and commissioning of disposal operations in June 1997, a first measurement of leachate quantities was carried out. The flow rate was about 26 cubic meters of leachate per day (Coad, 2001). This was surprisingly high, because the measurements were made during the dry season, and before operation of the recirculation system. At that time an average of 246 tonnes of solid waste was being disposed of at the site each day.

Specialists in Germany could not believe this flow rate measurement: "There should be no leachate at all during the dry season". But there was plenty of it. The only explanation at hand was that the waste in Gaza behaves quite differently from waste in Germany. It contains more biodegradable organics with a high water content, and more inert material, but less paper and other light fractions to absorb water. This type of waste simply de-waters during compaction at the disposal site - and therefore creates high quantities of leachate.

The magnitude of the leachate flow was alarming indeed and required immediate action before the start of the rainy season. The capacity of the storage pond was increased by about five times to 2,300 m^3 and much larger pumps and generators for recirculation were installed. In the meantime, more reliable data became available.

Measurement devices were installed and the average leachate flow during the winter 1999/2000 was found to be 27.4 m^3 per day. During summer this reduced to 25.4 m^3

per day. Peaks in winter did not exceed 38 m3/day except on one day when 68 m^3 was measured. The quantity in summer is fairly constant. It has not been possible, however, to show a correlation between precipitation events and leachate quantities. Solid waste quantities landfilled during this period averaged about 241 tonnes per day.

Based on the above data the following conclusions may be drawn:

- Leachate flow during the summer is around 10.5% of the weight of solid waste disposed of each day at the site. Most of this leachate is generated through de-watering due to compaction and only a small fraction may be due to recirculation.

- Leachate flow during winter (when most of the rainfall occurs) increases to only slightly more than 11% of the daily weight of solid waste disposed of at the site. The recirculation system is not operated during winter and the surplus is mainly due to precipitation.

It is surprising indeed that the variation between summer (dry season) and winter (rainy season) is not significant. It is also surprising that a landfill site, which accepts only 88,900 tonnes of waste each year, generates some 9,600 cubic meters of leachate per year.

Leachate samples were obtained and analyzed. Results indicate that the COD is about 40,000 mg/l and that the BOD is about 11,000 mg/l. This is quite similar to young landfill sites in Western Europe (Coad, 2001).

In December 2000, there was unusually high rainfall – 180 mm in one month, which is about three times the average for December and more than half of the average for a whole year. Leachate flow rates rose to 150 m3 per day, so that it was necessary to use tankers to take some of the leachate to a municipal wastewater treatment plant. (At the time of carrying out the research, Israeli restrictions do not allow access to the plant.) Some of the extra flow was coming from the second stage of the landfill, which had been excavated but could not be completed. This suggests that the leachate flow rates in the paper do not indicate maximum values because the rainfall in 1999/2000 was well below average.

This observation emphasizes the need for longer-term support for landfill operations. Not all operational problems appear in the first year. Site operators who are learning and developing their skills need on-going backstopping support.

7.2.6 Financial Economic

Investment costs of the landfill site are summarized in Table 7.1 below. They include all measures as described in this document, such as construction works and management facilities, the screening plant, and an allowance for final cover. Interest on capital investment is not considered because finance for all measures - except the land - has been provided on a grant basis.

Considering that the (virtual) disposal density is about 1.9 tonnes/m3, capital costs are equivalent to about US$ 2.5 per tonne of MSW delivered to the site. (This is calculated by dividing the cost per cubic meter [$4.8 in Table 7.1] by the virtual density.) This demonstrates that relatively high standards can be achieved at moderate cost. Running costs of the site in 1999 are shown in Table 7.2.

Based on the above tables, the total costs of the site in 1999 were about US$ 4.3 per tonne. Finally, disposal costs on a per capita basis are calculated in Table 7.3. Considering that the average household size in the project area is about 6.9 (source PCBS, 1997) disposal costs per household are about US$ 0.60 per month.

Total costs for solid waste management are US$ 3.6 per household per month. Hence, disposal costs according to the standards described in this document account for only about 17 % of the total SWM costs.

Table 7.1: Capital investment

Source: (Coad, 2001). Waste Management Infopage

Item	Investment (US$)
Access road (1.4 km)	140,000
Site office & truck scale	58,000
Land value (8.1 hectare)	510,000
Store & shed for machinery	17,000
Landfill construction works (6.0 hectare)	1,620,000
Leachate pond & pump house	210,000

Table 7.2: Running costs (1999)

Source: SWMC audit, 1999, Saba & Co., Gaza

Item	Cost (US$)
Staff & labor	27,800
O&M landfill machinery	31,000
O&M leachate recirculation	4,500
Management & overheads (1/3 of total SWMC)	25,000
Application of temporary cover (contractor)	16,000
Depreciation of machinery &	46,000

Table 7.1: Capital investment

Source: (Coad, 2001). Waste Management Infopage

Leachate recirculation system	130,000
Screening plant and installation	220,000
Planning and consultancy (international)	60,000
Supervision of construction works (local)	70,000
Final cover and re-plantation (estimate)	650,000
Total capital investment (US$)	**3,685,000**
Total capacity of the site (m3)	**772,500**
Capital investment per cubic meter	**4.8 US$/m^3**

Table 7.2: Running costs (1999)

Source: SWMC audit, 1999, Saba & Co., Gaza

equipment	
Miscellaneous	4,700
Total operating cost (US$)	**155,000**
Weight disposed at the site (1999 in tones)	**87,900**
Running costs per tonne	**1.8 US$/tonne**

Table 7.3: Disposal costs per capita (1999)

Total disposal quantity	Number of people served	Solid waste quantity per person	Total disposal cost per tonne	Disposal cost per person served
87,900 tonnes/year	372,800	0.244 tonnes/year	4.3 US$/tonne	1.05 US$/year

Note: Population according to Palestinian Central Bureau of Statistics (PCBS, 1998), applying a growth rate of 4.5 % per annum.

The SWMC has partially the financial ability to finance the implementation, operation and maintenance of the system.

Scavengers were observed in the SWMC landfill working in unhealthy conditions however, income has positive implications on the poor communities. Special budget for the depreciation of equipments is not available at the SWMC, which is one of the main problems facing the council. In addition, cost recovery is not being achieved since most of the people in the middle area cannot afford to pay for the SWM service due to the political situation.

7.2.7 Socio economic

The work of the Council has included a public awareness campaign to foster community participation. The recycling of decomposed waste is being considered.

The social status of SWM workers in the middle area is generally low. This owes much to a negative perception of people regarding the work, which involves the handling of waste or unwanted material. Such people's perception leads to the disrespect for the work and in turn produces low working ethics of laborers and poor quality of their work.

Because of insufficient resources available in the government sector of the PNA, collaborative projects often have attempted to mobilize community resources and develop community self-help activities. Communities in the middle area were given small economic as well as social incentives to participate in activities like placing containers far enough of their homes. The social incentive was directed towards the improvement of SWM service delivery to the community, and is created by public awareness and school education programmes being provided by the SWMC team. However, such programs are not sufficient.

At dumpsites, transfer stations, and street refuse bins; waste picking or scavenging activities are common scenes in the middle area. People involved have not received school education and vocational training to obtain knowledge and skills required for other jobs. They are also affected by limited employment opportunity available in the formal sector as a result of the prevailing political instability. The existence of waste pickers/scavengers creates often an obstacle to the operation of solid waste collection and disposal services. However, if organized properly, their activities can be effectively incorporated into a waste recycling system. Such an opportunistic approach is required for sustainable development of SWM programmes in the middle area.

Final cover will be progressively applied to the slopes of the site together with the planting of a vegetative cover. Horizontal surfaces are not covered to promote recirculation; they will be covered with substrate after closure of the site.

7.2.8 Institutional

Current institutional framework for SWMC is well structured; the board was elected from 13 municipals mayors as shown in Figure 7-1.

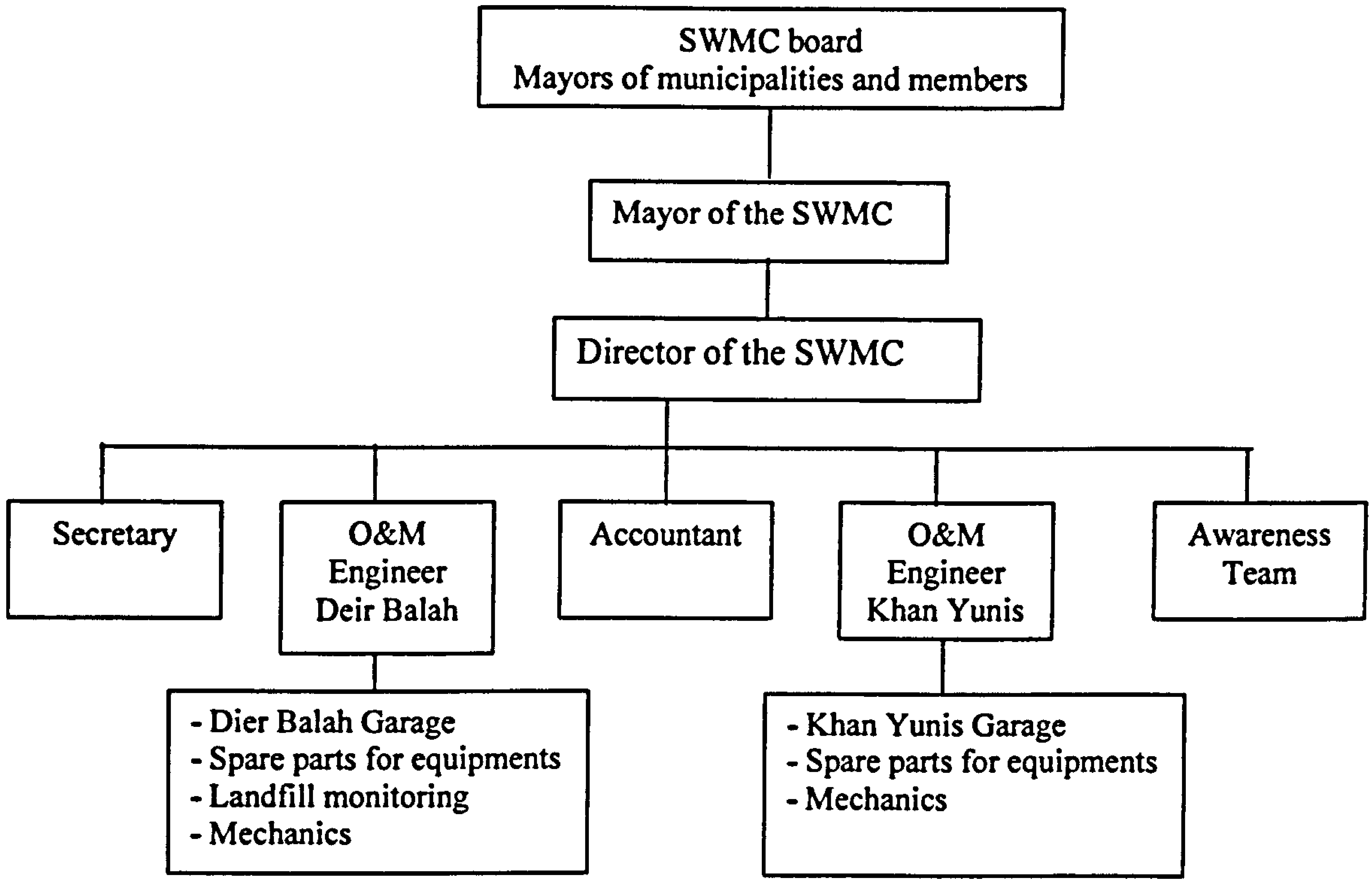


Figure 7-1: Organizational Structure of the Solid Waste Management Council

Source: (SWMC, 2002)

Staff of the council has received little training as the outside assistance stopped at the end of the construction stage. The Council has a Director, and also employs two Garage Managers (all with previous experience in SWM) and an accountant, and though previously most of the drivers and crew were employees of the municipalities in the area, more and more of them are now employees of the Council Specific training on financial management as well as landfill operation and management has been provided to the Staff through GTZ. The SWMC staff has the capacity to regulate to a certain extent, monitor the SWM operations in the services area.

The scope of training provided to the council has enabled them efficiently and effectively manage and environmentally sound operate the site with fairly little outside assistant.

7.2.9 Policy, Legal and Political

No standards and regulations with regard to MSW in addition, national framework on waste management was in place. However, member municipalities of the SWMC have jurisdiction and authority to plan, finance and operate waste management system and/or to contract them out. Rules of law on waste management are not sufficient or efficiently enforced. Strategy or plan for waste management at the national level is not available.

7.2.10 Case Study One – Landfilling

The SWMC is the official body responsible for SW service delivery including landfill operation and management in the jurisdiction of the council as explained in Chapter 8 as depicted in landfilling rich picture Figure 7-2.

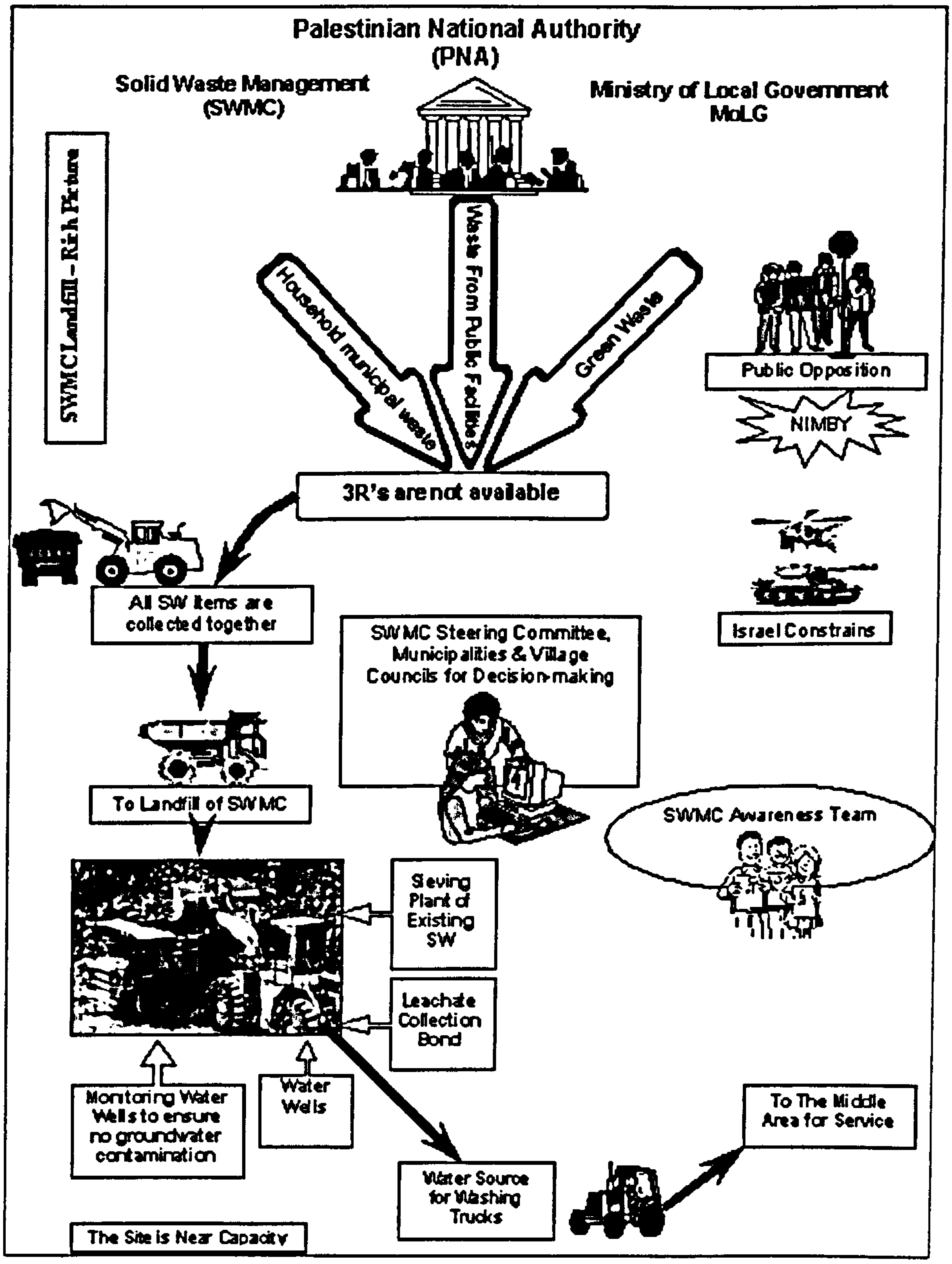


Figure 7-2: Rich Picture for the SWMC - Case Study One

Source: Developed by the Researcher

C: The population (local public) living in the middle area where the SWM services is provided and the general public of the Gaza Strip

A: SWMC, consultants, UNRWA

T: Landfilling as an environmentally sound disposal option thorough an engineered shared disposal facility in Deir El-Balah.

W: To produce complete disposal procedures (i.e that will identify significant technology suitable and applicable for decision-making process).

O: PNA, SWMC and MoLG

E: SWMC, working relations with consulting bodies, pressure from MoPIC, MoLG, MEnA and public opposition.

Therefore, three root detentions RD's for the Solid Waste Management Council, which adopted the sanitary landfilling as an environmentally sound disposal strategy for solid generated for can be defined as:

RD1

A Palestinian Local Authority represented by the SWMC as a coalition of 13 municipalities owned and manned system to collect, transport, raising awareness (3R's) and provide an environmentally sound disposal of solid waste service in keeping with the overall concerns parties like municipalities, village councils, Ministry of Environmental Affairs MEnA, Ministry of Health MoH, scheme of the Gaza Strip in order to improve the public health, environmental situation and enhance public participation to solid waste management sector.

RD2

A Local Authority, health environmental engineering and planning system was developed for efficient solid waste management practitioners so that, other actors like Solid Waste Management Council, and solid waste consultants could be assisted in the process of selecting the best service delivery proposing sanitary landfilling as an environmentally sound disposal strategy suitable for the middle area of the Gaza Strip.

RD3

An environmentally sound and sustainable solid waste service delivery owned by the Ministry of Local Government, operated by the SWMC in the middle area represented by the 11 municipalities, village councils, that receives solid waste plans, guidlines and initiatives for efficient and effective solid waste management in the context of the Palestinian National Authority PNA constrained by the orders of the Palestinian Legislative Council PLC and the president.

7.2.11 Conclusion

Upgrading and developing disposal standards by the SWMC and the PNA is a major challenge. Data about this subject are scarce and planners often rely on the experience gained in the industrialized world.

Different collection techniques are being practiced by the SWMC to handle high-density waste in the SWMC service area. The experience gained in Gaza suggests that properties of high-density wastes at the disposal site are quite different to the properties of waste at disposal sites in the industrialized world. Far more research is required to obtain data from different parts of the world under different climatic conditions. Flat areas without cover proved to be most suitable for leachate evaporation. Leachate recirculation helps to reduce houseflies because they do not breed and feed on the areas that are saturated with leachate. Fences are installed to control wind-blown litter.

This observation emphasizes the need for longer-term support for landfill operations. SWMC Landfill operators need to develop their skills through on-going backstopping support.

Lessons Applied

As discussed earlier, decisions on post-closure care have been postponed until more reliable data become available. Now, some three years later, the experience gained has been applied as follows:

Pond capacity, leachate return and evaporation system

Experience has shown that it is impossible to operate the leachate return and evaporation system during the rainy season (which lasts about 5 months, between November and April). The leachate sprinkling area on the landfill site becomes saturated and rainfall events create significant quantities of highly polluted runoff. This is not acceptable and must be avoided. It was therefore decided to create sufficient pond capacity to store all of the leachate generated during the rainy season (i.e. 5 months × 30.5 days × 27.4 m^3/day + 20 % safety margin = 5,000 m^3). This pond capacity of 5,000 m^3 is about 10 times larger than the initial design capacity!

Of course, the amount accumulated during the rainy season must be returned to the site for evaporation during the dry season - in addition to the quantities generated in summer. Large evaporation areas are required for this purpose and significant nuisance from bad smells is unavoidable.

Final cover

Apart from financial considerations, two factors have been considered for the design of the final cover system:

- The permeability of the waste body is low and only a small fraction of the rainfall is likely to infiltrate. The slopes of between 1:2.5 and 1:4 also encourage runoff. Planting of vegetation will increase evapotranspiration and further reduce leachate flows.
- The generation of leachate is likely to decrease substantially once the site reaches its capacity limit. The reason for this expectation is that the bulk of the leachate – perhaps as much as 90 % - is generated by de-watering of the waste as the pressure on it increases

- When no more waste is added the pressure stops increasing and so this de-watering effect will come to an end. Hence, once the site has been filled, the main source of leachate - fresh waste that has just been placed – no longer exists (Coad 2001).

7.3 CASE STUDY TWO: Palestinian Environmental Friends (PEF) – Community Composting

7.3.1 Introduction and background

In 1997, a Palestinian Municipal, Management Project (PMMP) through the Federation of Canadian Municipalities (FCM) in Canada has been given to Rafah municipality in order to improve capacity and institutional building of the municipality and to enhance public participation to the municipal decisions. One of the components of that project was to promote composting scheme with local farmers. Rafah city was chosen for such initiative because it's an agricultural area.

PEF has been founded as an environmental community based, non-profit organization to enable concerned people in the Gaza Strip to cooperate neglecting geological and political constrains and to work on reducing the environmental deterioration through enhancing public participation in environmental management issues. Members of PEF believe that a universal environment free from pollution, sustainable and suitable for new generations has to be created.

Aims of the organization:

- Protection of Natural Resources.
- Alerting and educating the public concerning the dangers threatening the local environment.
- Protecting wild life and wild habitats and encouraging the plantation of trees.
- Pay special attention to renewable resources.
- Reducing and controlling all forms of pollution to maintain and improve the standards of public health.
- Enhance public participation in environmental issues like water, wastewater and solid waste management.

Fields of activities:

- Waste water treatment and reuse including researches & studies.
- Sludge treatment and reuse including training.
- Solid Waste Management (Reduce, Reuse and Recycling 3R's and Composting) including awareness programs, training and demonstration Projects, workshops, seminars and consultancy services.
- Water quality management.
- Water conservation.
- Air pollution control.

Approach:

Based on the activities agreed between PEF and Rafah Municipality to enhance composting product among local farmers in Rafah, the project has been implemented through the following:

- Meetings and workshops
- Preparation of educational material (leaflets and posters)
- Data processing and reporting
- Training program: On Farm Composting in rural areas

7.3.2 Technical and operational

Theoretically, the potential for composting in the Gaza Strip is being addressed by local environmental NGO's and some donors like EU and GTZ as about two thirds of the domestic waste in urban areas consists of organic material. However, lack of willingness to separate waste and the use of small plastic bags for kitchen waste present constraints to its development. Although 75% of the organic waste in Gaza comes from households, the focus for compostable organics is on markets (4% of total waste) and eventually slaughterhouses (1% of waste), because of the high concentrations of organics from these sources (El-Hawi, et al., 2002). It has been found that, composting of green waste in Rafah city will reduce the waste generated by 10 % (Coad, 2000). In 1998, the European Union and Gaza Municipality have constructed a pilot plant aiming to compost 8 tones of organic (market) waste per day. The project has been frozen due to the current political situation and unavailability of budget to cover necessary running costs.

Experiments by the Islamic University in 1997 in Gaza have been undertaken to determine the value of decomposed waste. Preliminary investigations suggest that the decomposed waste, after sieving could be added to soil to improve its organic content. It is found that, the decomposed sieved product would be a useful cover material for the landfill itself. The reuse of the decomposed material in this way frees capacity in the landfill site for more waste. The heavy metal content of the samples was within European limits for compost. (Coad, 1997) argues that, if a market could be established for this material, it could be distributed to customers by the trucks that normally return empty from the disposal site. Experiments have been undertaken at the Deir El Balah landfill of the Solid Waste Management Council of central Gaza to determine the value of decomposed waste. It would also be a useful cover material for the landfill itself. The reuse of the decomposed material in this way frees capacity in the landfill site for more waste. The heavy metal content of the samples was within European limits for compost. Such material could be distributed to customers by the trucks that normally return empty from the disposal site.

A study by Rafah Municipality has been conducted in 1997 to formulate an integral plan to deal with the disposal system and treat solid waste materials in an environmentally sound way and to recover materials and energy. The study focuses on prolonging the current dump's age through finding suitable alternatives to be implemented in the coming years. The plan indicates that composting of organic fraction will help in reducing the waste quantity dump in the landfill.

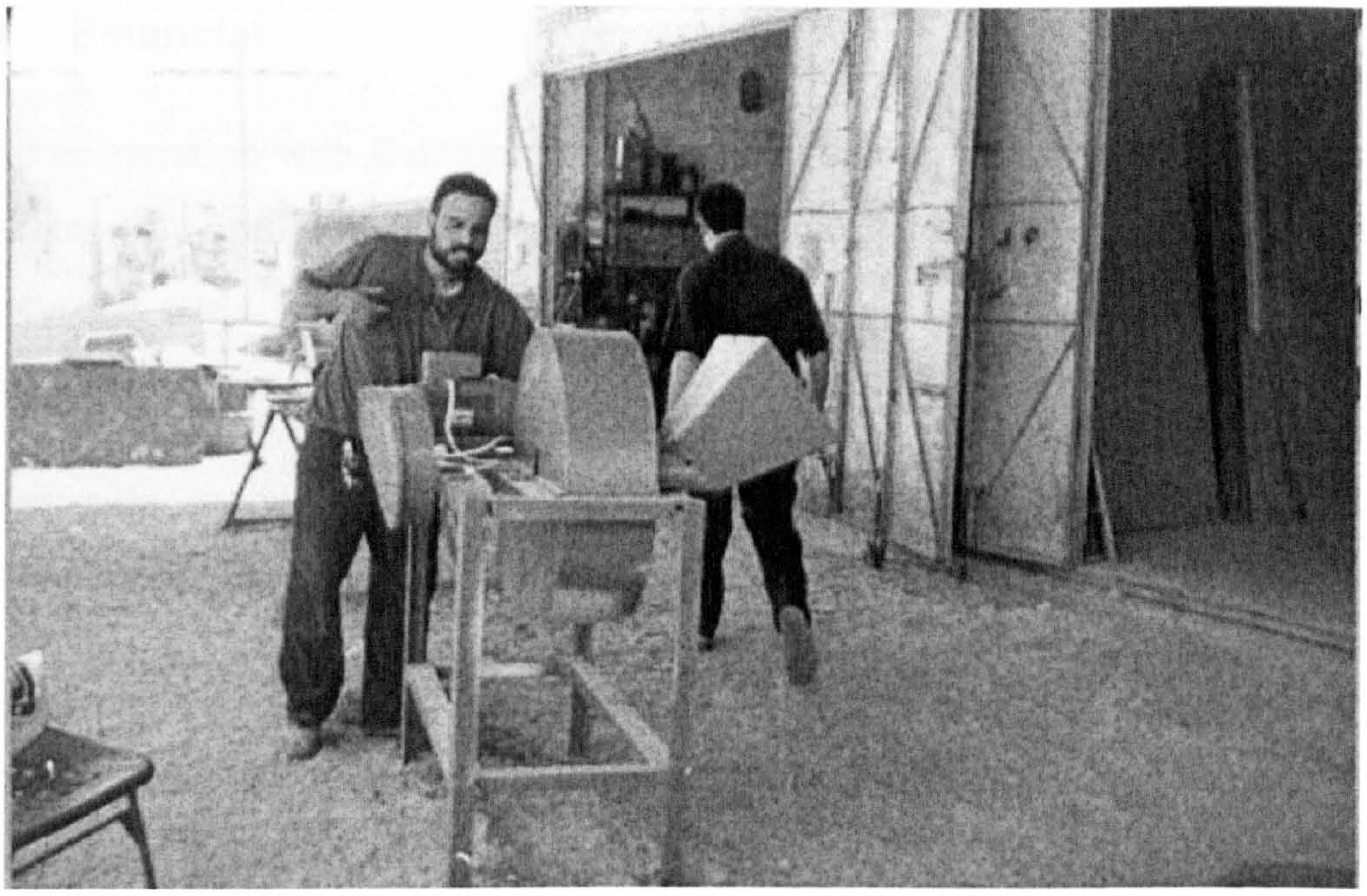


Photo 7.3: Compost Shredding Machine distributed by PEF to Farmers in Rafah

7.3.3 Environmental

The place where composting scheme is conducted has been selected in Musabeh village, north of Rafah city which is an agricultural area away from the high densely populated area. The place was selected based on the following criteria

- Agricultural area where composting product can be applied on different types of agricultural products.
- Results from the Soil analysis have shown that, soil is sandy one of high porosity. Plastic sheets were laid as lining material to ensure no leachate percolates to the ground aquifer.
- Relevant awareness raising programs were designed and implemented with target farmers.
- Leachate and gazes were not monitored.
- Analysis of heavy metals on composting product did not exist.

7.3.4 Financial

PEF in cooperation with Rafah municipality and funding from the FCM has started a pilot-composting project. PEF has set a financial mechanism to follow up and to cover the recurrent costs. PEF has the financial ability to finance, implement, operate and sustain composting pilot project.

Transparency, accountability and fiscal discipline of PEF staff through training, incentives, cost of conduct have been increased.

Composting product was distributed freely in order to enhance its market among farmers in Rafah. However, a survey has conducted by PEF resulted in, each tonne of compost can be sold for US$ 15-20 based on quality and its applications. PEF has special mechanism in approaching agencies, which is the key issue for the sustainability of the project. Increase revenues from resource recovery like the case with the composting pilot project has encouraged waste minimization at source. The close monitoring and evaluation performance through municipal financial and budgeting departments have resulted in financial control.

Finally, supporting local farmers with composting free of charge in the long run through PEF is not possible because PEF is an NGO with limited financial resources for financing such scheme. That's why municipality of Rafah has to allocate special budget for this purpose as part of SWM operations.

7.3.5 Socio economic

PEF has took the initiative and started a base line survey with the farmers in order to assess familiarity of compost as an end product. Willingness of farmers to use the product and whether the compost can be an environmentally sound disposal strategy parallel to the landfilling were investigated and researched. 40 farmers from different villages in Rafah were participated in the training, which designed and implemented by PEF, Palestinian Agricultural Relief Committee (PARC) and the municipality of Rafah. The project has extended for three months. During the training period, awareness programs on composting were conducted by PEF and PARC, collection points for green waste as leaves, grass, and food scraps, by microorganisms were proposed and arranged by farmers. Transportation means were also arranged and practical experiments of compost were demonstrated by the farmers on the field as part of the on job training. Participants, engineers and municipal officials have participated to the training. By the end of the project, 50 shredding machine, which assembled, locally for composting were distributed to the participants as incentives to ensure sustainability of the program as depicted in the rich picture for PEF. Photo 6.3 shows one of the shredding machines given to the farmers. This is not done on a commercial basis just on a pilot scale. The compost product has been applied to the agricultural land by farmers where they impressed with the results. The results were supportive to the interviewees and respondents opinions out of the main questionnaire and interpretations by farmers, local NGO's, municipal officials and UNRWA.

7.3.6 Institutional

Palestinian Environmental Friends is a non-profit community based organization (NGO). It was established in Rafah city south of the Gaza Strip by a group of Palestinian experts in the field of environment. The group would like to share in improving the environmental situation in the Palestinian territories. The aim of the organization is to protect the local environment and natural resources from pollution and mining through public awareness & environmental education. The organization aims to have sustainable and well-managed natural resources. PEF aims to have a wide range of cooperation with local regional and international organizations and individuals share its aims and activities. PEF has 7-elected board and 200 member, most of them are university graduates with environmental background. The organizational structure of PEF is shown in Figure 7-3.

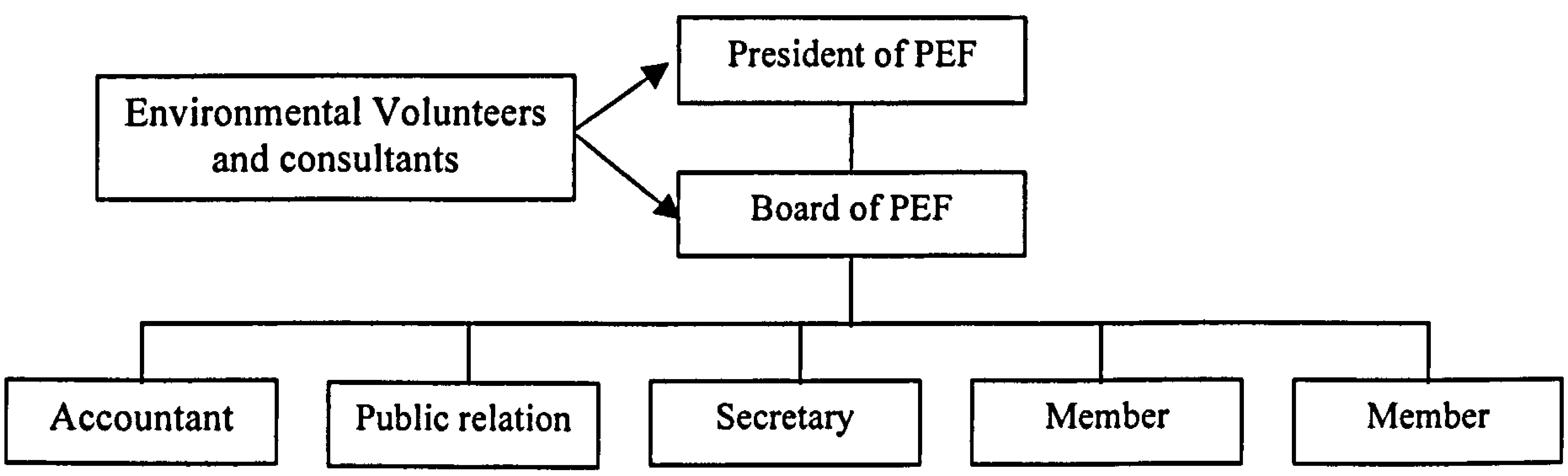


Figure 7-3: Organizational Structure of PEF

Source: PEF, 2002

7.3.7 Policy, legal and political

Composting is not being highlighted in the Palestinian environmental framework of the law. Depending on environmental legislation and regulation for PEF to monitor composting project was not possible. However, PEF has considered some environmental bylaws pertaining compost through the overall objectives of environmental protection. Effective regulations and procedures for private sector participation still ambiguous also legal enforcement, inspection structure was not effective

7.3.8 Case Study Two – Composting

PEF is a local environmental NGO based in Rafah city. A joint community-composting project between Rafah municipality and PEF and a fund from Canada has been implemented. In this project, PEF was the implementing agency including training for local farmers as depicted in the rich picture (Figure 7-4).

The CATWOE elements for this case study is developed as follows:

C: People living in Rafah

A: PEF, Rafah Municipality, Canada Fund, PARC

T: Composting of green waste as an environmentally sound disposal option parallel to landfilling

W: To produce compost from green waste of good quality using available technology that farmers can afford.

O: PEF, Rafah Municipality

E: PEF, special relations with Rafah municipality and PARC

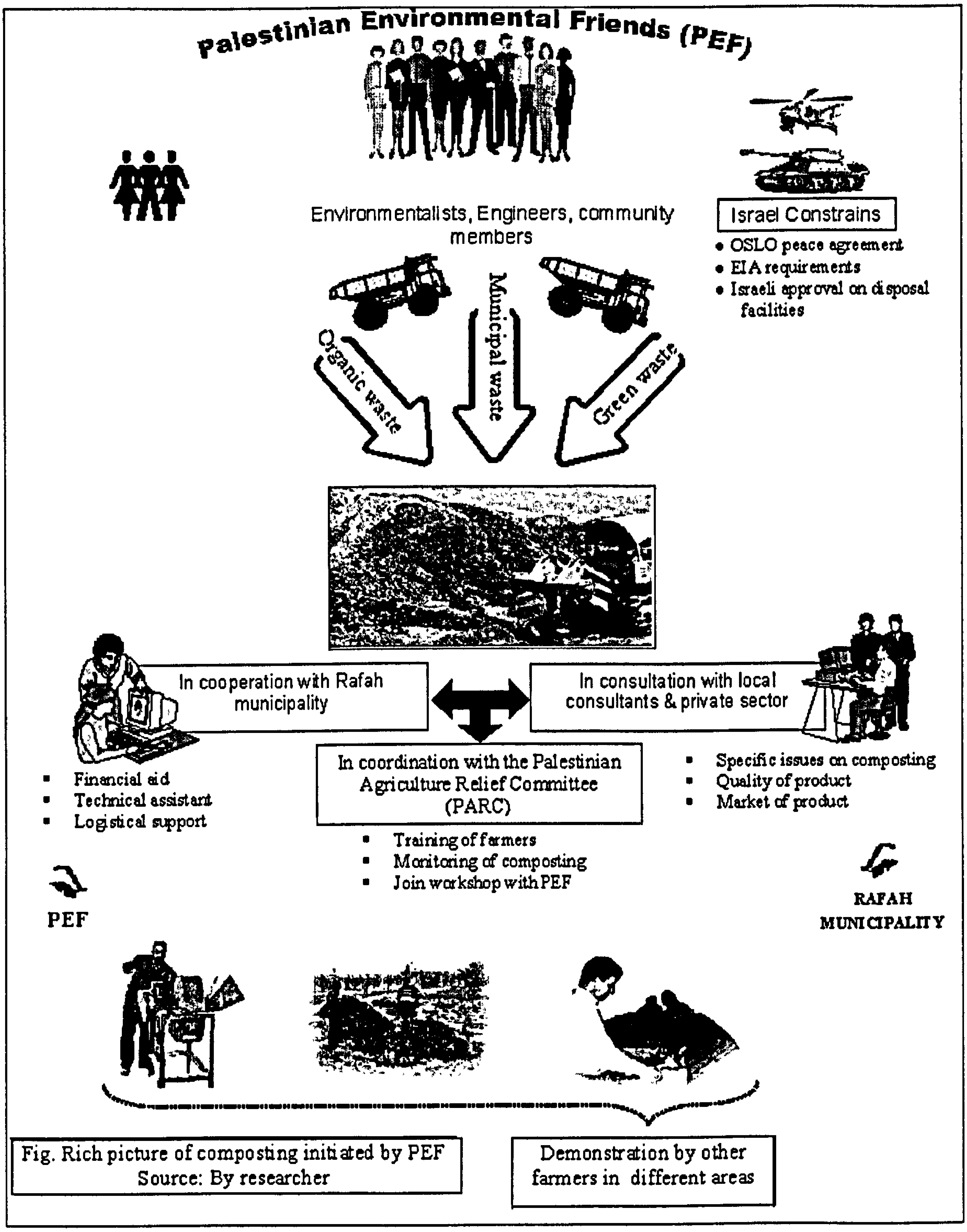


Figure 7-4: Rich Picture for Green & Organic Waste- Composting – PEF - Case Study Two

Source: Developed by the Researcher

7.3.9 Conclusion

Composting of selected organic materials can be valuable component as integrated waste management system. The significant question is rather how and to what degree will composting be integrated for maximum value recovery. Responses and interpretations from the participants have shown great sympathy with the compost as an end product and as a strategic disposal alternative to landfilling.

Most previous composting pilot projects, which were initiated by some Palestinian NGOs or municipalities, either focused on the technological or social aspects of composting. Much less attention was given to a detailed assessment of the market for compost.

Labour-intensive aerobic composting facilities have proved adequate technology for small community like the case of PEF and Rafah municipality. Lessons learned from PEF composting project are supporting results of the questionnaire (90% of the respondents all over Gaza Strip have responded with yes and yes with incentives). This result indicates sufficient statistics that compost can be an excellent soil conditioner and fertilizer.

Most of the participants were convinced to use the composting product as natural and organic soil conditioner, based on the successful results, the municipality of Rafah has agreed to proceed for the second phase of the project with PEF. The project has been implemented during the Intifada where economic situation is declining; many jobs have been created to local farmers.

For political reasons, Palestinian farmers like to encourage national products as part of minimizing trade with Israel since the compost project with PEF has come during the Intifada. In Israel, composting is heavily subsidized and the compost firms seemingly do not want to lose their monopoly in Gaza. Composting can be economically feasible to the extent that economic factors related to the landfills, markets and materials recovery approximate real financial and environmental cost.

7.4 CASE STUDY THREE: Gaza Municipality Case Study - Reduce, Reuse, Recycle - 3R's

7.4.1 Introduction and background

Gaza was a part of Palestine under the British mandate from the 1917-1948. The Arab-Israeli war in 1948 resulted in the current boundaries of the Gaza Strip. This huge population influx, combined with the loss of resources and disruption of domestic trade, created an unstable socio-economic situation. The economic situation continued to deteriorate because of the internal economic and political problems. In 1967, Israel occupied the West Bank and Gaza Strip, which resulted in Israel controlling the available resources and the economy of the occupied areas. The situation created almost complete dependence on the Israeli economy, with many people in Gaza working as unskilled laborers in Israel (MoPIC, 1998).

The population of Gaza City is expected to increase rapidly in the coming years, not only because of natural growth (more than 50 percent of the population is under 14 years of age. It is estimated that Gaza City will have approximately 600,000 inhabitants by the year 2010 doubles its current size, compared with 1.5 million for the Gaza Strip (MoPIC, 1998).

This case study will examine SWM issues in Gaza City, with particular emphasis on reuse, reduce and recycle (3R's) as an environmentally sound disposal options parallel to the landfilling.

Solid waste collection and daily cleaning

Municipality of Gaza – Health and Environmental Department is responsible for solid waste collection and daily cleaning throughout Gaza City, except in the northern and southern parts of the Beach Camp where UNRWA is in charge. Street cleaning is one of the most serious challenges facing MoG. The following are some recommendations by the MoG (Municipality of Gaza, 1996) to improve the current situation:

- increase cleaning efforts by adding more staff and equipment (containers with and without lids, collection trucks, and mechanical sweepers);

- clean the containers on a regular basis;
- gradually eliminate house-to-house collection to the extent feasible;
- clean up open dumps scattered throughout the city' and
- educate people about proper waste disposal practices (placing waste in bags and depositing bags inside the container at specific times, etc.)

In addition, the Municipality of Gaza in cooperation with the EU is enhancing the policy on waste management advocating the philosophy of Reduction, Reuse and Recycle (3R's) as a strategy initiated by the Ministry of Environmental Affairs and the Ministry of Local Government.

Table 7.4: Solid Waste Composition in Gaza Municipality by source of waste (by source of waste and overall, in MT/day)

Source: Gaza Municipality, 1996

Source	Type of Waste												
	Organic	**Paper**	**Plastics**	**Textiles**	**Glass**	**Iron**	**Non-ferrous**	**Hazar-dous**	**Const. Debris**	**Sand**	**Sludge**	**Other**	***TOTAL***
Household	108.5	11.6	14.6	4.3	1.0	1.6	0.3	0.7				0.3	**142.9**
Shops	5.7	4.6	3.3.	0.8	1.7	0.3	0.2	0.2				0.1	**16.9**
Market	6.1	0.8	0.8							0.4		0.2	**8.3**
Army	7.8	0.3	0.3		0.1	0.1	0.1					0.8	**9.5**
Restaurants	4.0	0.5	0.7		1.3		0.2					0.1	**6.8**
Hospitals/clinics	0.7	0.7	0.8	0.1	0.1			1.1				0.3	**3.8**
Schools	0.6	1.0	0.4	0.1	0.2		0.1					0.4	**2.8**
Offices, Public/Private	0.4	1.0	0.2	0.1	0.1							0.1	**1.9**
Industries	5.0	4.5	0.1	0.5	0.2							18.4	**28.7**
Construction									50.0	23.0			**73**
Street cleaning	0.5	2.5	2.5	0.5	0.2		0.5	0.1		25.0		0.2	**32**
Sewage cleaning											3.0		**3**
TOTAL	**139.3**	**27.5**	**23.7**	**6.4**	**4.9**	**2.0**	**1.4**	**2.1**	**50.0**	**25.4**	**26.0**	**20.3**	**329**
%	**42.3**	**8.3**	**7.2**	**1.9**	**1.5**	**0.6**	**0.4**	**0.5**	**15.2**	**7.7**	**7.9**	**6.3**	**100%**

Objectives of the Project

The project's general objective was formulated as "improved health and environment for the population of Gaza City". Its immediate objectives were formulated as:

- Gaza City Municipality has attained the capacity to provide regular and appropriate waste collection and disposal services cost-effectively without external assistant by 1997;
- Warranted and environmentally safe landfill operation without assistance established by 1997 for a period of 20 years; and
- Appreciation of the positive impact of waste collection practices on health status created among the population of Gaza City.

The project document distinguishes the following 6 outputs, which all to a more or lesser extent, have been realized during the project implantation period:

- Capacity of the municipality of Gaza City to plan, implement and monitor cost-effective health education and solid waste management services increased;
- Municipal management staff and providers of health education and waste collection and disposal services trained according to identified needs;
- Efficiency of municipal waste collection service increased.
- Improved environmental situation at present solid waste disposal site; controlled new solid waste disposal site with proper management of hazardous waste facilities achieved;
- Functional relations with the related development projects and institutions established;
- Understanding of waste collection and treatment services created; community participating in the organization, and community involvement in all districts of Gaza City achieved.

(Source: Agro Vision, 1998).

7.4.2 Technical and Operational

The daily generation of municipal solid waste in Gaza City ranges between 0.6-0.7 kg/capita/day; the municipal solid waste stream has a high organic content (65-70%). In 1996, the total daily generation of solid waste in Gaza City was estimated 330 MT/day (or about 120,450 MT/year) (MoG, 1996). Table 7.5 indicates the breakdown of this total quantity among different generation sources. Household wastes represents 43% of the solid waste stream, double the amount of construction debris generated in Gaza City. Wastes from street cleaning (primary sand) and industrial wastes rank third and fourth and contribute 9.7 % and 8.8% of the total solid waste stream, respectively. "Kamkha" wastewater sludge from tiles factories, make up a significant portion of the industrial waste stream due to the increase in construction activities since the end of the Israeli occupation ("Khamkha" seriously hampers land disposal operations at the landfill).

Table 7.5: Solid Waste Generation in Gaza City (by source of waste)

Source: Gaza Municipality (1996)

Source	MT/Year	Mt/Year Estimated 96)	% age
Household	143	52,200	43.4
Shops	17	6,205	5.1
Markets	8	2,920	2.4
Army	9	3,285	2.7
Restaurants	7	2,555	2.1
Hospitals/Clinics	4	1,460	1.2
Students	3	1,095	0.9
Offices, Public/Private	2	730	0.6
Industries	29	10,59	8.8
Construction	73	26,645	22.1
Street Cleansing	32	11,680	9.7
Sewage Cleaning	3	1,095	0.9
TOTAL	**330**	**120,450**	**100%**

Such as industrial wastes, construction debris, and sewage sludge. When these quantities are subtracted from the solid waste stream, the daily per capita rate becomes 0.61 kg/person, which is more consistent with the socio-economic characteristics of Gaza City.

Solid Waste Recycling in Gaza City

The recycling sector in the Gaza Strip will probably grow quite slowly because there is no established pattern to follow. Currently, a very small fraction of solid wastes is recycled, mainly steel scrap and a small amount of organic. The total MSW recycling is 9,068 tonne/year out of 215,000 tonne/year (a recycling rate of 4.21 per cent). Metals 5830 tonne, organics 1419 tonne, Paper and card 1080 tonne, Plastics 432 tonne, glass 200 tonne and cloth 107 as shown in Figure 7-5 (field work by researcher).

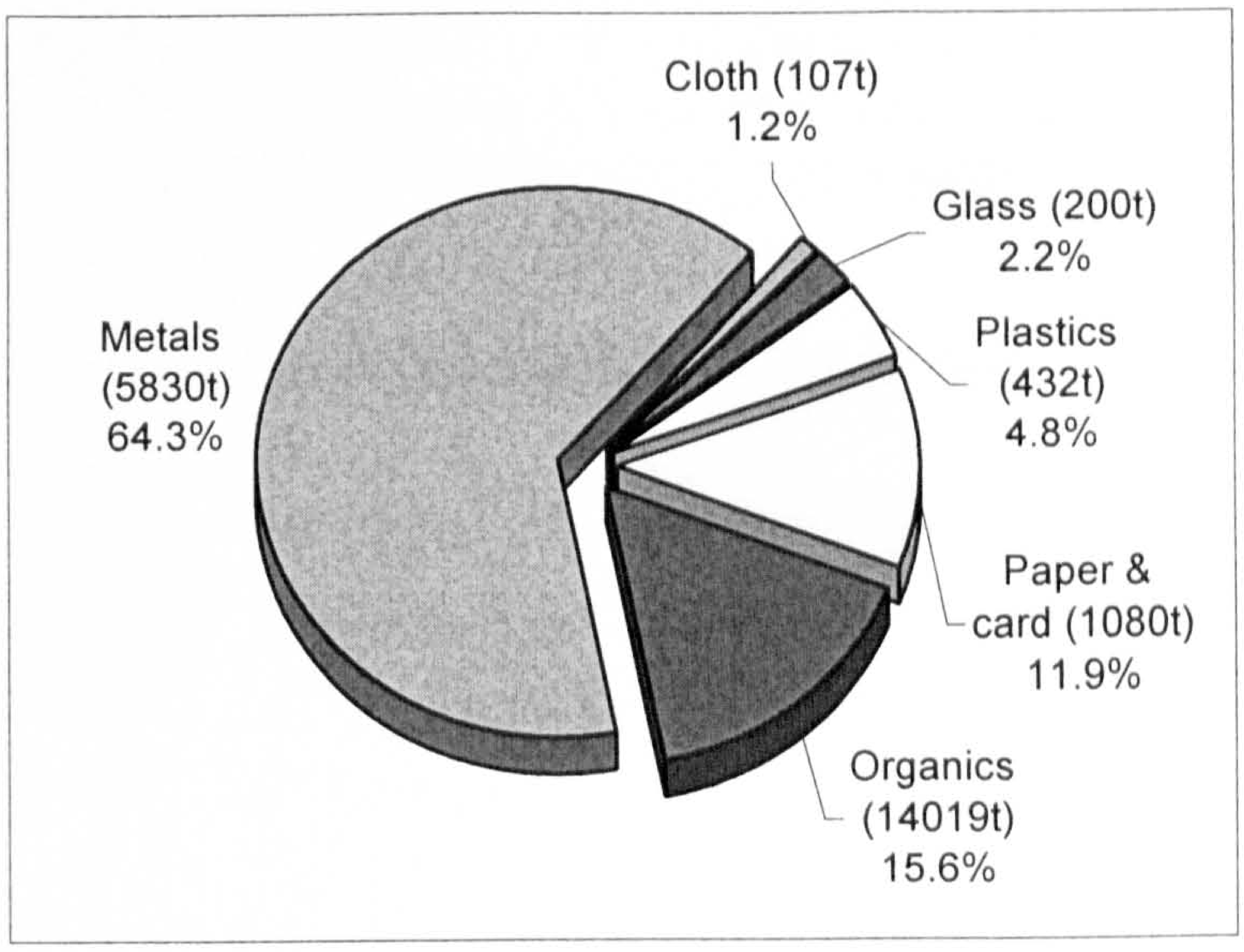


Figure 7-5: Estimated MSW recycling rates in the Gaza Strip (total 9068 tonne)

Source: by author

Some of the small micro-enterprises working in the Gaza Strip as middlemen collecting scrap to be sold to Israel for US$ 30/ton. Paper and cardboard are being collected and reprocessed locally as egg pots and boxes (Personnel interview).

Recycling activities in Gaza are low profile. "Reclaiming (i.e. collecting disposal materials) exists for metals. "Re-use" of waste exists in some factories like plastic producers. The solid waste disposal project imitative to encourage recycling failed because of lukewarm interest from the private sector (Agro Vision, 1998).

In the short term, MoG could encourage efforts to collect at the source those materials that currently have a market, such as paper and metals, and organic matter from markets in the near future (MoG, 1996). The MoG identified some of the collection points for recycling as depicted in Table 7.6.

Table 7.6: Examples of Selective Source Collection

Source: (Gaza Municipality, 1996)

Material	Collection Methods
Paper	A separate collection scheme for white paper was initiated for printer and copy shops, five selected schools, and five selected offices. The paper is collected by the owner of an egg-carton plant with no cost to MoG. Paper industries and homes. Is not collected separately.
Metals	There is some informal recycling of metal wastes form households, factories, and workshops. In addition, scavengers recover remaining metal waste from the dumpsite.
Construction debris	Homeowners and developers send their demolition debris directly to the emergency harbor for a fee) where they are used as fill and defense materials to expand the port.
Car batteries	Some car mechanics collect old batteries and sell them to a car battery manufacturing plant that recycles them; some car battery parts are exported to Israel (personal communication).

Equipment for sorting and processing solid waste

The MOG has all the mechanical equipment for a plant to sort and process solid waste (capacity 40 tonnes/hour), which was donated by the Spanish Government to the Palestinian National Authority. The equipment was built by the Spanish firm IMABE and consists of different belts; first stage sorting platforms, hoppers for falling material, centrifugal bag opener and separator, sorting platforms, over-band ferromagnetic separator, metal packing press, and different bailing presses.

In Gaza City, a very small fraction of solid wastes is recycled, mainly steel scrap and a small amount of glass. Waste pickers were observed in small numbers on most sites - more where wastes from Israelis are being disposed of. Coad, (1997) argues that, Gaza City is not ready yet for large-scale machinery operation.

In the Gaza Strip, (MoPIC, 1998) has estimated that, the agricultural sector generates over 2400 tons of plastic waste each year, most of which was burned in the open. Although contaminated with soil, and perhaps with pesticides, this source of plastic waste may be of some interest to the recycling industries. Opportunities for recycling in Gaza City have been the subject of a special study, and considerable work has been done to try to identify ways of reusing the slurry waste (Kamkha) from the tile industry. Other possibilities include plastics and construction waste.

7.4.3 Institutional and regulatory framework

The current organizational structure of MoG as described in the World Bank funded Municipal Infrastructure Development Project MIDP (of which MoG is one beneficiary). The new organizational chart of the Municipality identifies the following department as depicted in Figure 7-6.

- General administration;
- Finances;
- Garage and emergencies;
- Purchasing and procurement;
- Public health and environment;
- Operations and maintenance;
- Urban planning and organization; and
- Projects preparation and developments

Figure 7-6: Municipality of Gaza Organizational Chart

Figure 7-6: Municipality of Gaza Organizational Chart

The communities and project's efforts in establishing these relations resulted in an understanding about the mutual responsibilities towards making and keeping Gaza City clean and beautiful. Besides, the project used on many occasions local community centers, clinics, and schools to hold meetings, and to hold theatre and mobile Exhibition on the Environment performances.

From the previous evidences of the case studies, there is no national/regional, legal, institutional framework for reuse, reduce and recycle (3R's) of the solid waste generated in the Gaza Strip. This helps explain why the Gaza Strip, a small territory (365 km^2, 40 km long and 12 km wide), has four operating solid waste landfills. In addition to Gaza City's El Mazaraa landfill, the Gaza Strip has one landfill in Rafah in the south, one for the Middle Area municipalities, and one in the north. As explained in case study one the middle area offers a remarkable model for inter-municipal collaboration on the solid waste management council (SWMC). This council is responsible for overseeing the management of the landfill they share, including assessing disposal fees from the various municipalities.

Despite the absence of national laws or regulations for SWM, responsibilities for SWM are well defined. Municipality of Gaza Public Health and Environmental Department (HED), like other municipalities in the West Bank and Gaza Strip, assumes full responsibility for street collection and disposal; Municipality of Gaza employs a total of 370 employees in this sector (MoG, 1996).

Experience elsewhere strongly suggests that successful recycling often requires separation of recyclable materials at the source. (Coad, 1997) argues that, it is still too early to implement source separation schemes at the household level in Gaza City. Recycling is currently limited primarily to paper, metals, construction debris, and car batteries. Also the municipality plans to build a solid waste composting plant in cooperation with the EU but the project has been jeopardized by the current political problems.

7.4.4 Financial

In 1994, a solid waste disposal project for Gaza city has been funded by the European Union. As a result of several commissions between Gaza municipality and the EU represented by the Agro Vision Holland BV from the Netherlands for provision of technical assistant services to the municipality. The contract amount was ECU 1,285,000. In 1995-96, the Commission allocated ECU 5.8 million, of which ECU 5 million was made available under a second Financial Agreement OT/95/02 (budget line B7-711) between the Commission and the Municipality of Gaza City.

Generally speaking, the feasibility of the 3 R' should be investigated at the regional level (Gaza Strip) and not just the local level (Gaza City). This is because (1) the amount of recyclables in Gaza City alone may not be sufficient to justify the necessary investments in recycling plants and (2) Gaza City is not large enough to market recycled materials (Coad, 1997).

In the Gaza Strip very little recycling takes place from the discarded waste. A few scavengers were observed at Khan Younis landfill, Gaza and Deir El Balah, collecting metal, which they sell to dealers in Israel. Earnings are about US $5.50 per day per scavenger. Two scavengers were also seen at the Gaza City landfill. They collected scrap iron and car batteries, which they sold to dealers in Israel and earned about US $10 per day each.

Transparency, accountability and fiscal discipline of Gaza municipality staff through training, incentives, cost of conduct have been increased. Gaza municipality has special mechanism in approaching donor countries mainly in large infrastructure municipal projects.

Increase revenues from resource recovery like the case with the 3R's pilot project has encouraged waste minimization at source. The close monitoring and evaluation performance through municipal financial and budgeting departments have resulted in financial control with the assistant of the EU.

7.4.5 Environmental

In 1998, an assessment was made on the range of knowledge, attitudes and practices related to environmental health, hygiene and sanitation with the local communities, and their preferred ways of participating in project's activities in general and EHE/CP activities in specific.

The project organized many out-reach activities addressing the 3R's in the community. Activities were planned per City Area, and potential partners for EHE activities such as community leaders, NGO's and governmental organizations were asked to participate and later to assist in facilitating EHE activities.

A broad range of activities addressing 3R's have been implemented:

- Baseline and data accumulation;
- Crash cleaning public awareness at neighborhood level and at the beach;
- Support of regular cleansing by home visits, neighborhood meetings;
- Public information center by means Mobile Exhibition on Environment and participation in special exhibitions on the 3 R's;
- Youth program in schools. Summer camps and youth clubs;
- Restaurant programs;
- Shopkeepers visit;
- Mosque program;
- Health clinics program;
- Production of extension materials; and
- Training on 3 R's

Restaurants were visited by the EHE team per City Area to encourage owners to cooperate with the municipal waste collection system. A 3 R's Mobile Exhibition on Environment toured the schools and summer camps, as well as Theater show on garbage named Hafiza & Mtawa in an attractive manner has been appreciated by the children. In 1998, the Mobile Exhibition on Environment was expanded with a music theatre for children about the 3 R's. Basic concepts were explained, enhanced by pictures and real life examples of re-used materials. A small workshop followed the performance in which the actors discussed with the participants to re-use household and school waste products such as carton, paper and plastics.

The main reason for this project was the unfavorable environmental situation in Gaza City in 1994, which had a negative effect on the health status of the population. For example, the many uncollected piles of solid waste in those days contained mosquito-breading sites that caused transmission of infections. Many rats brooded and lived in and around the solid waste heaps and transmitted a variety of disease including plaque, leptospirosis, flea-born typhus, rat-bite fever, and salmonellosis.

7.4.6 Socio economic

The people of Gaza City are still adapting to the new waste collection services. MoG's Department of Health and Environment projects that about 70 percent of the population will bring their waste to the municipal containers by the end of 2000. Therefore, source separation (at the household level) of recyclable materials will be very difficult to achieve in the short term. Source separation may not be implemented before 10-15 years in Gaza City. During this period, the people would need to be convinced that it is better for the environment to sort their waste (MoG, 1996).

Assuming a population of 360,000 inhabitants in 1996, the daily amount of solid waste generated per capita can be estimated at 0.92 kg/person (330,000 divided by 360,000). This per capita rate includes solid wastes that are not generally included in the municipal solid waste stream. However, many families are in Gaza City are surviving form the scavenging in different landfills. One of the constraints on the 3R's in Gaza City is the transportation cost between different areas.

According to the reports by UNSCO, (2000), it was estimated that about 17 percent of the population of the West Bank and 33 percent of the Gaza Strip lived in poverty. Tentative estimates for (1994) suggest that while Gross Domestic Product (GDP) grew by 7.3 percent in real terms, Gross National Product (GNP) grew less (3 percent in real terms) due mainly to the continued loss of employment opportunities for Palestinian workers in Israel. Construction has traditionally occupied the largest share of Gaza's GDP, estimated at 69 percent in 1987.

Industry's share in Gaza's GDP was estimated at 13.7% in 1987 but declined to 12.2 percent in 1990. Based on personnel interview with Gaza Municipality in August 2002, hundreds of small-unregistered industries in food, textile, and metallurgy sector are spread throughout the city.

7.4.7 Case Study Three – 3R's

The Municipality of Gaza in cooperation with the EU is enhancing the policy on waste management advocating the philosophy of Reduction, Reuse and Recycle (3R's) as a strategy initiated by the Ministry of Environmental Affairs and the Ministry of Local Government as depicted in Figure 7-7.

The CATWOE elements for this case is developed as the follows:

C: People living in Gaza City and the Beach Refugee Camp

A: Gaza Municipality, UNRWA, EU

T: 3R's as part of waste minimization as an environmentally and economically means to extend landfill span and conserve natural resources.

W: To produce some recycled products as a means of surviving strategy to poor families as a source of income.

O: Gaza Municipality, private sector

E: Gaza Municipality, special relations with local community and private sector.

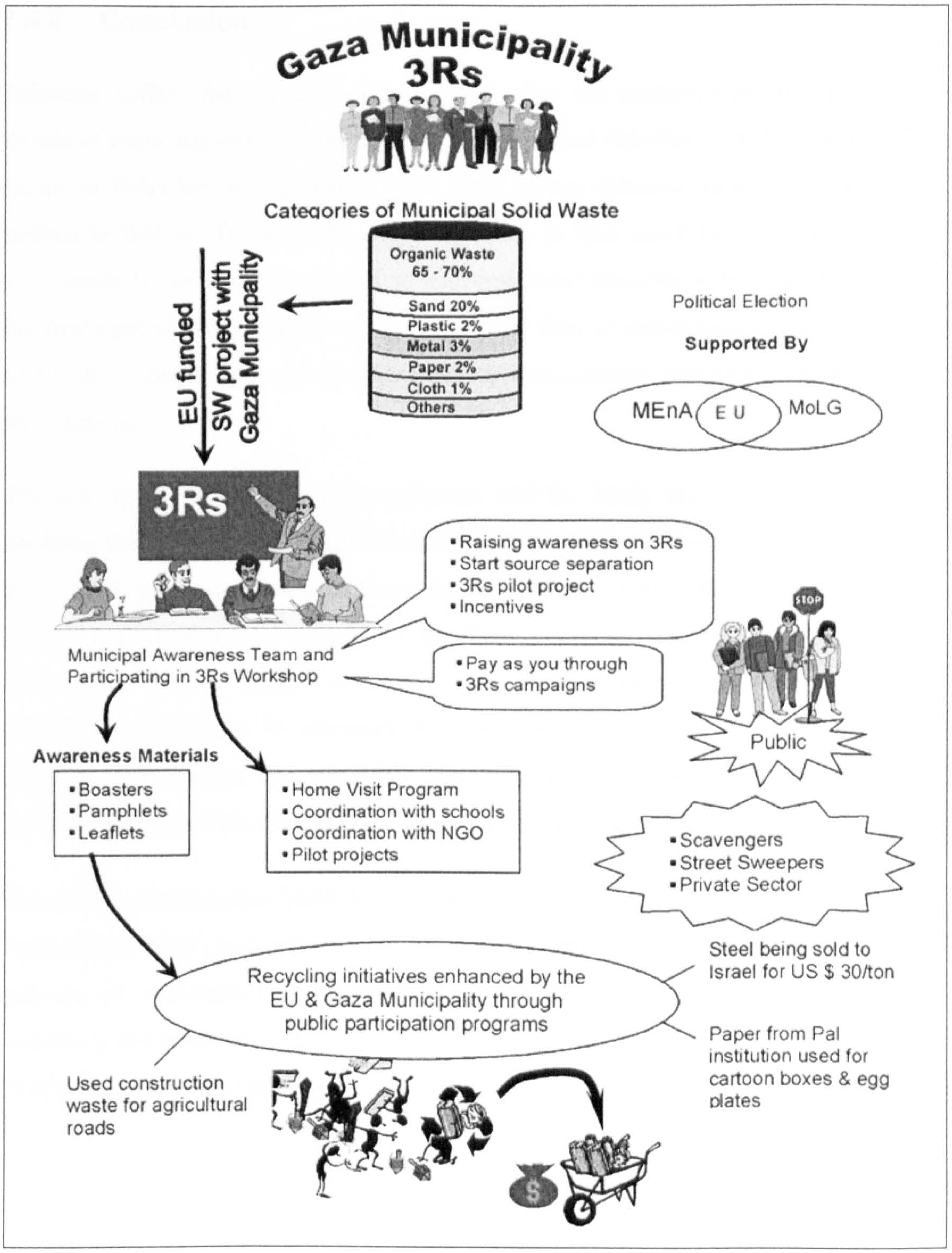


Figure 7-7: Rich Picture for Gaza Municipality - 3R's Case Study Three

Source: Developed by the Researcher

7.4.8 Conclusion

Palestine suffers from a lack of convenient sites for sanitary landfills, and so any means of reducing waste quantities is to be welcomed (El-Hawi, 1997). The recycling sector in Palestine will probably grow quite slowly because there is no established pattern to follow. To persuade people in Gaza to take more responsibility for their own waste is not easy. An appeal to environmental conscience may work for some, but many people are too lazy or do not have the time or inclination to take the trouble to become more aware of their impact on the environment and take responsibility for their actions.

The availability of markets for recyclables will inevitably play an important part in deciding the level of recycling achieved, and will influence participation rate in the 3 R's. The higher and more consistent the rate, and the lower and more consistent the contamination, then the higher the likelihood that markets for intermediates will emerge and sustain themselves. Before recycling can make a significant impact on quantities of waste to be disposed of, it will be necessary to develop reprocessing facilities and markets for recyclable materials, and to develop public awareness to motivate the public to consume less and separate recyclable material

Generally speaking, the feasibility of the 3R's should be investigated at the regional level (Gaza Strip) and not just the local level (Gaza City). This is because (1) the amount of recyclables in Gaza City alone may not be sufficient to justify the necessary investments in recycling plants and (2) Gaza City is not large enough to market recycled materials.

7.5 CASE STUDY FOUR: Incineration of Medical Waste – Shifa Hospital

7.5.1 Introduction and background

Medical Waste Situation in the Gaza Strip

The Ministry of Health, United Nation Relief and Works Agency (UNRWA), Non Governmental Organizations (NGO's), private sector and Military and Police Medical Services are the main providers of health care in Gaza Governorates. But the government bears the heaviest burden of health services (MoH annual Report, 1998). MoH is responsible for supervision, regulation and control for health services. There are 65 hospitals in Palestine under the responsibility of the MoH, Military services, NGO's Palestinian Red Crescent Society, private sector and UNRWA. 17 out of them are in the Gaza Strip, with ratio 66,949 persons per hospital and 48 are in the West Bank, with ratio 41,915 persons per hospital. The bed/population ratio is 1.4 beds per 1000 inhabitants. In addition, MoH provides 80% of beds in the Gaza Strip and it operates five hospitals. There are more than forty primary health care clinics under responsibility of the MoH and UNRWA, the second major health provider in the Gaza Strip (MoH, 2001). MoH has 8 hospitals in the Gaza Strip and Shifa Hospital is the largest one (Massrouje, 2000). Shifa Hospital is located in Gaza City and it has 562 beds and includes different specialty, such as Oncology Department, Operation Department, Cardiac Department, Dialysis, X-Ray Department (radiology), Blood Bank, Dentistry, Laboratory and Intensive Care, Additionally, it includes Maternity Department, Pharmacy, Pathology and Plastic Surgery and Buns. Moreover, more than 1000 employees are working in this hospital from the different disciplines. For being the major hospital in Palestine, this site was selected as a representative of hospitals to assess the disposal system (incineration) being applied. Incineration facilities were made available in Jericho and Gaza by donor countries (Spain government) as a means of solving the health care waste management problems.

How big is the problem?

The disorganized and chaotic management of health care waste leads, rightly or wrongly, to the public belief that an institution is an unhealthy place and failing in its responsibilities (Rushbrook, et al, 2000).

Health care waste in the Gaza is being collected and disposed of with domestic (general) waste. It is observed that, at the dumping sites at Shifa hospital , kids and scavengers have been noted to wait for hospital wastes so as to pick up the attractive sharp boxes, some of which are then re-used for the withdrawal of water from cisterns and or for other uses after being washed.

None of the health care waste containers are protected against scavengers or animals. At the same time, garbage collectors are unprotected. However, if and when vaccines are available, they are vaccinated every few months. Needles, bandages, remaining samples from laboratories, such as laboratories cultures are disposed of in plastic bags without being disinfected.

The major stakeholder in the production, transport and disposal of healthcare waste were given the opportunity to discuss the problems at two workshops held on the 3rd of January 1997 in Gaza with support from an international technical expert. At the commencement of the workshops on the appraisal of the seriousness of the current situation was made by the Minister of Health and the workshop participants were urged to consider the situation very carefully and report back on their deliberations. Representatives from the healthcare sector, municipal authorities and the private sector attended.

7.5.2 Technical and operational

The situation in respect with health care waste (HCW) management in Palestine has been a matter of concern for some time. Ministry of Health is responsible for monitoring of landfills and treatment including problems arising from solid waste in cooperation with MEnA and municipalities. (Qumboz, 2002) has found that, the amount of medical waste, which generated in health care organizations, is about 8 tonne/day and about 2.67 kg/capita/day. In Shifa Hospital (MoH, 2001). There is no segregation of the medical waste except sharps, which are collected in special boxes, donated by WHO. There are no storage rooms for medical waste. In addition, there is no system of color bags. In Primary Health Care Clinics (PHC), medical waste is being disposed with domestic waste without separation or any treatment process. Medical waste is collected in thin plastic bags, and there is no checking on the material to be incinerated. Oncology in Shifa department in Shifa hospital sends plastic containers containing cancer waste and they are incinerated with the MSW containers (Massrouje, 2000). The ashes are collected manually, sometimes they are thrown directly over the domestic waste, and sometimes they are collected in thin plastic bags easy to be punctured and disposal with domestic waste. The workers have no protective devises (special clothing, thick gloves, boots or goggles) or washing facilities. There is no documentation or registry of any data on incinerated items, except in paediatric hospital; date of incineration is registered. It was reported by the workers that there is no maintenance check up. In visiting the Landfill municipal disposal at "Al-Mazra'a", it was observed that there are special cell at Gaza landfill for medical waste, but they were empty, except for one concrete box, which had pharmaceuticals. In addition, leachate generated from health care waste was observed to be discharged jointly with other domestic liquid waste.

The incinerator was observed to work at temperature 500-850 degree centigrade and it is never reach 1000 degree centigrade. The height of the stack is 8 meters from the ground and there is no control device as shown in Photo 7.4, (Massrouje, 2000).

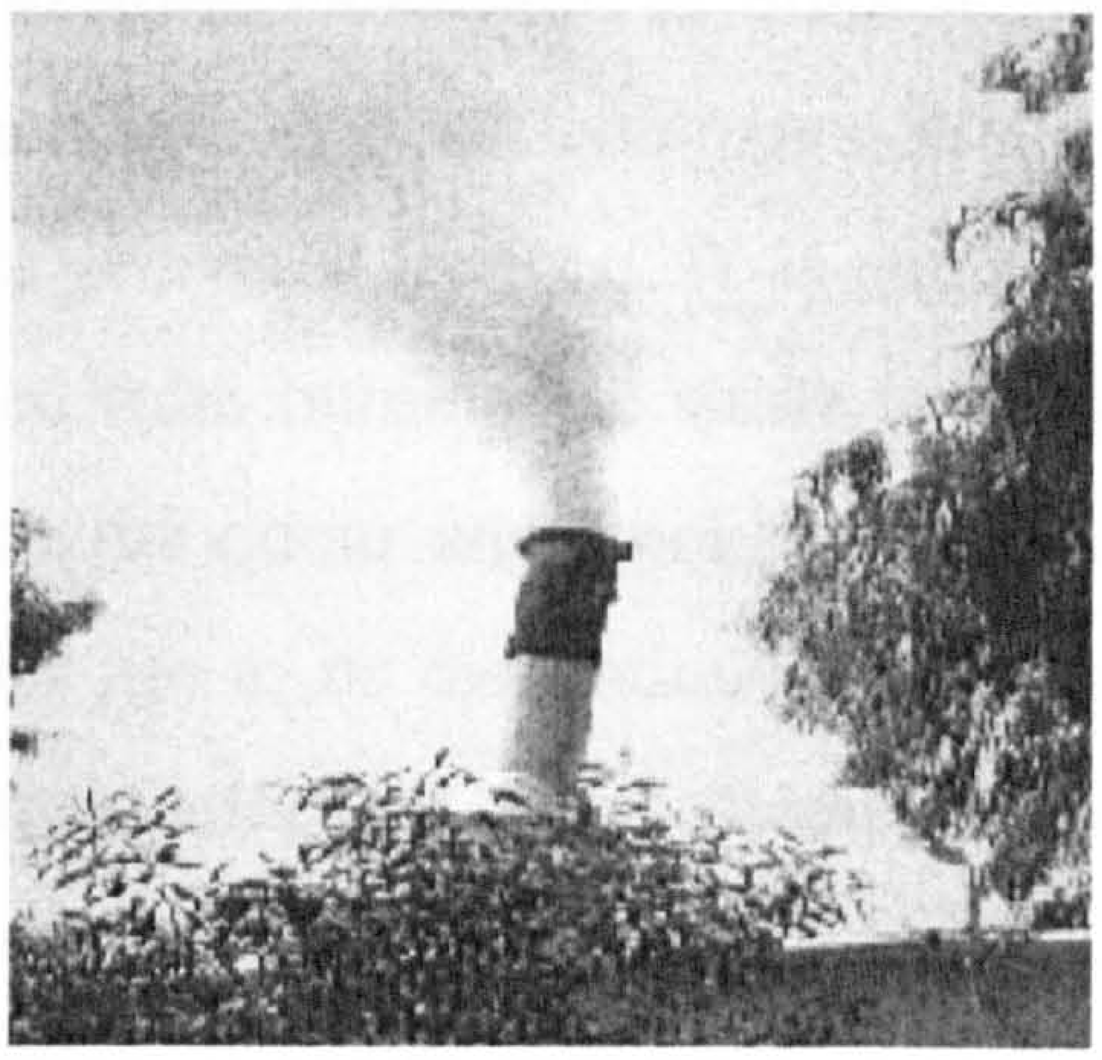


Photo 7.4: Chimney of Shifa Hospital Incinerator
Source: Massrouje, 2000

Pathology department wastes (2.6%) were used to be buried in Shifa hospital yard, but it was reported that since the current Intifada (2000), it has not been buried because of the hazards it causes, and it was accumulated under the stairs in Pathology department (Massrouje, 2000). (Bastone et al, 1989) has calculated the amount of health care waste in the five hospitals in Gaza (692 beds) using the average for developing countries (0.9 kg per bed per day), the amount of health care waste could be calculated at 623 kg a day. In March 1997, a survey was carried out in Shifa Hospital on the generation and the amounts and types of hazardous (Zaorob, 1997). It was calculated that 35% of the total amount of the waste generation of this hospital was hazardous waste. This indicates poor segregation practice according to the international standards (WHO, 1992).

7.5.3 Environmental

Documents to show readings, details or waste characteristics, amounts are not available as stated by the evaluation team. In addition, guidance, policy or precautions in which how to operate the incinerator is not available. Diagnosis of health workers operating the incinerators are not available, protective clothes, gloves, and other protective tools necessary for handling of health care waste even a bathroom for workers to have a shower after work are not available at the hospital. Trained staff to operate the incinerator is not available. Shaifa incinerator works at Temperature 800 Degree centigrade; around 500 kg is the daily burned waste at this incinerator. Odour and smoke produced by existing incinerator at Shifa hospital has resulted in public opposition that forced their use to be discontinued. No segregation of HCW from municipal waste. Leachate generated from HCW is not being taking good care of. At the same time, ash resulted from burning the waste is being disposed of jointly with municipal waste. However the odour and smoked produced by them caused public opposition that forced their use to be discontinued. The low chimney height and the proximity to residential areas added to the problems. Objections to the use of these treatment facilities have emphasized the need to examine alternative methods and to reconsider the whole question of health care waste management from the beginning. There is no control on incinerator emissions and no measurement of pollutants production.

7.5.4 Institutional

Lack of Organizational structure (Who is doing What) to deal formally with HCW services including participation, tendering and contracting. Skilled and trained staff to deal with HCW are not available. Staff working at Shifa hospital was not motivated to take training on HCW. Shifa hospital is not partnering with any Palestinian institution to deal properly with HCW problem. Inadequate practices are due to lack coordination between ministries and lack of knowledge between people who work in the health field.

7.5.5 Financial

In 1996, Spain government has donated an incinerator of type Kalfrisa to Shifa hospital. The incinerator has started to be operated in 1997. Shifa hospital doesn't have special budget to implement integrated health care waste management system. Mechanism to cover operation and recurrent costs of health care waste management at Shifa hospital doesn't exist. As a result, Shifa hospital was unable to cover operation and management of the incineration, which is the key issue for the un-sustainability of the facility. Cost of reduction and control of HCW is not available.

7.5.6 Socio economic

In 1999 an investigations by official team from the Ministry of Health, Ministry of Environmental Affairs, Hospital Administration and Total Quality Management Project to evaluate and assess the current situation of the Health Care Waste Management at the main three hospitals in the Gaza Strip. The results of the investigations have shown a very serious nature of the situation. They also reveal the fact that there is no satisfactory system of management of health care waste. Examples are given of children having easy access to, playing with and being injured by used medical equipment (such as syringes with needles) with all the associated risks being present such as that of infection and permanent injury arising from playing with discarded sharps and other health care waste. The autoclaving of waste from laboratories is not practiced in every case. Mismanagement also puts at risk municipal waste operatives and leaves health care waste on landfill sites open to scavenging by humans, animals and birds with the resultant risks of disease transmission. It is not possible to assess the extent of the problem of risk to employees because no records are kept of industrial injuries or illness affecting healthcare or municipal workers.

7.5.7 Legal and Policy

While primitive and rather inadequate municipal legislation regulating solid waste disposal in the West Bank and Gaza Strip does exist, nevertheless, it is common knowledge that such legislation is almost never enforced. Some hospitals have instituted initial procedures to regulate medical waste disposal, through the disinfecting of disposable materials and cultures before disposal. These procedures are not practised at any private laboratory in the area. Moreover, such procedures are not developed or applied in most hospitals as well. It is clear that much needs to be done in the area of examining existing legislation, assessing its relevance to present need, researching why it is that existing legislation is not being implemented, and formulating a legislation plan of action.

In Palestine, in 28 December 1999 a draft of environmental law was issued, in which medical waste is considered as part of hazardous waste where it should be governed by specific guidelines. Also an environmental assessment policy has been issued in which medical waste is considered as a national priority by official Palestinian institutions like MoH and MEnA.

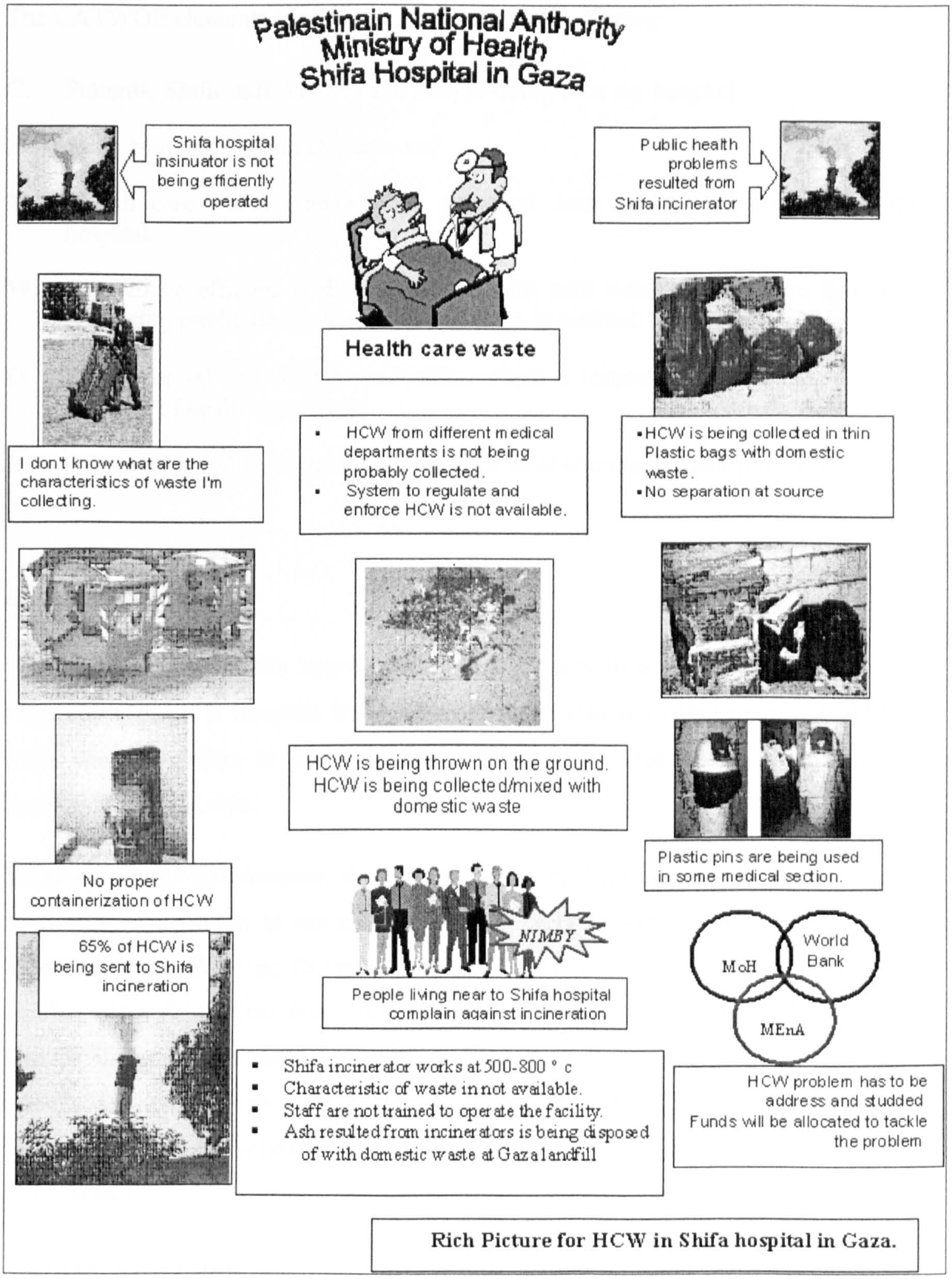
Proposed Recommendation, Summary, Conclusion Materials

- The medical waste handling and management is one of the neglected areas in the Health or Environmental sectors at the time when this issue is dealt with as a top priority issue in most countries in the world.
- Lack of resources including data requirements for policy formulation, planning and upgrading.
- The associated diseases related to medical waste like hepatitis, tetanus and aids in some cases.
- The need of understanding of what the risks are especially issues related to public health.
- The need of a comprehensive plan involving all associated personnel and all stages of the management process.

- A careful consideration of human factors - motivation, training and supervision are often the primary needs.
- A plan for sustaining improved practices, including provision for a regular supply of consumable, and maintenance and cleaning of equipments.
- To convince the health care facilities select a satisfactory facility for final disposal.
- Information should be collected about the incidences of illness and incidents involving medical waste among hospital employees, in order to determine what further action is needed.

7.5.8 Case Study Four – Incineration

Health care waste in the Gaza is being collected and disposed of with domestic (general) waste. It is observed that, at the dumping sites at Shifa hospital, kids and scavengers have been noted to wait for hospital wastes so as to pick up the attractive sharp boxes, some of which are then re-used for the withdrawal of water from cisterns and or for other uses after being washed. HCW has been explicitly in the next chapter. Figure 7-8 depicts rich picture incineration.



Rich Picture for HCW in Shifa hospital in Gaza.

Figure 7-8: Rich Picture for HCW – Incineration –Shifa Hospital Case Study Four

Source: Developed by the Researcher

The CATWOE elements for this case is developed as follows:

C: Patients, Shifa staff, visitors and People living near the hospital

A: Shifa hospital (Admin Department)

T: Health care waste management generated from various departments in the hospital.

W: To achieve efficient and sustainable health care waste management to ensure protecting public health that people in Gaza is entitled.

O: Shifa hospital and Gaza Municipality, which is responsible for transporting and disposal of health care waste.

E: Gaza Municipality, special relations with local community and private sector.

Lessons Learned

It became clear during the interview and discussions with staff at the health facilities particularly in Shifa Hospital that healthcare waste was not being managed and that there was no system in place to ensure that it was separated from the normal municipal waste stream.

Results from the questionnaire distributed to the target group showed that this matter needs urgent attention to ensure that it is properly managed. A summary of the outcomes of the Working Groups illustrates that there is a need to study the issue in much greater depth than that which can be achieve in Workshops. The Working Groups illustrated the need to establish a task Group considering of all the major stakeholder with clearly defined terms of reference and in particular to rapidly identify a short term solution and develop a longer term strategy after carrying out a pilot project.

This case study is primarily concerned with the hazardous wastes generated by health care facilities. Simply, because it is known that the ability to infect other living organisms and the ability to produce toxins are the most significant characteristics of these wastes. The International community represented by the World Health Organisation WHO has called several years ago to consider hospital wastes as special wastes. Consequently, a working group on hospital waste management was held in

Bergen in 1983 to produce recommendations on this subject. Included in this group of solid wastes were pathological tissues taken during surgical procedures and contaminated materials, such as hypodermic needles, bandages, and outdated drugs.

It is believed that a substantial proportion of medical waste output is generated by the secondary and tertiary care centres of the country, most notably hospitals. In the West Bank, there are currently 19 operational hospitals, while there are 6 in the Gaza Strip, totalling 25. Within these institutions, it is estimated that there are about 3000 beds. Under normal circumstances, the governmental hospitals have an occupancy rate of 70% while the nongovernmental hospitals have almost an occupancy rate 30%.

It is not clear that this is due to negligence, but probably due mainly to the list of pressing upgrading priorities indicated by these institutions. At the same time, there is clear evidence of the need for an awareness campaign-taking place within these institutions, directed towards the work force as well as towards decision makers at these institutes. Once a system is in place, it is doubtful that the existing work force would have enough expertise or experienced personnel who can run a well-defined medical waste handling system. This implies that upgrading/training schemes are needed in the near future.

The initial results revealed that medical wastes disposal or treatment is altogether either overlooked or underestimated and not given the proper attention. They further revealed that no definitive criteria exist for waste segregation on any level as all waste is treated equally and disposed off in the same manner. There is no assigned task force for handling waste in general and the medical type in specific. Porters are assigned to take waste and dispose it with the domestic waste in addition to other assignments such as room cleaning, food carrying and kitchen work. Everything is done manually without protection. And the safety precautions are at a minimum, if at all since there is no segregation.

- To propose and set a suitable property of collection, transportation and final disposal of medical waste generated in Gaza clinics with special focus on community clinics and hospitals.
- To remind the hospital porters, who deal with medical waste every day, know that they are dealing with hazardous waste.

- To raise the awareness to those people through proper health education given by expert doctors also, to provide necessary training for the workers.

- To provide some recommendations to the PNA to be adopted by the Min. of Health after other community clinics demonstrate like this project.

- To protect the public health and provide personal hygienic to those whom deal with medical and infectious waste.

- To produce a technical material/ report on medical waste management, which will be discussed in a workshop associated with some acceptable recommendation.

Data gathering on medical waste quantities, composition, handling problems, disposal and safety procedures to be collected, very limited number of local studies or surveys were conducted on quantities or composition of medical wastes in the Gaza Strip.

It should be noted that not all health care institutions need to operate their own decentralized medical waste handling system. Such a scheme has at times proven to be the wrong solution to the health care waste problem. Alternative options exist and must be taken into consideration when planning for the future upgrading of the system, including perhaps a serious investigation of including the private sector within such schemes. In the next paragraph, solid waste indicators will be introduced in the light of the four disposal options highlighted for the four case studies.

7.6 Developing Indicator Applicable for Solid Waste Disposal

In this section the analytical framework is developed by showing which indicators can be used as measurement tools for the 6-point system of Environmentally Sound Perspective described earlier. At this point it should be stated clearly that the indicators used, which refer to technical & operational, institutional, financial, socio economic, environmental policy/legal dimensions, are qualitative indicators that are used to analyze, express or describe aspects through which the variables contribute to particular goals (landfilling, composting, recycling and incineration). They can hardly measure quantitatively the contributions they make, because they refer to very different types of aspects that cannot be easily weighed against each other.

Nevertheless, these indicators can reveal the variables influencing the solid waste process and thus are relevant to show policy makers and other actors where they put forward efforts in order to develop a disposal strategy of MSW for the Gaza Strip.

7.6.1 Approaches to indicators classification and use

The most commonly used framework for developing environmental indicators, the Pressure-State-Response (PSR) framework, was developed by the OECD in the early 1990's. In reaction to an increasing interest in the measurement of environmental damage (such as ground water pollution as a result to leachate percolation) and in evaluating the effectiveness of environmental policy measures. The PSR framework is based on the idea that human activities exert pressure on the environment (represented by pressure indicators), thereby changing the quality of the environment and the quantity of natural resources (represented by state indicators). Society responds to these changes through environmental, economic and sectoral policies (represented by response indicators). Policy responses affect individual and collective actions (i) to mitigate, adapt to or prevent human-induced negative impacts on the environment, (ii) to halt or reverse environmental damage already inflicted, and (iii) to preserve and conserve natural resources (UNCSD, 1998).

Some indicators were very difficult to answer because of the complexity in gathering the relevant information. The indicators that were adoptable and answerable were used to analyze the different variables in the four case studies. The indicators selected from the literature reviewed and used for the analysis and assessment of the case studies is presented in the Table 7.7.

7.6.2 Developing and Applying Solid Waste Indicators

The indicators that are presented in Table 7.7 are based on the literature review and on discussions with leading persons in the Gaza Strip of solid waste management research and practice. The solid waste indicators were developed in such away to be reliable, readable, and measurable to help policy-makers and the PNA make proper decisions on the disposal option of MSW.

That's how indicators of solid waste being selected to represent disposal alternatives mentioned in the four case studies. Later on, each variable was given a weight based on its importance and effectiveness.

Indicators shown in Table 1 in Appendix II were based on criteria analysis developed for the research. However, the scoring of indicators was based on professional judgment of the author. The author judgment alone and is presented as work invalidated from other sources. This is why it is given in the appendix, as an example of how these indicators could be developed. If these indicators to be fully developed for research purposes, their relevance needs to be justified and they need to be validated in the proper way (further research).

7.6.3 Criteria for selecting indicators

Some of the technical problems that limit the relevance and the applicability of the selected indicators can be avoided or reduced by following a simple set of criteria when developing indicators. Indicators need to be substantively relevant, be valid for the areas to which they relate and reliable (UNCHS, 1997). The OECD (1990) also adds that indicators should be easy to understand, even for people that are not experts on the issues concerned, in order that assessments may be valued by larger groups of people.

After a review of the existing literature, a first list of indicators was compiled. Based on the criteria for selecting indicators that were relevant, reliable, and measurable, a core set of indicators was selected to be used in assessing variables in the different case studies. These indicators were divided into six dimensions, which were then used to study each variable. Some indicators were very difficult to answer because of the complexity in gathering the relevant information. The indicators that were adaptable and answerable were used to analyze the different variables in the selected case studies. The indicators that were not used for the assessment of the various variables could be studied to see whether they can be improved in definition and availability of data. The above criteria describe the "ideal" indicator and not all of them will be met in practice. In the present study, indicators are reviewed according to the following criteria:

- relevance to the goals,
- validity;
- measurability, taking into account availability of data, quality of data, and international comparability.

7.7 Rating Matrix and Indicators to Measure Effectiveness of Disposal Options

By clustering these indicators, the different options available for the design (or improvement) of a waste management system could be given a rating on each aspect influencing disposal option.

These ratings could be summed up and the total would thus indicate the overall percentage of the disposal option. However, the question remains whether some aspects are more important than others, some might be "necessary", others just "sufficient" conditions for "disposal alternative". Also the question, which criteria are most suitable and which weights appropriate, needs to be answered.

7.7.1 Analysis preceding the selection of new technologies

Selecting appropriate waste technologies is not an easy matter. It depends on the local context in which the technology will be applied but also on national and even international conditions (Klundert et, al,. 2001)

The general conditions used to assess and analyze the different variables/aspects and the area of investigation as shown in Table 7.7 (WASTE, 2001 P:27)

- Low labor costs and extreme shortages of capital; an indication that solutions should minimize capital expenditure and minimize hand and animal power (economic aspect).
- A waste stream dominated by organic waste (environmental aspect)
- A complex informal sector that is very active in collection, separation and recycling of waste (social aspect)

- Significant mixing of hazardous wastes with municipal waste (environmental aspect)
- Few people adequately trained in SWM (institutional aspect)
- High proportions of the urban population with low levels of education, combined with low awareness in the community of the health and environmental hazards of waste (social aspect)
- Inadequate physical infrastructure (institutional and technical aspect)
- Shortage of spare parts, especially from abroad, because of lengthy procedures for obtaining foreign exchange and arranging clearance (institutional and legal aspect)
- Weak legal context for contracting and bias against contracting with micro and small enterprises (legal and institutional aspect).

Table 7.7: ISWM Aspects and the selection of waste management technology

Source: (WASTE, 2001),

ISWM	Areas to investigate
Technical	1- Waste quantities, waste composition, density 2- Capacity of collection or treatment technology (how much waste can be collected, how many people can be served, which areas can be served with it) 3- Physical infrastructure (condition of road and traffic) 4- Sturdiness of equipment/technology 5- Local availability of spare parts
Environmental	6- Effects on technology on the environment 7- Effect of technology on opportunities for reuse and recycling 8- Working conditions & environmental health of waste workers
Financial-economic	9- Capital and labor cost 10- Operation and maintenance costs compared with waste management budget 11- Feasibility of covering depreciation (cost of replacement)
Socio-cultural	12- Average level of awareness among population 13- Willingness and ability to pay 14- Cultural attitude towards waste and implications for waste handling, separation at source, recycling 15- Gender and sex roles relating to management of waste within the household
Institutional	16- Skill level waste management staff 17- Procurement methods for imported spare parts

ISWM	Areas to investigate
Policy/Legal/political	18- Political priorities (e.g. increase employment, reduce imports, improve environment) 19- Policy and regulations regarding technologies and equipment 20- Contracting rules; biases in contracting procedures

The indicators presented in Table 7.7 are based on a review of the exiting literature related to indicators and goals for the disposal strategy, on the criteria for the selection of indicators. These indicators will be again examined in the light of case studies using an evaluation matrix as explained in Appendix II.

7.8 SUMMARY

This chapter presents the concept of the disposal strategy of MSW, in the context of the selection of technologies and the design for MSW system. Technologies applied on MSW disposal strategy were adopted from the technology of integrated solid waste management. In the environmentally sound strategy of municipal solid waste disposal option concept, some solid waste indicators were distinguished: Technical, environmental, financial, socio-economic, policy/political and institutional aspects. As described in chapter 4, the integration of the six own specific ways determines to the sustainability of the system. The integration of the six aspects is instrumental in both the assessment and the planning of a sustainable waste management disposal strategy and so they play a role in the assessment of the disposal options using these indicators. The principle and mechanisms of MSW were explained and their relevance for the technology selection and system design were outlined. It is emphasized that waste management is not a purely technical issue but that other aspects need to be taken into account, while selecting a technology or design a system; some factors (institutional and financial) were more influential than others.

SSM has been applied to the four case studies representing disposal options. Rich pictures developed for each case has described the existing/problem situation of disposal means, institutional arrangements, organizational structure, conflicts and constrains. Root definitions described what the system is and what it aims to achieve- as each stakeholder sees it. CATWOE elements developed for cases have illustrated beneficiaries or victims, who perform the transformation process with some inputs, description of worldwide, which makes the transformation meaningful, the person who cam stop the transformation and finally the constraints from the surrounding environment.

In these four case studies, some of the aspects considered have a much bigger influence than others on the final choice of the system. In practice, the relative importance of the aspects will vary from one solution to another and there is no universal “best solution”. That’s how indicators of solid waste being selected to represent disposal alternatives mentioned in the four case studies. Later on, each variable was given a weighted score based on its importance and effectiveness.

Some indicators were very difficult to answer because of the complexity in gathering the relevant information. The indicators that were adoptable and answerable were used to analyze the different variables in the four case studies. The indicators selected for case studies were used for the analysis and assessment. Evaluation for the four disposal options as resulted from table 5 and figure 1 in appendix II have indicated that institutional and financial percentages for landfilling option were 21% and 8% respectively while 12% and 4.8% for composting option. The 3R's were 12% and 5.6% respectively; the last option (incineration) was 6% and 4.8% respectively as explained in Table 5 Appendix II.

CHAPTER 8

PART V: CONCLUDING PART

CHAPTER 8: DISCUSSION AND SUMMARY

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CHAPTER 8:DISCUSSION AND SUMMARY

This chapter addresses solid waste management process in the Gaza Strip in an attempt to contribute to the development of a disposal strategy of municipal solid waste. The objective of this chapter is to summarize and conclude together with some reflections on the research developed in this thesis. The literature highlighting SWM existing situation in the Gaza Strip has been reviewed. The analysis has provided an holistic overview and demonstrated the need for an environmentally sound disposal strategy for the MSW in the Gaza Strip.

The approach taken borrowed SSM concept based on system thinking representing the real world has been applied to the SWM. The application of SSM to the case studies representing disposal options through the traditional seven stages of the SSM and the interaction between the system components has resulted in some findings and conclusions. The application of solid waste technology in the case studies through selecting of criteria and indicators has led to the development of an evaluation matrix of disposal options see the appendix. Although this matrix was constructed, its not claimed that this evaluation was the main core to judge the disposal alternatives (further research is needed in this area).

This chapter is divided into three sections where SSM was used for the situation analysis of the disposal options through case studies as illustrated in section one. Section two, which answers the research questions. Section three, is the combination of section one and section two in order to achieve the research objective represented by the disposal strategy of MSW suitable for the Gaza Strip as the following:

Section one; of chapter eight, deals with the concept of SSM and its qualitative characteristics. The conceptual model generated from the SSM was a significant objective of this research. It also made a significant contribution in its differentiation between hard and soft system thinking. SSM was used as a guiding set for the analysis and assessment of the SWM in the context of the sustainability agenda. It is a tool that represents a significant contribution to the development of a disposal strategy of MSW suitable for the Gaza Strip case. During this research, it became clear that considerable work has been done on waste management issues but there were many areas where information was absent. The greatest challenge was to the weakness of SSM to be applied to the technical and economical part of SWM strategy within the context of sustainability. Also the weakness of SSM was found with the technical accessibility of human activity system. The strength of SSM was seen to be the participative and accessible nature of rich pictures together with the overall discipline and action orientation of the methodology.

However, SSM has proved an effective tool in analyzing and assessing the institutional and social aspects influencing SWM. Finally, the desirable/feasible, needed changes resulted from the conceptual model will be to develop actions in order to improve the solid waste disposal situation.

Section two; of chapter eight, presents answers to the initial research questions. Some conclusions are on the need to adopt new intellectual positions in order to move towards an environmentally sound disposal option for the MSW in the Gaza Strip. It has been demonstrated throughout this research that the goals of sustainable disposal options require an integrated SWM associated with more participation of the public in SWM decision-making, which will result in improvement of solid waste process. A holistic view starting from the generation to the disposal is needed at each stage of the activity.

The work has been concentrated around some key issues presented in chapter five and this part of the thesis returns to them in an attempt to answer the research questions defined as:

- How can MSW disposal contribute to the development of sustainable disposal strategy objectives?
- Are there any Palestinian strategies and policies of waste disposal?
- What is happening in the process of SWM and the institutions concerned with the service delivery within the Palestinian system, these questions could be divided into the following:
- To what extent SSM can be applicable tool for the analysis of solid waste management in the Gaza Strip?

- Can solid waste indicators be developed for disposal options represented by case studies?

Section three; had the objective of illuminating the way to develop an environmentally sound and sustainable disposal strategy for the Gaza Strip. An objective was to integrate available knowledge for the synergetic development of integrated sustainable solid waste management framework. A strategy of MSW disposal will support the development of a Palestinian waste management Action Plan. The possibility for a program of further research and development is the final concern of this research.

8.1 Section One: SSM and Its Applications

Soft System Methodology and system thinking approaches contributed to the concept of the qualitative perspective and inter-relationship with their perceived relationships with options and the conceptual model created have illustrated the understanding of SWM, in the "real world". The application of SSM to the four case studies representing waste disposal process and institutions involved in the service delivery is the key issues towards developing a Palestinian strategy of MSW in the Gaza Strip.

Other objectives of the application of SSM to the four case studies are the feasible and desirable changes developed from the comparison of real world with the system thinking. These actions have to be taken into consideration in a trial-and-error manner. In SSM, this concerns comparing the system world to the real world in order to improve the disposal situation. This issue was demonstrated by (Von Bulow, 1989) study that SSM is a methodology that aims to bring about improvement in areas of social concern by activating people involved in the situation learning cycle which is ideally never-ending.

Due to the scarcity of land available for landfilling in the Gaza Strip and as illustrated in stage one of the SSM any means of waste minimization scheme is to be welcomed (El-Hawi and Hamilton, 2001); (Haklay, 1999) described this specific problem and its environment in this stage. The current situation of the disposal problem has been analyzed in the initial stage as described by (Checkland, 1991: 163).

The rich picture shows clearly the SWM process starting from collection to the final disposal also actors, owners and victims including relations between them. (Haklay, 1999) argues that rich picture helps analysts to understand the problem. Checkland & Scholes, (1990) states that, rich pictures were used as a technique for structuring and expressing the problem situation).

Checkland (1991) highlighted that, in stage two, the problem situation has been defined more clearly. In this stage, SWM processing, institutions involved in service delivery, constraints and public opposition (NIMBY) has been illustrated.

Root definitions describe what the system is and what it aims to achieve-as each stakeholder sees it (Haklay, 1999). Root definition starts in stage three after crossing the line to the system-thinking world. In chapter six, three root definitions were developed for the SWM in the Gaza Strip in general at the regional level for the Gaza Strip in order to highlight who is responsible for what. In addition, root definition for the landfilling disposal option represented by the SWMC is developed since this option is the most common option being adopted by the PNA as explained in chapter seven.

According to the primary task root definition, disposal strategy of MSW is a national and environmental sanitation document. This strategy should translate into detailed measures; Policies and actions will also require a contacted effort from other authorities, ministries and municipalities. From the environmental protection viewpoint, MEnA has been assigned to perform as the official body to monitor and evaluate the effectiveness of plans and policies. The CATWOE elements, which is the first step after formulating the root definition identified for the SWM has led to the development of three root definitions as depicted in chapter seven. The CATWOE elements developed for the case studies as explained in chapter seven were instrumental in the creation of root definitions, which in tern leads to the development of revised disposal strategy and alternatives. The CATWOE elements clearly define clients, owners and victims of the service, transformation of the activity, worldview, and the environment. These elements helped in analyzing and understanding the problem situation including gaps between institutions involved in SWM service delivery.

In stage four where modeling the activities within the system occurs, the conceptual models happens in the "system thinking" world, and is an analytical part of understanding solid waste management problem situation. The CM is the result of a connection between stage 3 and 4. In the model, minimum activities associated with SWM exist for the described transformation. That's how the model is being built (based on the verbs in the RD) from these activities considering the relations between them.
Because of lower level description of the process "institutional arrangements", which followed by the CM, this level can be explained as the following: A disposal strategy of MSW is the ongoing purpose, these activities (planning, institutional arrangements, regulation and enforcement mechanism) as long as in the process will result in disposal policy and strategy formulation. Palestinian institutions (MEnA, MoPIC, MoLG) are responsible for SWM planning, policy and strategic formulation. The CM presents the interaction between the system components that RD describes for disposal alternatives as depicted in Figure 4 in Chapter Six.

Stage five, where the conceptual models will be compared to the rich pictures with the reality and discussed with the problem owner (local authority) through review of three phases: ***phase 1***, organizational structure, responsibilities of institutions involve in SWM decision-making. In this stage, clear mandate of institutions responsible for SWM service delivery was not available, lack of influential authority applied to SW in terms of bylaws, regulation and enforcement mechanism in addition, to the gaps found between MEnA and MoPIC in solid waste coordination and facilitation as depicted in the rich picture Figure 2 in Chapter Six. According to the suggestion from the CM, institutions responsible for SWM service delivery should work cooperatively and involved in the planning process.

Phase 2, connections and communication channels. In this stage, deficiencies of proper links have been observed between institutions responsible for SWM policy and regulations as explained in Figure 6 in Chapter 6. Finally, the CM recommends the creation of Solid Waste Management Experts Office (SWMEO) in order to provide evaluation and assessment of SW situation including feedback to the institutions responsible for SWM decision-making. ***Phase 3,*** time constraints related to the Israeli frequent siege and boarders closure, Palestinian bureaucracy of making decisions and lack of Palestinian experience in related issues.

Stage six, where the SWM problem is clearly expressed, the analyst is expected to have a very good knowledge about the system where solutions should be prescribed. The solutions should be discussed with the problem owners (municipalities, village councils, UNRWA) to find which are feasible or desirable. According to Checkland (1999), there are three types of possible changes: Structural, Procedural and attitude. Proper methods and techniques found (composting, 3R's) as waste minimization strategy supported by SWMEO will be considered as explained in chapter six.

Considerable funding from the international donors to SWM sector has been allocated for the sake of capacity building and improving the work of Palestinian institutions responsible for SWM. Some improvements and changes the SWM system have been provided through institutional arrangements in order to develop an environmentally sound sustainable disposal strategy. The key strategy arrangements: MEnA and MoPIC should work closely and cooperatively in SWM planning process, donors should consider SW plans developed by MEnA and MoPIC who are responsible for SW decision-making process and monitoring, control and follow up on SWM issues. A two-way communication channel has to be created by MoLG in order for the solid waste disposal process to be improved. Public participation is relatively new to the Palestinian culture and most of the time happens at the end of the process: there is a need to enhance public participation in SWM decision-making. Finally, the Proposed SWMEO will be responsible for prioritizing SW projects and evaluation of organizational structure of Palestinian institutions involved in SWM decision-making. The above changes/arrangements have bridged the gap resulted from stage five.

Stage seven (the final stage) of the SSM is the implementation of the needed and agreed changes. Proper analysis should not stop at this stage, the whole SWM system should be evaluated to produce coherent, conclusions that are structurally viable, procedurally applicable, economically feasible, politically acceptable and attitude prescriptive.

The four case studies selected to represent the four disposal options already exist in the Gaza Strip. In chapter seven, where selection of technologies and design for SWM system were adopted from the integrated sustainable SWM context. The SWM indicators distinguished (technical, institutional, financial, socio-economic, environmental and policy/political) were developed. The integration of the six influential aspects determines the sustainability of the system. The integration of the six aspects is instrumental in both planning and implementation of a sustainable waste management disposal strategy and so they play a key role in the selection of disposal alternatives. In these four case studies (see chapter seven), some of the factors considered have a much bigger influence than others on the final choice on the system. In the practice, the relative importance of the factors will vary from one solution to another and there is no universal "best solution". That's how indicators of SWM being selected to present disposal alternative explained in the four case studies. Later on, each variable was given a weight based on its important and effectiveness. Some indicators were very difficult to answer because of the complexity in gathering the relevant information. The indicators that were adoptable and answerable were used to analyze the different variables in the four case studies. The indicators selected from the literature review were used for the analysis and assessment of SWM as explained in chapter seven.

From the case studies, its found that the technical aspect was the mostly covered one followed by institutional while the socio-economic, environmental aspect were of low attention. Lack of policy and regulatory formulation was observed and as a result no enforcement mechanism was in place. These results have been supported by SWM selected indicators developed for the case studies. However, an institutional problem has been emerged from the analysis of SWM existing situation using SSM. This institutional problem has been properly dealt up with from the sustainability and integrated context, which is the key issue towards developing a SWM disposal strategy. Results from the questionnaire indicated that, lack of coordination among the relevant institutions often results in different institutions becoming the national counterpart to different external support institutions for different SWM collaborative projects. In addition, there are often duplication of responsibilities of institutions involved and gaps/missing elements in the regulatory provisions for the development of effective SWM systems. From the above evidences it's concluded that, national disposal strategy of MSW in the Gaza Strip doesn't exist. These findings were supported by the results from the analysis of SWM existing situation using SSM and the application of case studies by selection of criteria and indicators representing disposal options as explained in Chapters 6 and 7.

8.2 Section two: The Answers to the Research Questions

The main objective of this section is to present answers to the initial research questions posed by this research. The questions and answers are presented below:

The first research question was:

How can MSW disposal contribute to the development of sustainable disposal strategy objectives?

The environmentally sound disposal of MSW was the key and significant objective of this research. The four case studies selected from the Gaza Strip where each case represents one of the disposal options. The initial results from the first case study have shown that landfilling was the practice being adopted by the SWMC as the only mean of MSW treatment. No other options were observed although its estimated that around 65-75% of the MSW generated was organic waste and composting was not being considered by any municipality. The second case study (composting) presented by local NGO showed that, although composting is being highlighted as an environmentally sound disposal option parallel to landfilling and despite the willingness among local farmers to use the product with some incentives if it is in a good quality it has never been widely enhanced in the Gaza Strip. Although the compost has proved one of the accepted environmental options, this option (compost) is not being adopted on a governmental scale. The third case study, Gaza Municipality where the 3 R's were practiced on a very small scale through an EU funded project. The project was not demonstrated to cover other parts of the Gaza Strip it is ended by the end of the fund. The fourth case study is an incineration plant donated by Spain Government and installed at Shifa hospital to be used for Health Care Waste Disposal through incineration means. Lessons from this case study, has shown failure option due to the technical problems represented by separation of different types of waste at site is done only for sharps, health care waste (HCW) is being collected and transported with the municipal waste. Institutional problem, represented by the lack of responsible institution mandated for managing HCW. Environmental problems, represented from the smoke and air pollution which have never been monitored by any institution also, ash resulted from Shifa incineration is disposed of with domestic waste. Finally, the legal problems represented by the lack of regulation, legislation and enforcement mechanism to ensure an environmentally safe and sustainable way for HCW disposal.

The answer to this first question was through the analysis of disposal options using SSM and the application of solid waste indicators. Results from the four case studies have stressed the need to adopt a national SWM strategy depending on the integrated and sustainable disposal options represented by landfilling, composting, 3R's and finally incineration. These options were recommended due to the following reasons: scarcity of land available for landfilling, lack of clear mandates for institutions responsible for SWM decision-making process, these results have been clearly identified through the application of SSM as explained in chapter seven.

Tchobanoglous et al. (1993) has described integrated solid waste management (ISWM) by the selection and application of appropriate techniques, technologies, and management programs to achieve specific waste management objectives and goals. Understanding the inter-relationships among various waste activities makes it possible to create an ISWM plan where individual components complement one another.

According to Qasim and Chiang (1994), a successful SWM utilizes many functional elements associated with generation, on-site storage, collection, transfer, transport, characterization and processing, resource recovery and final disposal. All these elements are interrelated and must be studied and evaluated carefully before any SWM system can be adopted.

(UNEP, 1996) stressed that, waste hierarchies are usually established to identify key elements of an ISWM plan. The general waste hierarchy accepted by industrialized countries is comprised of the following order: reduce, reuse, recycle, recover waste transformation through physical, biological, or chemical processes (e.g., composting, incineration, landfilling).

Klundert et al. (2001) argues that, ISWM insight is that most waste management problems have to do with something other – or more – than money and equipment. Some problems have to do with the attitude and behavior of citizens, waste management staff, private enterprises and waste pickers. Other problems are caused or made more serious by factors that are not technical or financial, but relate to managerial (in) capacities, the institutional framework, the environment, or the social or cultural context. In these cases, it is not money or equipment that provide solutions, but rather changing social, institutional, legal, or political conditions that's why SSM and its applications was the best and proper approach used for the analysis and assessment of SWM in the Gaza Strip.

The Second Research Question was:

Are there any Palestinian strategies and policies of waste disposal?

Referring to the concerned institutions responsible for disposal strategy and policy formulation, also from the tools used in the research (observation, interview, questionnaire, case studies and literature review), no disposal strategy was adopted by the Palestinian National Authority. Stakeholders used to select their own way to manage their solid waste in isolation of others. This was clear through the four case studies in chapter seven. Donors were heavily intervening in the policy of recipient Palestinian cities so these cities have to be committed to the conditions and orders of those donors. This issue was showed that, no SWM strategy is available in the Gaza Strip. The incineration of Shifa hospital was a good example of how the PNA is not involved in SWM either in technology choice or in decision-making process as explained in case study four in chapter six.

The Third Research Question was:

What is happening in the process of SWM and the institutions concerned with the service delivery within the Palestinian system?

The process of SWM in the Gaza Strip like any other developing countries starts from the generation, collection/transportation and final disposal. 3R's, composting or any other waste minimization scheme were practiced on a community level. Landfilling was the main disposal option adopted by the PNA as illustrated in case study one in chapter seven.

According to Tchobanoglous et al (1993), ISWM has been defined in terms of the integration of six functional elements: waste generation, waste handling and separation, storage and processing at source, collection, separation, processing and transformation of solid waste, transfer and transport and finally disposal. Results from the case studies have shown that, source separation do not exist which resulted in lack of reprocessing facilities and markets for recyclable materials, and public awareness to motivate the public to consume less and separate recyclable materials is not available although interviewee to use recycled products was acceptable percentage (68%). Although some of the small micro-enterprises working in the Gaza Strip as middlemen collecting scrap to be sold to Israel for $ 30/ton also paper and cartoon are being collected and reprocessed locally as egg pots and boxes. The PNA is not motivating or supporting these businesses (El-Hawi et al 2002).

Landfilling used to be the ultimate disposal option for solid wastes at the Gaza Strip. Other alternatives like composting were implemented on a small scale with local NGO's, 3R's as an EU funded project with Gaza Municipality which stopped by the end of the fund and finally the incineration which donated by Spain government and installed at Shifa hospital is not efficiently being operated and functioning, these cases were explicitly discussed in Chapter seven.

Several institutions at the national level are involved in SWM service delivery including respondent to public claims. Those institutions are: the Ministry of Local Government represented by municipalities, village councils and SWMC whom are responsible for solid waste operation. Apart from the refugees camps, where the services are largely provided by UNRWA. Some of local environmental NGO's are involved in solid waste projects on a community scale including public awareness and community participation as illustrated in the CATOWE elements and rich pictures in Chapter Seven.

The lack of coordination and cooperation among relevant institutions often results in different parties becoming the national counterpart to different external support institutions for different SWM collaborative projects without being aware of what other institutions are doing. This leads to duplication of efforts, wasting of resources, and un-sustainability of overall SWM programmes. The only cooperation between municipalities and UNRWA is limited to some activities in the environmental health awareness associated with SWM. UNRWA uses municipal dumpsites for a special fee according to the contract signed between them.

The Fourth Research Question was:

To what extent SSM can be an applicable tool for the analysis of SWM in the Gaza Strip?

Soft System Methodology offers a different approach for the whole SWM process. As explained in chapter five and six under the application of SSM to the SWM, the analysis will start by identifying the problem situation, which represented by the scarcity of land available for landfilling, quantities and characteristics of solid waste generation in the Gaza Strip. Understanding the various world view through the rich pictures which represented by the SWM problem situation and institutions involved in SWM decision-making including policy and strategy formulation as illustrated in stage two of Chapter six.

SSM is the ability to present and consider contentious viewpoints and incorporate them into the analysis. This is particularly important in SWM, as away to present different world-views and at least present "stakeholder" institutions. As an example, in the "sustainable development" discussions, it is argued that one of the most important part is the public represented by "next generation". In SSM it is possible to subscribe RD and CM for this hypothetical point of view. Finally, the different outputs of SSM can be used as a communication tool between the different stakeholders: the RP can be represented as a common ground for the problem situation and the RD and CM can help in conveying the different perspectives among stakeholders.

The Fifth Research Question was:

Can solid waste indicators be developed for disposal options represented by the case studies?

Solid waste indicators were used to help in analyzing and assessing some influential aspects affecting disposal options like the case with the six influential aspects, while SSM is only being used for the analysis of SWM existing situation with special focus on institutional and organizational structure represented by cooperation and coordination of concerned Palestinian stakeholders involved in SWM service delivery.

Solid waste indicators were explained in chapter seven and in the appendix II. Solid waste indicators and selection criteria developed for each case study have bridged the gap of what SSM has left open. For example, the technical and economical aspect of solid waste was extensively elaborated in the selection of technologies in chapter seven while in SSM is not covered. However, SSM when triangulated with other methodologies was a powerful tool in the analysis of SWM existing situation, which helped in policy and strategy formulation.

Indicators also have enhanced the integrated sustainable SWM through the application of selection alternatives. A core set of solid waste indicators were selected used for the assessment and evaluation of disposal options however, these indicators were not the core of this research to develop MSW disposal strategy.

The indicators developed for this research were more for illustration of how such indicators could be of value in this area rather than quantitative validated indicators. A full sensitivity analysis has not been carried out for the indicators developed, although sensitivity analysis is briefly conducted (see the appendix II - further research in chapter nine). Results from the sensitivity analysis showed that, institutional aspect for landfilling option of the SWMC case study was of great value, which supports the importance and priority for the disposal strategy to be considered by the PNA. Also sensitivity analysis has emphasized that integrated sustainable SWM was not considered by the PNA. Financial aspect was not affected by the sensitivity analysis which indicate that financial aspect was one of the constraints that the PNA is facing although this aspect was prioritized by decision-makers as the second potential indicator needed for SWM disposal strategy as explained in table 6 in the Appendix II.

Since indicators for infrastructure have been adopted by the PNA, it was a trial to select SWM indicators for the case studies representing disposal options. Although these indicators were developed, SSM is still the core of this research triangulated with other approaches, which used in the analysis of SWM in the Gaza Strip. That's why SSM has been adopted to help in policy formulation and develop a disposal strategy through the analysis and application of SSM to the four case studies as illustrated in Chapter seven.

8.3 Section two: The Assessment of Aims and Objectives

This section deals with the need to propose recommendations to define strategy for the MSW in the Gaza Strip. This strategy will be developed in the light of the aims and objectives of the research. They contribute to the understanding the need for the sustainable disposal strategy of MSW in the Gaza Strip.

The aims and objectives of this research were achieved through adopting some of methodology through the following approach:

- Quantitative and qualitative approaches were used to critically highlight the SWM problem.
- The case study tools was used for the analysis and assessment of SWM existing situation represented by the four case studies (landfilling, composting, 3R's and incineration) as explained in chapter six.
- SSM was used as guidelines that support the process of organizational change represented by no clear roles and mandates of institutions involved in SWM decision-making including disposal policy and strategy formulation.

Aims and objectives were achieved through the possible application of SSM, which represented by the lack of organizational structure (who should do what), lack of cooperation and coordination between institutions concerned with the decision-making of SWM disposal process.

SSM is triangulated with other methods (qualitative, quantitative and case study) in order to achieve research objectives represented by the understanding and analyzing of SWM existing situation with special focus on the disposal options. These methodological tools were also help in achieving and assessing the influential aspects affecting disposal options.

CHAPTER 9

CHAPTER 9: CONCLUSION AND RECOMMENDATION

CHAPTER 9: CONCLUSION AND RECOMMENDATION

This research has investigated the current waste management practices in the Gaza Strip and identified the prerequisite for sustainable waste management through analyzing the disposal alternatives resulted from the SSM applications and case studies in attempting to achieve an integrated disposal policy and strategy suitable for the Gaza Strip. The analysis of policies and strategies on waste practices exposed several issues identified as essentials as the tools and instruments in achieving the aims and objectives of sustainable waste management. It is obvious from the results of this research that the disposal of municipal solid waste policy and strategy addressed by interviewee and decision-makers are established with the aim of protecting the public health and reduce the amount if solid waste being landfilled due to the scarcity of land available for landfilling. These policies and strategies conform to the aims and objectives of sustainable waste management, which expect to balance the economic cost of waste disposal and development with the protection with the quality of the environment. It is apparent from this research that these policies and strategies can be achieved if coordination, facilitation and cooperation among Palestinian institutions involved in SWM decision-making is achieved.

There is a particular concern in the Gaza Strip about the area of land that will be required for landfill disposal of waste, and whether sanitary landfilling is a sustainable option for Gaza as explained in landfilling case study in chapter seven. Landfilling was the most common disposal option being practiced and adopted by the PNA in the Gaza Strip, other options like composting, 3 R's, and incineration were not being considered on a national level as illustrated in Table 5 in the Appendix II. Composting in the Gaza Strip has been practiced on a pilot and community scale, no governmental institution was adopting this option. The 3 R's where recycling has been addressed by Gaza municipality through EU funded project where no coordination and facilitation with concerned institutions was arranged. This project has ended by the end of funding. The incineration donated from the Spanish government and installed at the Shifa hospital for the purpose of disposal of health care waste where no official body is responsible for the operation, maintenance and management of this facility including collection and disposal, these practicing has resulted in a failure of this disposal option although incineration has been widely adopted by developed countries as suitable means for HCW disposal. These results were concluded from the literature review that SSM and case study methodology combined for the analysis of SWM existing situation supported with the solid waste indicators and selected technologies as explained in the Table 5 in the Appendix II

According to the analysis of SSM and case study methodology of SWM existing situation, no Palestinian disposal strategy for SWM on a national level was available. Also coordination, cooperation and facilitation between Palestinian institutions concerned with SWM was fairly existing. From the conceptual model (CM) resulted from the application of SSM, gaps were found between institutions concerned with SWM decision-making and others involved in SWM service delivery. This was clear when comparing CM with the rich picture (RP). The power of SSM applications will contribute to the development of an Integrated Waste Management Strategy based on the sustainability agenda through the following:

- SSM focuses more on learning the SWM problem situation, represented by the scarcity of land needed for landfilling, separation at source was not existing, recycling and composting were on a pilot scale as illustrated in the case studies in chapter six. SSM and case study methodology were combined in attempt to understanding the richness of the human activity system in reality and conceptualizing the specific SW disposal problem in a global (or holistic) context.

- SSM was presented as guidelines that support the process of organizational change represented by no clear rules, responsibilities and mandates of institutions involved in SWM decision-making including disposal policy and strategy formulation.

- Links and relation created through SSM between structure and process resulted from stage 2 focusing on the SWM problem situation expressed. These links were represented by concerned institutions should work closely in order to achieve smooth SWM decision-making process. Relation created represented by connection and communication channels for institutions responsible for SWM decision-making.

- In SSM, the SW disposal problem solution stages (6 and 7) are open-ended where the problem solving methodology can be adopted. As described by (Checkland, 1999) that, structural, procedural and attitude were key elements help in problem solution as depicted in stage six and seven in chapter six.

- Root definitions, which are the output of stage three which describe what, the SWM system is and what it aims to achieve as each Palestinian stakeholder sees it. Each root definition uses a certain perspective of the system. This system will be modeled in stage four as explained in chapter seven by subscribing the RD is focusing different views about the SWM problem and the expected solution for MSW disposal option. The RD should include CATWOE, which can be viewed as answers to the questions: Whom? (Clients) Who? (Actors) What? (Transformation) Why? (Assumptions) (World view) Where? Or what influences the SWM system. In the four case studies where CATWOE elements were key issues towards presenting institutions involved in SWM decision-making process which leads to policy and strategy formulation. It is concluded that CATWOE were successfully applied to the four case studies representing disposal options as illustrated in Chapter seven.

- Conceptual model is the output of the activities presented in the RD and CATWOE elements, which were, clearly defined roles and responsibilities of institutions, stakeholders involved in decision support system (DSS) including coordination and facilitation between them.

- SSM and its application in analyzing SWM is not well known. However, SSM has proved useful tool in pursuit of sustainable management practices and well tested since "environmental management is social science for social change" where solid waste has great dimension. SSM gives recommendations that support the process of organizational change, from the initial modeling to taking action

- Rich picture, root definition, CATWOE elements and conceptual models for solid waste are still unclear to stakeholders. So, introducing Palestinian institutions to the SSM technique and its applications should be investigated (further research).

- Finally, SSM proved a suitable approach for structuring, expressing, modeling the available information and as a result solving the problem of SWM in the Gaza Strip.

It's concluded from case studies, assessment and analysis of solid waste indicators; the following are the key findings:

- Institutional and financial aspects were the most influential factor addressed by decision-makers necessary for developing SWM strategy.

- Landfilling, composting, 3R's and incineration were not adopted by the PNA as an integrated sustainable disposal strategy, this was clear from the Table 5 and Figure 1 in Appendix II

- Other influential aspects like environmental, socio-economic, policy and legal were not at the top priority as identified by the interviewee.

- The technical aspect represented by various technologies applied to the system by different institutions was of great value.

The next section is about the issues that need to be addressed to assist in moving towards developing an environmentally sound sustainable disposal option for the Gaza Strip.

Recommendations

This section deals with the need to propose recommendation to develop SWM disposal strategy for the Gaza Strip. These recommendations will be made in the light of the answers to the research questions that illuminated issues concerning disposal alternatives. They contribute to understanding the need for disposal policy and strategy.

MEnA, (1999) through the draft of Palestinian Environmental Strategy document has made some recommendations to the Palestinian National Authority in order to improve the SWM. However, this strategy has not covered the disposal part of MSW.

From SSM and case studies, disposal strategy taking into account institutional arrangements, clear mandates with roles and responsibilities for those institutions do not exist. Decisions on SWM were made on a random base where duplication of roles and responsibilities were observed. Through the application of SSM to SWM existing situation MoPIC, MEnA should cooperate and work closely to achieve smooth SWM decision-making process including disposal policy and strategy formulation. In this regard, MoLG should be involved in the planning process.

In consideration of CM as explained in figure 4 chapter six, Solid Waste Management Experts Office (SWMEO) is recommended to be created from SW specialists, MEnA, MoPIC, MoLG and private consultants in order to achieve three goals:

- Analysis and assessment of SW planning process including priority projects
- Re-organizational structure and responsibility matrix of institutions responsible for SWM decision-making
- Provide technical assistant to institutions or key ministries involved in SW services

The next list represents some recommendations regarding SWM policy and strategy:

A comprehensive national SWM disposal strategy taking into account close coordination, cooperation and facilitation to fulfill the following:

- MEnA and MoPIC should work closely and cooperatively in SWM planning process
- Donors should consider SW plans developed by MEnA and MoPIC
- MEnA and MoPIC should be responsible for SWM decision-making process
- MEnA and MoPIC will be responsible for monitoring, control and follow up on SWM issues through enhancing of public participation.
- MoLG should create two-way communication channel in order to improve the disposal process of MSW.
- Proposed SWM Experts Office (SWMEO) will be responsible for prioritizing SW projects, evaluation of organizational structure of Palestinian institutions involved in SWM decision-making.
- Municipalities, SWMC and village councils under the umbrella of the MoLG are the responsible/Implementable body for SW process including responding to public claims.
- Efficient communication with NGO's and UNRWA to achieve integrated disposal options of MSW should be enhanced.
- Public should be involved at all levels of SWM starting from planning process to decision-making which is the key issue to the sustainability of the service.

By comparing these recommendations to the main observations from the SSM analysis, it is possible to recommend some changes to the MSW disposal system. The most apparent change is structural change. The mismatch between key ministries leading to duplication of efforts, wasting of resources, and un-sustainability of overall SWM programs should be avoided through clear and proper coordination among relevant agencies. Therefore, the role of MEnA should be recognized in the regulations. This could be done by recognizing the Palestinian Legislative Council (PLC) as the main authority in SWM planning in the Palestinian system; such change can be initiated by MEnA but must go through the legislative process through the government and the PLC.

Several procedural changes can be advised; firstly, adopting the recommendations on the disposal options and alternatives in the creation of a sustainable integrated SWM system by making the process formal and obligatory. The stakeholders will have to respond positively and cooperatively to the new SWM procedures and will have to consider their response to the planning process carefully. Secondly, the communication channel between MEnA and MoPIC jointly with the SWMEO should receive formal recognition. It is recommended to trust professional judgment of the SWMEO and to believe that MEnA and MoLG would not easily influence them during the SWM planning process. Finally, it is recommended to use computerized system to improve the decision support system (DSS) in SWM applications to help evaluate the local properties of the plan and to exploit the facilities that are already installed in MEnA. For these new structures to work changes of attitudes is necessary.

The attitude changes are the most contentious. The main changes of roles and responsibilities of key ministries involved in MSW policy and strategy formulation including decision-making were focused on mandates and job description. This is a major change in positioning of the different bodies and probably will be the main source of obstacle for a change as can be seen from the case studies.

Landfilling, composting, 3R's and incineration as an integrated sustainable disposal option is recommended to be adopted by the Palestinian National Authority from the application of SSM and the case studies aiming to achieve an environmentally sound disposal strategy for the municipal solid waste management in the Gaza Strip. Incentives and motivation programs to enhance public participation in waste management decision-making should be encouraged.

Comprehensive SWM legislation must be formulated so that effective sustainable SWM programs can be laid out. This legislation should include the organization for waste regulation, collection and disposal. It is through the appropriate provision from these laws and regulations that the "right and proper" local authority, will be able to manage, regulate and monitor all waste activities within specified conditions.

From the above text and based on the sensitivity location of the Gaza Strip, the four disposal options should be considered as an integrated and sustainable disposal options on a national level. The following diagram (Figure 9-1) summarizing the disposal strategy proposed for the Gaza Strip.

Recommendations for Future Research

- Solid waste measurable validated indicators and evaluation matrix of solid waste management through scoring system
- Full sensitivity analysis for the disposal options of solid waste
- Application of SSM to other public services like water, wastewater, public health and construction management.

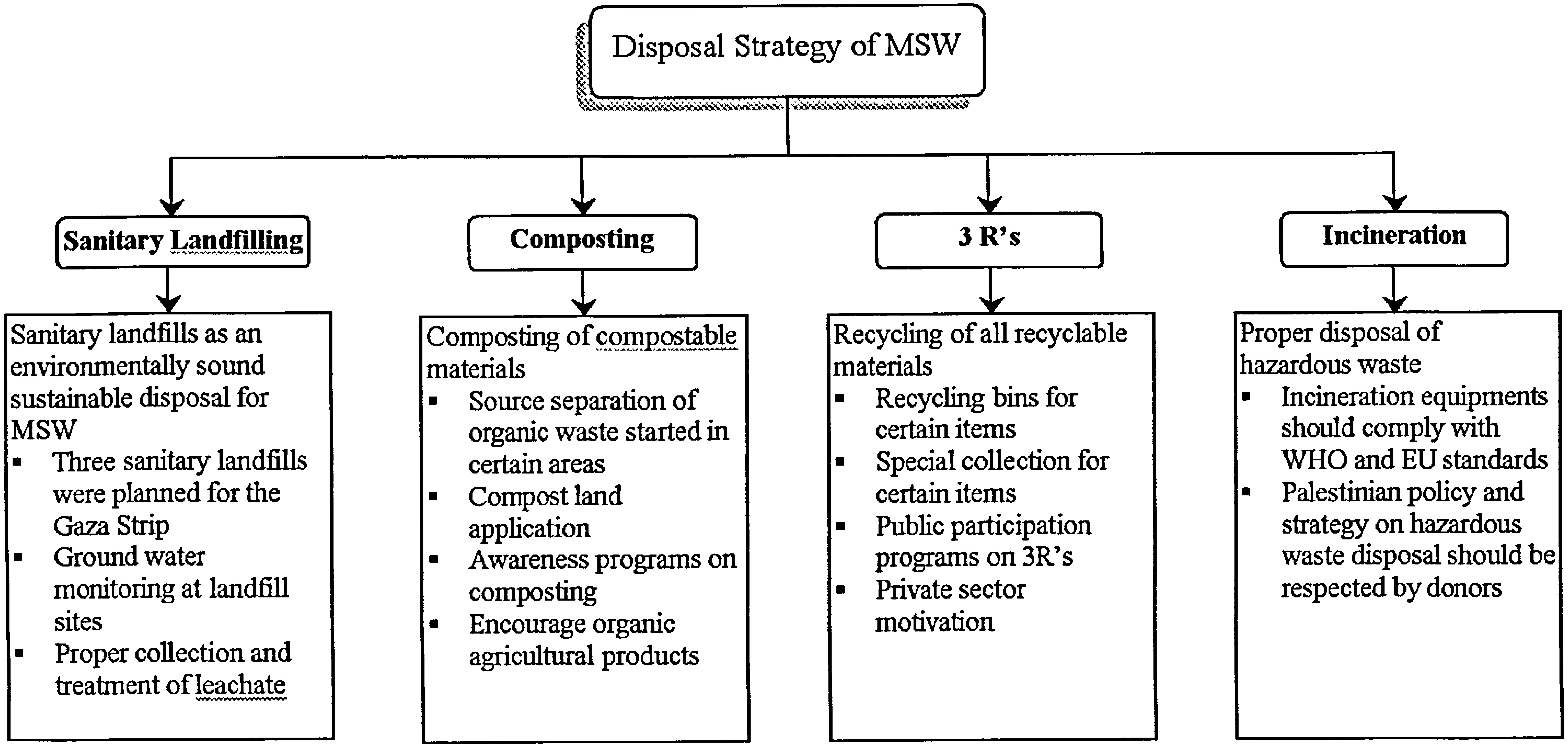

Figure 9-1: Disposal Strategy Recommended for the Gaza Strip

I- APPENDIX I: SOLID WASTE MANAGEMENT QUESTIONNAIRE

School of Construction and Property Management

Salford University

Objectives of the questionnaire

Objective (1) Analysis of critical assessment of the current situation of the collection, recycling, composting, disposal options and other available alternatives suitable for the Gaza Strip.

Target group

Municipal staff, SWMC's, UNRWA, SW specialists/environmentalists, NGO's, concerned ministries (like Ministry of Environmental Affairs, Ministry of Health, Ministry of Industry, Public and decision-makers.

Objective (2). Analysis of critical assessment of the institutional setup, organizational structure and responsibility matrix in DSS and other SWM decision-making process.

Target group

Ministries, Municipalities, SWMC's, UNRWA, NGO's, universities, research centers, private sector, donors and decision-makers.

Objective. (3). Analysis of critical assessment of the community education and public participation in SWM.

Target group

Public, Municipalities, NGO's, community leaders, municipal awareness teams and community centers.

Questions to cover the first objective

Q1. How do you evaluate and assess the SW collection in your neighborhood?

V. Poor [ ] Good [ ]Not sure [ ]V. Good[ ]

Q2. Solid Waste Recycling:

a) Do you see recycling as an environmentally sound disposal strategy of MSW?

Yes [ ] No [ ]Not sure [ ]

b) Are you willing to participate in source separation?

Yes [ ] No [ ]Not sure [ ]

c) Are you willing to use recycled products?

Yes [ ] No [ ]Not sure [ ]

Q3. Composting

a) Are you familiar with the composting as an end product to be used as soil conditioner, fertilizer and other land applications?

Yes [ ] No [ ]Not sure [ ]

b) Do you think composting could be a long –term disposal strategy as an efficient tool to lengthened life span of existing landfills?

Yes [ ] No [ ]Not sure [ ]

c) Are you willing to use the compost as end product?

Yes [ ] No [ ]Not sure [ ]

d) Do you think that composting can be a long-term disposal strategy parallel and alternative to the landfilling?

Yes [ ] No [ ]Not sure [ ]

Q4. How do you evaluate and assess the SW transportation in your neighborhood?

V. Poor [ ] Good [ ]Not sure [ ]V. Good [ ]

Q5. How do you evaluate and assess the SW disposal in your neighborhood?

V. Poor [ ]Good [ ]Not sure [ ]V. Good [ ]

Q6. Is it reasonable to consider landfilling as a suitable disposal method in the long term?

Yes [ ] No [ ]Not sure [ ]

Q7. What's needed to be done (research, data collection, consultancies, pilot projects, feasibility studies) to determine whether there are satisfactory alternatives to landfilling ?

Research [ ] Data collection [ ] Consultancies [ ]

Pilot projects[ ] All other options/alternatives [ ].

Q8. How can we increase the life of a landfill, or get more waste into each hectare?

Recycling [ ] Separation at source [ ]Composting [ ] Incineration [ ]

All other options/alternatives [ ].

Q9. What can be done to reduce the quantities of waste that require landfilling?

Legislation [ ] Recycling [ ] public awareness [ ] Economic incentives [ ]

Q10. Number of Landfills

a) How many landfills should there be in the Gaza Strip?

One landfill [ ] Two landfills [ ]Three landfills [ ]More [ ]

b) What are the factors that affect this number?

Annual increase of waste generation [ ]Land available for landfilling [ ]

Legislation [ ] Incineration [ ] All other options/alternatives [ ].

c) Who should decide which sites might be used?

Municipalities [ ] ministries [ ]consultants [ ]SW experts [ ].

Group of all [ ]

Questions to cover the second objective

Q1. How the relations between municipalities, village councils and UNRWA being improved?
Sharing SW equipments [ ]Exchange information [ ]
Sharing the same landfill [ ]Joint Training and maintenance programs [ ].

Q2. How institutions involved in SWM decision-making communicate, cooperate and coordinate with each other?
Regular coordination meetings [ ]Net meeting [ ] SW quarterly Bulletin [ ]
All options [ ].

Q3. How do you assess the ability of the institution providing SW services in your neighborhood including executing, planning, monitoring and enforcing?
V. Poor [ ] Good [ ]Not sure [ ]V. Good [ ]

Q4. How do you evaluate the performance of municipal staff responsible on SW service delivery in your area?
V. Poor [ ] Good [ ]Not sure [ ]V. Good[ ]

Q6. Do you think that SWM should be the responsibility of the municipalities, village councils and joint service councils with private sector?

Strongly Agree, SA [ ] Agree A [ ]Undecided U [ ]Disagree D [ ]

Q7. Do you think that putting the SW services into private sector hands leads to higher efficiencies and lower service costs?
Strongly Agree, SA [ ] Agree A [ ]Undecided U [ ]Disagree D [ ]

Q8. Do you think that SWM decision –making being taken properly i.e institutions involved in service delivery are the right selection?
Yes [ ] No [ ]Not sure [ ]

Q9. Do you think that putting SW services in competition with the private sector will enhance and motivate the performance of the local authority?

Q10. How do you evaluate the SWM legal aspects i.e bylaws, monitoring and enforcement mechanism?
V. Poor [ ] Good [ ]Not sure [ ]V. Good [ ]

APPENDIX I: SOLID WASTE MANAGEMENT QUESTIONNAIRE

Questions to cover the third objective

Q1. Are there any programs available to encourage, motivate and enhance public participation to solid waste management in your locality?

Yes [ ]   No [ ]Not sure [ ]

Q2. Do you think that community involvement to SWM operations will lead to proper management and to the protection of human health and the environment?

Yes [ ]   No [ ]Not sure [ ]

Q3. Is the community willing to pay for better service?

Yes [ ]   No [ ]Not sure [ ]

Q4. Do you think that cooperation and coordination between municipalities and communities can make the best possible decisions for the reduction and management of solid waste?

Yes [ ]   No [ ]Not sure [ ]

Q5. Do you think community should be involved in planning, designing, regulating, tariff structure and other community development programs associated with successful of new solid waste management solutions?

Yes [ ]   No [ ]Not sure [ ]

Q6. What problems relating to SWM are caused by public behavior?

Random dumping [ ]   Open burning [ ]Sending SW with children [ ].

Q7. What is being done to change this behavior?

Suitable container system [ ]Municipal police/fines [ ]

Awareness campaigns [ ]Economic incentives [ ].

Q8. How do you evaluate the SW activities with the community being performed by municipal awareness teams?

V. Poor [ ]   Good [ ]Not sure [ ]V. Good [ ]

Thank You

APPENDIX II: SOLID WASTE INDICATORS

II- APPENDIX II: SOLID WASTE INDICATORS

Table II.1: Solid Waste Management Council – Landfilling – Case Study One

Variable	Description	Score
	(1) Technical & operational	
1.1 Composition of waste	▪ About 240 tonne of MSW are disposed of at the site daily. ▪ The SWMC and UNRWA are collecting 90% of waste generated in the middle area. ▪ High percentage of organic matter sand, metal and other items. Landfilling operation and management are available. ▪ Accurate data on solid waste being dumped to the landfill as a result to the computer system installed at the entrance. ▪ SWMC landfill service communities with a total population about 370,000. ▪ Eleven towns, villages and five refugee camps are being served by SWMC. ▪ Access road to the landfill site has been constructed.	4
1.2 Existing practice	▪ Around 66,000 tonne of MSW per year being collected (75% of total waste). Personal communication. ▪ Transportation being used by the council is durable and unified for smooth operation and maintenance (O&M). ▪ Equipments being used by the SWMC are durable and unified for smooth O&M. ▪ Scavengers collect steel and scrap as surviving strategy, to be sold to Israel for US$30/tonne. ▪ Screen of existing waste at the landfill to be used as soil conditioner and daily cover.	3
1.3 Sitting of disposal facility	▪ The site was an old dump facility; located north of Deir El-Balah city; it has been rehabilitated to sanitary landfill utilizing available engineering materials. ▪ Landfill design and selection of construction/engineering materials were completed through GTZ and SWMC.	4
1.4 Technology	▪ Data on local climate, water resources and hydrology is available. ▪ O&M at the landfill site is relatively viable. ▪ Technical specifications for the landfill including leached collection and treatment were available. ▪ Equipments selected for collection, transportation and final disposal were designed and assembled locally to suit local conditions. ▪ The experience of construction the landfill site was the first in the region. However, providing guidance on leachate quantities is not available. ▪ Selected technology for landfill construction including leachate collection and treatment is adequate and environmentally acceptable. ▪ As a result to the successful outputs, a similar SWMC for the northern area of the Gaza Strip was proposed to be established by the GTZ. ▪ The SWMC pilot projects are being managed by municipalities (member to the council), the council has financed GTZ. ▪ An access road to the landfill as well as weighing bridge and other necessary infrastructure for the site is available. ▪ Data information was collected through: SW coordination meetings, networking with municipal members, observation and studies.	5

Table II.1: Solid Waste Management Council – Landfilling – Case Study One

Variable	Description	Score
	▪ An assessment of sieving the existing waste to use the product as soil conditioner or as daily cover was potentially practiced. ▪ Some composting on small scale, recycling materials and daily cover were anticipated as by-products. ▪ The council has received considerable technical assistant from the GTZ and other international experts.	
	(2) Institutional	
2.1 Structure roles and responsibilities	▪ A decision to stop open crude dumping and rehabilitate the existing open dump into sanitary landfill has been taken by the council. ▪ Current institutional framework for waste management is well structured; the board was elected from municipals mayors. ▪ Roles of SWM are clearly defined by the council. ▪ SWMC in cooperation with GTZ has put waste management activities and plans. Now SWM is the responsibility of the council. ▪ Staff of SWMC was selected/recruited with previous SWM experience. ▪ Staff of the council has received little training as the outside assistance stopped at the end of the construction stage. ▪ Specific training on financial management as well as landfill operation and management has been provided to the Staff through GTZ. ▪ The council has set a adequate plans to improve the systems through necessary equipments, unified compacted trucks, weighing bridge, daily cover and daily computerized/achieving statistics on the quantities of waste being dumped to the site. ▪ The council has improved its capacity to adapt to the newly emerged technology such as leachate collection, treatment and sieving of existing waste to be used as soil conditioner and daily cover. ▪ The scope of training provided to the council has enabled them efficiently and effectively manage and environmentally sound operate the site with fairly little outside assistant.	4
2.2 Operational Capacity	▪ The SWMC staff has the capacity to regulate to a certain extent, monitor the SWM operation in the service area. ▪ Specific training on financial management as well as landfill operation and management has been made available to the council staff through GTZ.	3
2.3 Incentives	▪ Number of incentives schemes of monitoring value to motivate the staff have been developed by the council for instance, overtime policy and promotion strategy, retirement and provident fund scheme was adopted. ▪ Due to the successful promotion of the council, the MoLG has made a grant possible to the council as direct assistant for the purpose of extending the landfill site since it is near capacity. ▪ Palestinian politicians, administrators and steak holders were concerned with the improvement of waste disposal. ▪ The council has good access to donor assistance; the GTZ is covering the salaries of some staff in addition to some of the running costs.	2
2.4 Innovations and partnerships	▪ In circumstances, the council contracts private equipments owners in the collection, transportation and landfill operation. ▪ UNRWA and NGO's were providing solid waste services in partnership with the SWMC. ▪ Informal sector waste pickers (scavengers) are collecting	4

Table II.1: Solid Waste Management Council – Landfilling – Case Study One

Variable	Description	Score
	recyclable materials like steel and scrap.	
	(3) Financial	
3.1 Financial	▪ The council has the financial fairly ability to finance the implementation, operation and maintenance of the system. ▪ Investment costs about US$ 3,685,000 equal to about US$ 4.8 per cubic meter and US$ 2.5 per tonne (without interest on capital investment). ▪ Running costs (1999) about US$ 155,000, equal to US$ 1.8 per tonne. ▪ Total costs of disposal (1999) are US$ 4.3 per tonne, equivalent to US$ 0.60 per household per month. ▪ Current revenue and expenditure on waste management is available.	2
	(4) Socio-economic	
4.1 Waste picking	▪ Scavenging activities are common schemes in the middle area. ▪ Around 300 families are benefiting from scavenging in SWMC landfill (personal communication). ▪ Each family benefit around US$100 from scavenging activity (personal communication). ▪ Potential impact on livelihood of waste pickers. ▪ Waste pickers at the SWMC landfill found it scavenging activities easy due the location of then site close to their residents. ▪ Waste pickers use donkey carts to transport recycled items collected from landfill.	3
4.2 Others	▪ Waste pickers are working in unhealthy conditions, no safety measures are being considered. ▪ Public is not concerned on the existing and proposed disposal system as part of low education on the subject. ▪ No pressure is being practiced on the board of SWMC council to improve disposal facilities. ▪ Plan for monitoring and follow up the landfill site after care upon closing down is available.	2
	(5) Environmental	
5.1 Initial environmental risks	▪ Environmental regulation on ground water monitoring, open burning and physical contact with waste were practiced. ▪ No enforcement mechanism is being practiced by the council. ▪ SWMC have some power to influence waste disposal practices in the community of the middle area. ▪ No risks anticipated to the population, resources or workers are expected since no hazardous materials are associated with the MSW being disposed to the site.	2
5.2 Long-term environmental risks	▪ Groundwater samplings on a regular base to ensure no pollution associated with leachate percolation is occurred. ▪ Currently, there are some Israeli restrictions on the staff working at the landfill equipments are not operating freely. ▪ Hazardous and other special waste are not allowed to be dumped at the site.	1
	(6) Policy and Legal	
6.1 political priorities	▪ Number of jobs was created by the SWMC. ▪ Reducing imports of landfill materials. ▪ Mitigation measures were considered as part of environmental	3

Table II.1: Solid Waste Management Council – Landfilling – Case Study One

Variable	Description	Score
	considerations. ▪ Due to the Israeli constraints' during the current political clashes, SWMC was prohibited from using the landfill	
6.2 Policy and regulation	▪ No standards and regulations regarding MSW. ▪ SWMC have jurisdiction and authority to plane, finance and operate waste management system. ▪ Rules of the law on waste management are not sufficient enforced. ▪ Strategy to plan for waste management at the national level is not available.	2
6.3 Contracting rules	▪ SWMC has its own procedures in contracting and no bias was practiced. ▪ In certain occasion, SWMC contracts private sector to do collection, transportation and landfill operation.	4

Table II.2: Composting of Organic Waste – Palestinian Environmental Friends PEF – Case Study Two

Variable	Description	Score
	(1) Technical & operational	
1.1 Waste reduction	▪ 65-70% of the waste generated is organic including green waste. ▪ Composting of green waste by PEF has resulted in waste reduction by 10% of the green waste in Rafah. ▪ Data on technical guidelines for waste reduction and preventive has been disseminated to local farmers in Rafah.	4
1.2 Waste collection	▪ 80% of the waste generated in Rafah city is being collected by Rafah municipality and UNRWA. ▪ Data on waste generation and composition, statistics, haul distances is available. ▪ Shredding machine for green and organic waste have been provided to local farmers by PEF as incentives to promote composting scheme. ▪ Storage, transfer station and transportation were integrated system with PEF. ▪ Training on operational and maintenance capacity for composting equipments are available by PEF, Rafah municipality and Palestinian Agricultural Working Committee (PARC). ▪ Composting manual in Arabic have been produced and distributed to local farmers. ▪ Record keeping and monitoring system to support continuous improvement of compost product was established.	4
1.3 Resource recovery	▪ Green waste separation at source through education and economic incentives is available by PEF, Rafah municipality and Federation of Canadian Municipalities (FCM). ▪ Data on types and quantities of recycable generated, collected and recycled is relatively available. ▪ Resource recovery through tax and duty exemptions, credit, training is fairly available. ▪ Data on types and quantities of green waste in the pilot area were gathered by PEF staff, Rafah municipality and other volunteers.	3
	(2) Institutional	
2.1 Institutional building	▪ Waste management functions under jurisdiction of PEF were consolidated. ▪ Roles and responsibilities in waste management has been made clear. ▪ Transparent procedures for competitive bidding and contracting out of waste management service have been established by PEF. ▪ PEF has improved organization of the informal sector and increases and increases its integration into the formal waste management system and participates in tendering and contracting.	2
2.2 Organizational development	▪ Pay-scales and incentive systems have been adopted by. ▪ Recruitment and promotion procedures based on, PEF and voluntary consultants have adopted merit and performance. ▪ Transparent system of rewards and penalties is not available.	1
2.3 Human resource development	▪ Skills and educational levels of waste management staff within PEF has been assessed, training needs have been defined. ▪ Training programs to promote composting scheme has been designed and implemented by PEF, Rafah municipality and PARC. ▪ Cooperation with local NGO to conduct compost training for farmers has been achieved.	3

Table II.2: Composting of Organic Waste – Palestinian Environmental Friends PEF – Case Study Two

Variable	Description	Score
2.4 Innovations and partnership	▪ PEF has implemented the pilot composting project in Rafah in cooperation with Rafah municipality, PARC and local farmers. ▪ PEF works in partnership with local NGO's to ensure sustainable composting products	3
	(3) Financial	
3.1 Budgeting and cost accounting	▪ PEF has received a grant from FCM to implement composting as pilot project in cooperation with Rafah municipality. ▪ PEF has fairly the financial ability to finance, implement, operate and sustain composting pilot project. ▪ Capital and recurrent costs of composting is not available. However, they covered through the Canadian grant. ▪ PEF has special mechanism financing recurrent costs. ▪ Transparency, accountability and fiscal discipline of PEF staff through training, incentives, costs of conduct have been increased. ▪ Revenues for waste management were earmarked.	1
3.2 Revenue generating mechanism	▪ Introduce farmers in Rafah to the composting initiatives with special incentives to promote composting as an environmentally sound disposal option. ▪ Provide consultancy to local authority and NGO's on composting. ▪ Work with Rafah municipality to improve revenue collection through composting of green and organic waste. ▪ Increase revenues from resource recovery like the case with composting pilot project.	1
3.3 Cost reduction and control	▪ PEF has encouraged waste minimization at source. ▪ PEF and Rafah municipality in close monitoring and evaluation performance through municipal financial and budgeting departments have resulted in financial control. ▪ Cost savings from improved maintenance, from waste exchange systems are not available.	2
	(4) Socio-economic	
4.1 Monitoring of public health	▪ Morbidity and other cause waste-related disease in composting locations were not efficiently monitored. ▪ Working conditions in composting facility was not healthy. ▪ Safety and mitigation measures and protecting equipments were not available	1
4.2 Design of systems	▪ A plan to cover unnerved areas with green waste collection as prepared by PEF and Rafah municipality was developed. ▪ Stakeholders/and their interests in composting scheme was identified. ▪ Social profile of areas to participate in composting scheme in Rafah through social surveys, focus group discussions, key informant interviews, and other techniques were prepared. ▪ Demand and needs of compost users (level and quality of compost product through community meetings, social surveys and other social research methods were developed.	2
4.3 Green waste separation	▪ PEF and Rafah municipality has set a system for collection of green waste including collection points. ▪ Transportation means have been made available for local farmers. ▪ Shredding machine for green waste was distributed to farmers as incentives to promote composting scheme in Rafah.	3

Table II.2: Composting of Organic Waste – Palestinian Environmental Friends PEF – Case Study Two

Variable	Description	Score
4.4 User participation	▪ Local farmers, neighborhood committees, citizen panels, local NGO's were involved in monitoring and implementation of composting pilot project. ▪ Communication channels between local government and users public meetings, community workshops were established. ▪ Awareness raising programs on composting to mobilize communities to build a base for collective participation, using clear and simple messages and popular channels of communication (such as puppet show, religious leaders in mosques, festivals and competitions) were conducted ▪ Capacities of low income group like farmers, to enable them to participate in composting manufacture were built ▪ Linkages and trust between different groups of NGO's, farmers, local government, private sector and other actors involved in composting scheme through joint management committee, coordinating platforms were developed.	3
4.5 Social conditions	▪ PEF in cooperation with Rafah municipality have improved status of composting manufacture by providing farmers and other participants with uniforms and training ▪ Compost working condition was improved by providing farmers with protective wear (gloves, boots), give them better tools. ▪ Measures to improve working condition and to raise their awareness on health and hygiene conditions (e.g. introduce special sorting area on landfill, provide farmers with protective wear, water and sanitary facilities) were relatively introduced..	3
	(5) Environmental	
5.1 Rulers and regulations	▪ Environmental legislation governing collection, composting is not available. ▪ No environmental regulations are prerequisite by MEnA or Rafah municipality for composting localities.	1
5.2 Environmental sound practice	▪ Green waste left at farm lands, streets, empty lots or burnt in the open were monitored by PEF at the study area in Rafah. ▪ Green waste truck was covered during transportation. ▪ Amount of recyclables were monitored by PEF. ▪ Environmental effects at composting facility were not monitored. ▪ Leachate and gases generated were not controlled. ▪ Resource recovery through awareness rising, incentives, training, access to shredding machine and other composting tools were made available to participants. ▪ Waste exchange system on composting was introduced.	1
5.3 Education and awareness raising	▪ Awareness raising programs on composting manufacture from green waste were initiated by PEF. ▪ Guidelines, composting manual in Arabic to promote composting among local farmers were published by PEF. ▪ Brochures, pamphlets and other awareness materials were distributed.	3
	(6) Policy and Legal	
6.1 Planning and policy	▪ Decentralize responsibilities for compost decisions to the local level. ▪ Waste management strategic plans highlighting composting as an environmentally sound disposal option was addressed. ▪ PEF has made waste management and composting scheme a high priority in policy and funding decision.	1

Table II.2: Composting of Organic Waste – Palestinian Environmental Friends PEF – Case Study Two

Variable	Description	Score
6.2 Regulatory framework	▪ An effective byelaws and ordinances for waste management and composting still ambiguous. ▪ Legislation enhancing integrated sustainable SWM promoting composting was not efficient. ▪ Effective regulations and procedures for private sector participation still ambiguous. ▪ Legal enforcement and inspection structure is not effective. ▪ Civil society and media were not playing their actual role as watchdogs.	2

Table II.3: Reduce, Reuse and Recycle (3R's) – Gaza Municipality – Case Study Three

Variable	Description	Score
	(1) Technical & operational	
1.1 Waste collection reduction and prevention	▪ 70% of the total amount of waste is being collected by Gaza municipal jurisdiction while UNRWA is collecting 80% from refugee camp (Beach Camp). ▪ Data and statistics on waste generated from the city and per source is relatively available. ▪ Municipal equipments for collection, transportation and disposal is fairly durable. ▪ A system for hazardous waste separation is NOT available. ▪ Preventative maintenance procedures don't exist. ▪ Total MSW recycling is 9.068 tonne/year out of 215,000 tonne/year. ▪ Recycling rate is 4.12 percent	4
	(2) Institutional	
2.1 Institutional building	▪ Reuse, Reduce and Recycle (3R's) under the jurisdiction of Gaza municipality and fund from the EU was consolidated. ▪ Roles and responsibilities on 3 R's have been made clear. ▪ Neighborhood committees as well as municipal awareness team were established. ▪ Gaza municipality has started the 3 R's on a community scale with some communities in Gaza city.	2
2.2 Organizational development	▪ Special incentives for communities practicing 3R's have been arranged. ▪ Recruitment and promotion procedure based on merit and performance have been developed. ▪ Transparent system of rewards penalties is fairly available.	2
2.3 Innovation and partnership	▪ Gaza municipality has implemented the 3 R's project jointly with local community and NGo's. ▪ Gaza works in partnerships with private sector to promote and sustain the 3 R's.. ▪ Gaza municipality facilitates market for recycled products through special festivals.	2
	(3) Financial	
3.1 Budgeting and cost accounting	▪ EU has funded solid waste disposal project where the 3R's was the main part. ▪ Gaza municipality has got the financial ability to implement 3R;s project through EU funding. ▪ Capital and recurrent costs of the 3 R's is partially available through the EU. ▪ Gaza municipality in cooperation with donor community has arranged special mechanism to cover recurrent costs.	*2*
3.2 Revenue generating mechanism	▪ 8 communities in the Gaza Strip were introduced to the 3 R's with some incentives to promote and sustain this technique. ▪ Some consultancies on revenue generating of the 3 R's were provided by Dutch consultant. ▪ EU experts were working with Gaza municipality to improve 3 R's scheme through incentives. ▪ Increase revenues from resource recovery like the case with paper and steel recycling were introduced.	*1*
3.3 Cost reduction and control	▪ Waste minimization at source as pilot project through the 3 R's EU funded project has been encouraged. ▪ Performance related pay-schemes in Gaza municipality was	*1*

Table II.3: Reduce, Reuse and Recycle (3R's) – Gaza Municipality – Case Study Three

Variable	Description	Score
	introduced. ▪ Monitoring and evaluation of performance to increase the efficiency was not available. ▪ Solid waste coordination meetings among municipalities headed by MoPIC were initiated to discuss latest development in SWM issues including 3 R's, fees and taxes.	
	(4) Socio-economic	
4.1 Monitoring of public health	▪ Morbidity and other cause waste-related disease in 3 R's locations was not monitored. ▪ Localities where practicing 3R's are unhealthy conditions.	1
4.2 Design of System	▪ Neighborhoods communities, NGO's and concern private sector were introduced to the 3R's activities. ▪ The EU experts, Gaza municipality and other stakeholders have introduced valuable experience and consultancies on 3 R's. ▪ EU and the World Bank have worked with Gaza municipality to improve SWM tariff structure and billing system. ▪ Increase revenues from resource recovery were not possible. ▪ Demand and needs were assessed by Gaza municipality (level of quality of service) through community meetings, social survey and other social research methods.	2
4.3 Separation of special items	▪ System of source separation of special items in certain neighborhoods was proposed by the EU solid waste disposal project. ▪ Incentives to promote the 3 R's were not available. ▪ Poor market for recycled products.	2
4.4 User participation	▪ Local NGO's, community committees and neighborhoods were introduced to the 3 R's. ▪ Community meetings to address 3 R's were conducted through the project including awareness raising campaign to enhance public participation in SWM using simple messages such as puppet show, religious leaders, festivals and community competitions. ▪ Linkages with recycling groups and private sector on a small scale and other actors involved in 3 R's through community meetings were establishment.	2
4.5 Social conditions	▪ Gaza municipality thorough municipal awareness team in cooperation with neighborhood committees initiated 3 R's through training, pilot projects including recycling tools. ▪ Awareness hygienic and public health were not available. ▪ Income earning potential of formal sector through tax exemptions, import duties on raw and waste materials, access to credit were not available.	2
	(5) Environmental	
5.1 Rulers and regulations	▪ Environmental legislation on 3 R's is not available. ▪ Facilities of 3 R's on a community scale have been established like the case with steel and paper recycling.. ▪ EIA as an Israeli obligatory before 3 R's as facility site selection was a prerequisite.	1
5.2 Environmental sound practice	▪ Monitoring of different items of waste was made possible in specific area where the 3 R's is initiated. ▪ Transportation means of certain items of waste was not available. ▪ Amount of recycled materials in the project area were estimated as presented in table (7-8) on 3 R's.	1

Table II.3: Reduce, Reuse and Recycle (3R's) – Gaza Municipality – Case Study Three

Variable	Description	Score
	▪ Resource recovery on 3 R's through awareness rising, incentives, training were made available to local NGO's and community committees. ▪ Waste exchange system on 3 R's was introduced.	
5.3 Education and awareness raising	▪ Gaza municipality has initiated awareness raising programs on 3 R's. ▪ Guidelines and manuals to promote 3 R's as an environmentally sound disposal was not available. ▪ Sustainability of 3 R's awareness programs was not possible due to the lack of financial resources.	2
	(6) Policy and Legal	
6.1 Planning and policy	▪ The 3 R's as part of municipal strategic plan have been addressed as an environmentally sound disposal option. ▪ Gaza municipality through the EU solid waste funded project has prioritized 3 R's as a high component in policy formulation and funding decision. ▪ Official policy or legal aspect tackling 3R's was still undelivered. The EU project has been delayed due to the current political conflict situation.	1
6.2 Regulatory framework	▪ An effective by-laws and enforcement mechanism on the 3 R's still ambiguous. ▪ Legislation enhancing integrated sustainable SWM and promotion 3 R's was fairly functioning. ▪ Effective regulation and procedures for private sector participation on 3 R's still ambiguous. ▪ Regulation on source separation to promote 3 R's was not possible.	2

Table II.4: Incineration of Health Care Waste – Shifa Hospital – Case Study Four

Variable	Description	Score
	(1) Technical & operational	
1.1 Waste reduction and prevention	▪ About 8 tonne per day is the total health care waste generation from Shifa hospital based on 2.67 kg per capita per day. ▪ Waste minimization or separation of health care waste is not available. All items are mixed together. ▪ System of collection of health care waste including collection points is not available. ▪ Transportation means for transporting health care waste out of Shifa hospital to the landfill doesn't exist. All waste are collected together. ▪ Colored bins/containers for health care waste doesn't exist.	2
1.2 Health care waste collection	▪ 65% of the health care waste generated in Shifa hospital is being collected in thin plastic bags (Massrouje, 2000) ▪ Data on health care waste, generation is 8 tonne per day but composition, statistics, haul distances at Shifa hospital is no available. ▪ No segregation of the medical waste except sharps, which are collected in special boxes, donated by WHO. ▪ Neither storage room for health care waste nor system of color bags is available.	1
1.3 Resource recovery	▪ Health care waste separation at source through education and training is not available at Shifa hospital. ▪ Economic incentives of proper management of health care waste are not available. ▪ Resource recovery through tax and duty exemptions, credit, training is not available.	1
1.4 Disposal and treatment	▪ Records keeping and characteristics of health care waste being incinerated are not available. ▪ Proper treatment of health care waste is not available. Waste is being disposed of with domestic waste. ▪ Technical performance of treatment facilities is not available.	1
1.5 Handling of health care waste	▪ Data on types, quantities and source of health care waste in Shifa hospital is not available. ▪ Existing practices regarding health care waste is being addressed by the World Bank for investigation. ▪ Technical guidelines for sound management of health care waste handling are not disseminated. ▪ Possibilities for separation at source and for separate treatment and disposal were not identified.	1
	(2) Institutional	
2.1 Institutional building	▪ Transparent procedures for competitive bidding and contracting out health care waste services are not available. ▪ Organizational structure to deal formally with health care waste services and participation of tendering and contracting are not available. ▪ Responsibility matrix for that should do what pertaining health care waste is still ambiguous.	1
2.2 Organizational development	▪ Pay-scale and incentive systems for the staff of health care facilities is not available. ▪ Recruitment and promotion procedures based on merit and performance is not available. ▪ Transparent system of rewards and penalties pertaining health care waste is not available	1

Table II.4: Incineration of Health Care Waste – Shifa Hospital – Case Study Four

Variable	Description	Score
2.3 Human resource development	▪ Skills and educational levels of health care waste management staff within Shifa hospital were very low level. ▪ Training of the staff at Shifa Hospital has been addressed by the MoH, MEnA and the World Bank. ▪ Staff working in Shifa hospital was not motivated to take training on health care waste management.	1
2.4 Innovation and partnership	▪ In 1997, the MoPIC in partnership with the MoH has initiated a workshop to highlight health care waste as an environmentally and public health problems, ▪ Shifa hospital is not partnering with any Palestinian institution to deal properly with health care waste problem.	1
	(3) Financial	
3.1 Budgeting and cost accounting	▪ Shifa hospital through the MoH has the authority to raise funds for its activities however, funds through fees or taxes for health care waste is not available. ▪ Shifa hospital doesn't have budget to implement health care waste pilot project. ▪ Capital and recurrent costs of health care waste is not available. ▪ Mechanism to finance recurrent costs of health care waste at Shifa hospital is not available.	1
3.2 Revenue generating mechanism	▪ Incentives to encourage waste minimization like source reduction, recycable products, good management and control practices and waste segregation are not available. ▪ Fees or billing system for health care waste disposal at Gaza landfill is not available. However, hazardous waste cell has been built by the EU but the system doesn't exist. ▪ Consultancies from local authority, NGO's or private sector regarding health care waste management costs are not available. ▪ Revenue from HCW resource recovery is not available.	1
3.3 Cost reduction and control	▪ Waste reduction, reuse and recycle, good management and control practices and waste segregation are not available. ▪ Performance related pay-scheme in Shifa hospital, which linked to efficiency improvement is not available. ▪ Monitoring and evaluation of performance for increasing the efficiency is not available. ▪ Cost saving from improved maintenance, from improved financial management and planning for the health care waste service is not available.	2
	(4) Socio-economic	
4.1 Monitoring of public health	▪ Morbidity and other cause of waste-related disease in health care waste locations were not monitored. ▪ The workers have no protective devises (special clothing, thick gloves, boots or goggles) or washing facilities. ▪ Periodic diagnosis for workers involved in health care waste is not available. ▪ Working conditions of the health care waste is unhygienic.	1
4.2 Design of systems	▪ A master plan to deal with health care waste in Shifa hospital is not available. ▪ Stakeholders and staff concerned with health care services are interested to learn about health care waste. ▪ Stakeholder and their interest in health care waste is not being taking good care of. ▪ Social profile of areas to participate in health care waste scheme	1

Table II.4: Incineration of Health Care Waste – Shifa Hospital – Case Study Four

Variable	Description	Score
	through social surveys, focus group discussions, key informant interviews and other techniques were not available.	
4.4 User participation	▪ Neighborhoods NGOs and general public are not involved in planning and monitoring of health care waste activities. ▪ Communication channels between Shifa Hospital and the public pertaining health care waste is not available. ▪ Awareness rising programs on health care waste to mobilize staff at the Shifa hospital and to build a base for collective participation, using clear and simple messages and popular channels of communications are not available.. ▪ Complaint mechanisms for the general public against improper collection and illegal dumping of health care waste within Shifa hospital doesn't exist. ▪ Linkages and trust between different groups of NGO's, health care staff and other actors involved in health care waste management through joint management committee, coordination platforms are not available.	1
4.5 Social conditions	▪ Cooperation between Shifa hospital and municipality of Gaza to ensure safe storage and handling of health care waste in medical departments to minimize as far as practicable the residual health risk are not available. ▪ Working conditions of the health care waste is unhygienic; uniforms, protective wear like gloves, boots and other tools are not available. ▪ Measures to improve working conditions and to raise awareness on health care waste issues like protective wear, water and sanitary facilities are not available.	1
	(5) Environmental	
5.1 Rulers and regulations	▪ Environmental legislation governing collection and disposal of health care waste is not available. ▪ Establishment of health and hazardous waste facility was a prerequisite by the Israeli in Oslo agreement.	1
5.2 Environmental sound practice	▪ Health care waste were observed left at the ground mixed with domestic waste in and near to plastic containers. ▪ Transportation means for health care waste is not available. ▪ Source reduction, recyclable products, good management, control practice and waste segregation are not available. ▪ Environmental effects of health care waste were not monitored. ▪ Leachate and gases generated were also not monitored. ▪ Resource recovery through awareness raising, incentives, training, access to protective wear and tools were not available. ▪ Ash resulted from the incineration at Shifa hospital is disposed of with domestic waste.	1
	(6) Policy and Legal	
6.1 Policy and legal	▪ National framework law to deal with health care waste is not available. ▪ Plans to finance and operate health care waste systems at Shifa hospital are not available. ▪ Regulations on health care waste service are not available.	1
6.2 Planning and policy	▪ An effective bylaws and ordinances for health care waste is not available. ▪ Legislation to enforce health care waste system was not available.	1

Table II.4: Incineration of Health Care Waste – Shifa Hospital – Case Study Four

Variable	Description	Score
	• Gaza municipality is responsible for the disposal of health care waste.	
6.3 Regulatory framework	• Effective regulations and procedures of private sector participation is not available. • Legal enforcement and inspection structure is not available. • Civil society and media are not playing their actual role a watchdog.	1

Table II.1 which includes the ISWM aspects and the selection of waste management technology was distributed to 10 local people whom are in decision-making and policy formulation level in the field of SWM in the Gaza Strip, weights for each aspect was given by the interviewee. These weights were as follows: 15% for the technical, 30% for institutional, 20% for financial, 10% for socio-economic, 10% for environmental and finally 10% for policy and legal aspect. Scores for sub-variables were given based on data information for each case study gathered from the site It is concluded from these evidences that, institutional followed by financial were the most influential aspects addressed by the experts, sum of these two influential aspects were 50% and the rest of other aspects (technical, socio-economic, environmental and policy and legal) were 50%. Results from the scoring were analyzed using excel and weighted scores as well as weighted score percentages were obtained as depicted in Table 7.13 and Table 7.6 using the following formula:

Weighted score = Σ weight × score

Weighted score Percentage = Weighted score/ maximum score.

Table II.5: Evaluation Matrix for Disposal Options

Option 1: Landfilling					
Criteria	Sub variable	Weight (%)	Score	Weighted Score	Weighted Score %
1. Technical	Total	15%	20		
	1.1	5	4	20	4
	1.2	2	3	6	1.2
	1.3	2	4	8	1.6
	1.4	6	5	30	6
	Sub Total %		**16**	**64**	**12.8%**
2. Institutional	Total	30%	20		
	2.1	10	4	40	8
	2.2	5	3	15	3
	2.3	5	2	10	2
	2.4	10	4	40	8
	Sub Total %		**13**	**105**	**21.0%**
3. Financial	Total	20%	5		
	3.1	20	2	40	8
	Sub Total %		**2**	**40**	**8.0%**

Option 2: Composting					
Criteria	Sub variable	Weight (%)	Score	Weighted Score	Weighted Score %
1. Technical		15%	15		
	1.1	6	4	24	4.8
	1.2	7	4	28	5.6
	1.3	2	3	6	1.2
	Sub Total %		**11**	**58**	**11.6%**
2. Institutional		30%	20		
	2.1	10	2	20	4
	2.2	10	1	10	2
	2.3	5	3	15	3
	2.4	5	3	15	3
	Sub Total %		**9**	**60**	**12.0%**
3. Financial		20%	15		
	3.1	8	1	8	1.6
	3.2	8	1	8	1.6
	3.3	4	2	8	1.6
	Sub Total %		**4**	**24**	**4.8%**

Option 3: 3R's					
Criteria	Sub variable	Weight (%)	Score	Weighted Score	Weighted Score %
1. Technical		15%	5		
	1.1	15	4	60	12
	Sub Total %		**4**	**60**	**12.0%**
2. Institutional		30%	15		
	2.1	12	2	24	4.8
	2.2	13	2	26	5.2
	2.3	5	2	10	2
	Sub Total %		**6**	**60**	**12.0%**
3. Financial		20%	15		
	3.1	8	2	16	3.2
	3.2	8	1	8	1.6
	3.3	4	1	4	0.8
	Sub Total %		**4**	**28**	**5.6%**

Option 4: Incineration					
Criteria	Sub variable	Weight (%)	Score	Weighted Score	Weighted Score %
1. Technical		15%	25		
	1.1	2	2	4	0.8
	1.2	3	1	3	0.6
	1.3	2	1	2	0.4
	1.4	6	1	6	1.2
	1.5	2	1	2	**0.4**
	Sub Total %		**5**	**15**	**3.4%**
2. Institutional		30%	20		
	2.1	10	1	10	2
	2.2	10	1	10	2
	2.3	5	1	5	1
	2.4	5	1	5	1
	Sub Total %		**4**	**30**	**6.0%**
3. Financial		20%	15		
	3.1	8	1	8	1.6
	3.2	8	1	8	1.6
	3.3	4	2	8	1.6
	Sub Total %		**4**	**24**	**4.8%**

Option 1: Landfilling

Criteria	Sub variable	Weight (%)	Score	Weighted Score	Weighted Score %
4. Socioeconomic		10%	10		
	4.1	5	3	15	3
	4.2	5	2	10	2
	Sub Total %		5	25	5.0%
5. Environmental		10%	15		
	5.1	4	2	8	1.6
	5.2	3	1	3	0.6
	5.3	3	2	6	1.2
	Sub Total %		5	17	3.4%
6. Policy & Legal		15%	10		
	6.1	8	3	24	4.8
	6.2	7	2	14	2.8
	Sub Total %		5	38	7.6%
	TOTAL	100%			57.8%

Option 2: Composting

Criteria	Sub variable	Weight (%)	Score	Weighted Score	Weighted Score %
4. Socioeconomic		10%	25		
	4.1	2	1	2	0.4
	4.2	2	2	4	0.8
	4.3	2	3	6	1.2
	4.4	2	3	6	1.2
	4.5	2	3	6	1.2
	Sub Total %		9	18	4.8%
5. Environmental		10%	15		
	5.1	4	1	4	0.8
	5.2	3	1	3	0.6
	5.3	3	3	9	1.8
	Sub Total %		5	16	3.2%
6. Policy & Legal		15%	10		
	6.1	8	1	8	1.6
	6.2	7	2	14	2.8
	Sub Total %		3	22	4.4%
		100%			40.8%

Option 3: 3R's

Criteria	Sub variable	Weight (%)	Score	Weighted Score	Weighted Score %
4. Socioeconomic		10%	25		
	4.1	2	1	2	0.4
	4.2	2	2	4	0.8
	4.3	2	2	4	0.8
	4.4	2	2	4	0.8
	4.5	2	2	4	0.8
	Sub Total %		7	14	3.6%
5. Environmental		10%	15		
	5.1	4	1	4	0.8
	5.2	3	1	3	0.6
	5.3	3	2	6	1.2
	Sub Total %		4	13	2.6%
6. Policy & Legal		15%	10		
	6.1	8	1	8	1.6
	6.2	7	2	14	2.8
	Sub Total %		3	22	4.4%
		100%			40.2%

Option 4: Incineration

Criteria	Sub variable	Weight (%)	Score	Weighted Score	Weighted Score %
4. Socioeconomic		10%	25		
	4.1	2	1	2	0.4
	4.2	2	1	2	0.4
	4.3	2	1	2	0.4
	4.4	2	1	2	0.4
	4.5	2	1	2	0.4
	Sub Total %		4	8	2.0%
5. Environmental		10%	15		
	5.1	4	1	4	0.8
	5.2	3	1	3	0.6
	5.3	3	1	3	0.6
	Sub Total %		3	10	2.0%
6. Policy & Legal		15%	10		
	6.1	8	1	8	1.6
	6.2	7	1	7	1.4
	Sub Total %		2	15	3.0%
		100%			21.2%

Abbreviations for Landfilling Option

(1) Technical & Operational	(1.1) Composition of waste	(1.2) Existing practice	(1.3) Sitting of disposal facility	(1.4) Technology
(2) Institutional	(2.1) Structure roles and responsibilities	(2.2) Operational Capacity	(2.3) Incentives	(2.4) Innovations and partnerships
(4) Socio-economic	(4.1) Waste picking	(4.2) Others		
(5) Environmental	(5.1) Initial environmental risks	(5.2) Long-term environmental risks		
(6) Policy and Legal	(6.1) Political priorities	(6.2) Policy & regulating	(6.3) Contracting roles	

Abbreviations for Composting Option

(1) Technical & Operational	(1.1) Waste reduction	(1.2) Waste collection	(1.3) Resource recovery	
(2) Institutional	(2.1) Institutional building	(2.2) Organization development	(2.3) Human resource development	(2.4) Innovations and partnerships
(3) Financial	(3.1) Budgeting & cost accounting	(3.2) Revenue generating mechanism	(3.3) Cost reduction & control	
(4) Socio-economic	(4.1) Monitoring of public health	(4.2) Design of system	(4.3) Green waste separation	(4.4) User participation
(5) Environmental	(5.1) Rulers & regulation	(5.2) Environmental sound practice	(5.3) Education & awareness raising	

Abbreviations for 3Rs Option

(1) Technical & Operational	(1.1) Waste collection, reduction & prevention				
(2) Institutional	(2.1) Institutional building	(2.2) Organizational development	(2.3) Innovations & partnerships		
(3) Financial	(3.1) Budgeting & cost accounting	(3.2) Revenue generating mechanism	(3.3) Cost reduction & control		
(4) Socio-economic	(4.1) Monitoring of public health	(4.2) Design of System	(4.3) Separation of special items	(4.4) User participation	(4.5) Social Conditions
(5) Environmental	(5.1) Rulers & regulation	(5.2) Environmental sound practice	(5.3) Education & awareness raising		
(6) Policy and Legal	(6.1) Planning & policy	(6.2) Regulatory framework			

Abbreviations for Incineration Option

(1) Technical & Operational	(1.1) Waste collection, reduction & prevention	(1.2) Health care waste collection	(1.3) Resource recovery	(1.4) Disposal & treatment	(1.5) Handling of health care waste
(2) Institutional	(2.1) Institutional building	(2.2) Organizational development	(2.3) Human resource development	(2.4) Innovation and partnership	
(3) Financial	(3.1) Budgeting & cost accounting	(3.2) Revenue generating mechanism	(3.3) Cost reduction & control		
(4) Socio-economic	(4.1) Monitoring of public health	(4.2) Design of system	(4.3) Health care waste separation	(4.4) User participation	(4.5) Social conditions
(5) Environmental	(5.1) Rulers & regulation	(5.2) Environmental sound practice			
(6) Policy and Legal	(6.1) Policy & legal	(6.2) Planning & policy	(6.3) Regulatory framework		

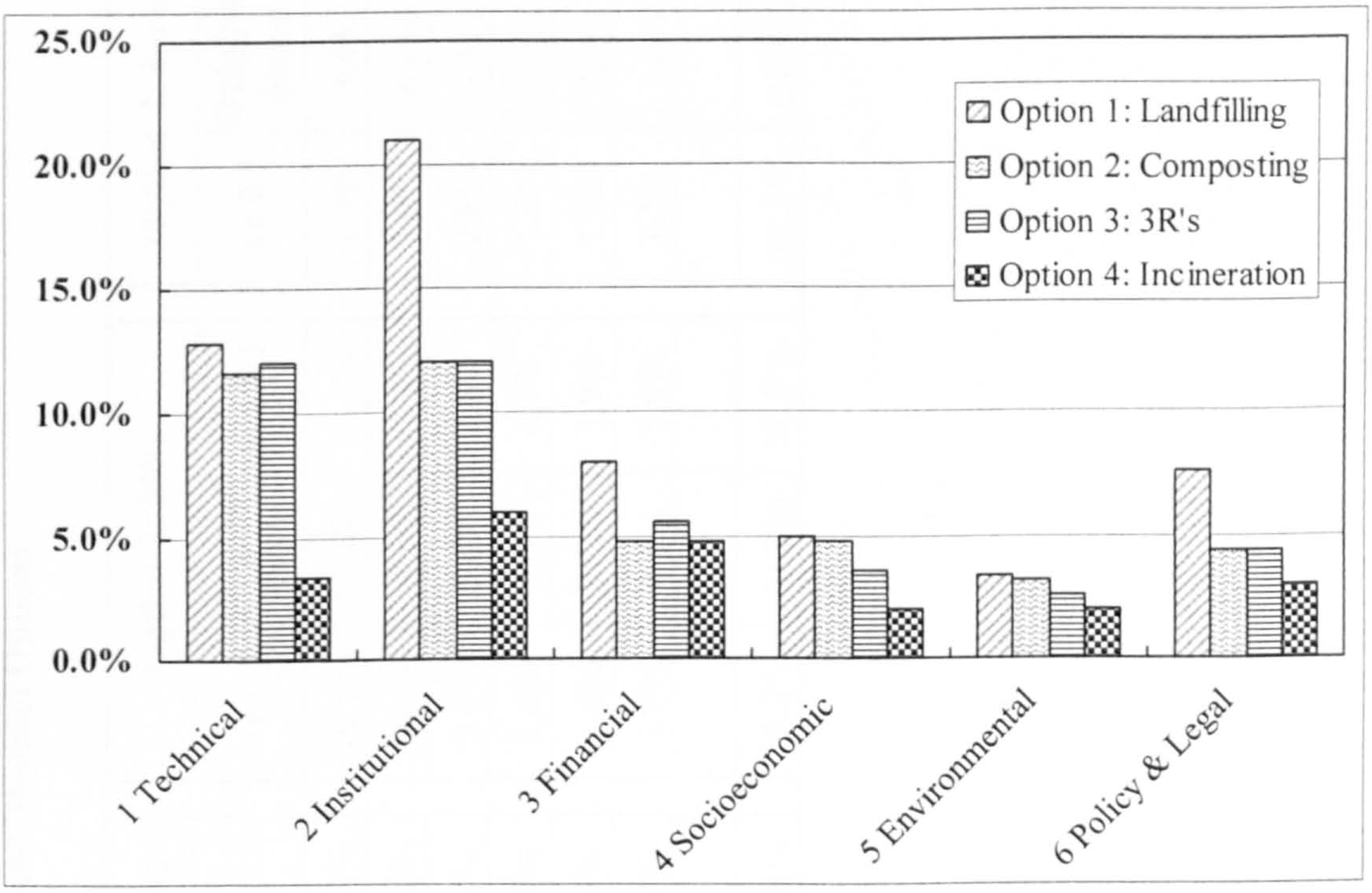

Figure II.9-2: Weighted Scores of the Four Disposal Options

Table II.6: Sensitivity Analysis of Different Disposal Options

Criteria	Weight	Option 1: Landfilling			Option 2: Composting			Option 3: 3R's			Option 4: Incineration		
		-ve 0.5	Original Score	+ve 0.5	-ve 0.5	Original Score	+ve 0.5	-ve 0.5	Original Score	+ve 0.5	-ve 0.5	Original Score	+ve 0.5
1- Technical	15%	11.3%	12.8%	14.3%	10.1%	11.6%	13.1%	10.5%	12.0%	13.5%	1.9%	3.4%	4.9%
2- Institutional	30%	18.0%	21.0%	24.0%	9.0%	12.0%	15.0%	9.0%	12.0%	15.0%	3.0%	6.0%	9.0%
3- Financial	20%	6.0%	8.0%	10.0%	2.8%	4.8%	6.8%	3.6%	5.6%	7.6%	2.8%	4.8%	6.8%
4- Socioeconomic	10%	4.0%	5.0%	6.0%	3.8%	4.8%	5.8%	2.6%	3.6%	4.6%	1.0%	2.0%	3.0%
5- Environmental	10%	2.4%	3.4%	4.4%	2.2%	3.2%	4.2%	1.6%	2.6%	3.9%	1.0%	2.0%	3.0%
6- Policy & Legal	15%	6.1%	7.6%	9.1%	2.9%	4.4%	5.9%	2.9%	4.4%	5.9%	1.5%	3.0%	4.5%
Total %age		47.8%	57.8%	67.8%	30.8%	40.8%	50.8%	30.2%	40.2%	50.5%	11.2%	21.2%	31.2%

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