Addressing the Barriers Hindering the Practice of Strategic Environmental Assessment
- a Case Study of Biogas Production from Municipal Solid Waste in Jordan

Master’s Thesis Prepared By:

ABEER J. SALAH
P.O. Box 850751, Amman 11185, Jordan
Tel: +962 (6) 551-7436

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(B’ism Illah Al-Rahman Al-Raheem)

In the Name of God, the Holiest and Most Merciful
Addressing the Barriers Hindering the Practice of Strategic Environmental Assessment

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List of Acronyms

Biological Oxygen Demand  BOD
Carbon Dioxide  CO₂
Carbon Monoxide  CO
Combined Heat and Power  CHP
Combined Services Councils  CSC
Danish International Development Agency  DANIDA
Environmental Assessment  EA
Environmental Impact Assessment  EIA
Final Disposal Sites  FDS
General Corporation for Environmental Protection  GCEP
Global Environmental Fund  GEF
Greenhouse Gases  GHG
Gross Domestic Product  GDP
Gross National Product  GNP
Hydrogen Sulphide  H₂S
Jordan Biogas Company  JBCO
Jordanian Electric Power Company  JEPCO
Methane  CH₄
Middle East  ME
Ministry of Energy and Mineral Resources  MEMR
Ministry of Municipalities, Rural Affairs and the Environment  MMRAE
Municipal Solid Waste  MSW
Municipality of Greater Amman  MGA
National Electric Power Company  NEPCO
National Environmental Strategy  NES
Nitrogen Oxides  NOx
Policy, Plan or Program  PPP
Royal Scientific Society  RSS
Royal Society for the Conservation of Nature  RSCN
Solid Waste  SW
Strategic Environmental Assessment  SEA
Sulphur Oxides  SOx
Tons of Oil Equivalent  TOE
Total Solids  TS
United Nation Development Program  UNDP
United Nation Economic Commission for Europe  UNECE
United Nations Framework Convention on Climate Change  UNFCCC
United States Agency for International Development  USAID
United States Department of Housing and Urban Development  USHUD
Volatile Organic Compounds  VOC
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Summary

Strategic Environmental Assessment (SEA) is identified as one of the most effective tools available, for integrating environmental considerations into the early decision making process. Nevertheless, several barriers are hindering the prevalence of this tool from becoming more practised. This paper address these barriers, aiming to test the effectiveness of a proposed simplified SEA methodology, identify new obstacles potentially hindering SEA prevalence, comment on obstacles currently identified in literature to be hindering SEA practice and suggest ways to overcome these obstacles.

Therefore, a hypothesis is proposed suggesting that one of the main obstacles facing SEA prevalence is the fact that current SEA methodologies, which mainly evolved from project level environmental impact assessment (EIA) procedures, are tedious and extremely detailed. At the decision making level, details are not as important as identifying the main issues and mitigation measures required for a proposed policy, plan or program. Therefore, a more simplified methodology, containing less detail and the use of special tools and techniques which deal with the broader perspective of higher level decision making, should achieve the main purpose behind conducting an SEA, while reducing the time and funding required.

The hypothesis is tested through conducting a case study for a proposed program of “Biogas Production from municipal solid waste (MSW) and Collection from Landfill Sites in Jordan” which aims to assess the suitability of this technology for Jordan in comparison with selected alternatives (No Action and MSW Composting), identify and mitigate any impacts resulting from its implementation, and assess if the proposed program can achieve its claimed objectives in alleviating some of the negative environmental impacts of the country’s current solid waste disposal system. The methodology used is based on available SEA methodologies, with simplifications made in the assessment of the current environmental situation, analysis and predictions of environmental impacts (based on qualitative analysis), and the use of scenarios and system thinking approach. Results indicate that the proposed Biogas Program offers the best compromise between feasibility, impacts on the environment which can be mitigated, and compatibility with existing environmental policy objectives.

The case study results support the proposed hypothesis, where the use of a simple, qualitative assessment, that does not entail great detail in impacts prediction, and mainly addresses the broader concepts and major issues related to the studied policy, plan or program, can be effectively used to highlight the main issues and mitigate the identified impacts. Thus making sure that the sustainability and carrying capacity concepts are successfully integrated in the course of the assessment, and the final decisions made. Consequently, request is made for practitioners and researchers to start viewing SEA and EIA as two separate tools, which complement each other. Stressing the need to develop SEA methodology and tools, in such a way that can deal with the broader perspective of the policy, plan or program. This should further aid in overcoming some of the barriers currently considered to be hindering the practice of SEA, including the fragmentation in higher level decision making, uncertainty and lack of precision in impact prediction, lack of application and shared experience in SEA practice.

Correlation is made to other barrier identified as hindering SEA prevalence, mainly related to the sustainability and carrying capacity concepts. These important concepts are not yet well grasped and understood by the public, and to an extent by decision makers. Thus, hindering the achievement of public participation and political support for environmental consideration into the decision making process. Recommendations are made to enhance the support for programs promoting public awareness regarding environmental issues and the sustainability and carrying capacity concepts, which should reflect positively on public participation and political support for SEA practice.
Section I: Background

1.1 Introduction

Strategic Environmental Assessment (SEA) is identified as one of the most effective tools available, which can strengthen the integration of environmental consideration in the early decision making process. Thus ensuring that environmental considerations and possible alternatives are addressed, the earliest possible, in parallel with economic and social factors when decisions are made concerning a policy, plan or program.

Nevertheless, and despite the availability of methodologies and procedures, SEA has failed to become a commonly used tool in most countries. Even in the very few countries which implement it, the application is still considered at a limited scale. Several reasons have been suggested to explain this delay in prevalence, but to no avail. SEA remains a tool facing many obstacles, and is yet to become more commonly practised.

Developing countries are facing new arising problems with grave environmental implications as a result of their current solid waste (SW) management systems. These systems do not portray sound practices that are able to support the much talked about “sustainable development” concept. With the anticipated population growth, economic development, and their corresponding SW generation, related issues and impacts are growing at a fast rate beyond the countries’ managing capacities in addition to the environments’ carrying capacity.

Jordan, is a small developing country in the Middle East region. Recently, the current practices of SW management have brought forward several issues and serious environmental impacts which need to be addressed urgently and without delay. Therefrom, a program is proposed by the United Nations Development Program (UNDP) in Jordan, suggesting the introduction of landfill gas collection systems in parallel with Biogas production technology from municipal solid waste (MSW) for its use in electricity generation. This is mainly in an attempt to alleviate some of the existing impacts of landfill sites, while demonstrating the benefits and feasibility of “waste-to-energy” concept. In addition to building local capacities and promoting local renewable energy sources in Jordan and the Middle East region.

1.2 Objectives

The main objectives of this paper are the following:

1. Test the effectiveness of a proposed simplified SEA methodology, as a tool for the integration of environmental consideration into early decision making.
2. Identify obstacles potentially hindering SEA from becoming a more widespread and commonly practised tool, and suggest means to overcome them.
3. Comment on the obstacles which are stated in literature to be currently hindering SEA prevalence, and suggest ways to overcome them.

1.3 Hypothesis

Existing methodologies and procedures for SEA are tedious and extremely detailed. This is one of the main obstacles facing the prevalence of SEA, as a more commonly used tool at the decision making level.

Current available SEA methodologies have mainly evolved from project level environmental impact assessment (EIA) procedures, and therefore are burdened with the details inherited from them. With the broader concepts incorporated in SEA and associated with higher level decision making, these details become complex thus time and money consuming, to an extent that is becoming one of the main barriers hindering the prevalence and practice of SEA on a more common level.
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At the decision making level, detailed impact analysis is not as important as identifying the main issues and mitigation measure required for a proposed policy, plan or program (PPP). Therefore, a more simplified methodology, containing less details, should be able to achieve the main objectives of conducting an SEA for a proposed PPP. Thus reducing the time and funding needed for conducting these studies, and helping to overcome some of the obstacles hindering their practice.

1.4 Methodology

The effectiveness of the proposed simplified SEA methodology is tested through conducting a case study prepared for a proposed program of "Biogas Production from MSW and Collection from Landfill Sites in Jordan", aiming to assess the suitability of this technology for Jordan in comparison with other possible alternatives, and if the suggested program can actually achieve its claimed objectives without creating new negative impacts.

The case study is constructed based on the currently available and acknowledged SEA procedures, where the need for conducting an SEA is identified, scoping process and relation to other relevant PPPs and system boundaries are established. Thus leading to the identification of different alternatives, based on the stated objectives of the proposed program, and similar SEA studies conducted in developed countries.

The proposed simplifications in SEA procedures are introduced in the environmental analysis. These are mainly achieved through using a qualitative rather than quantitative environmental assessment where various tools and techniques are applied, these are:

- **Impact or pressure indicators**, which measure the human impacts on the environment, are used in order to measure and describe baseline environmental conditions and predict impacts for the studied alternatives.

- **Scenario approach**, which describes and compares the anticipated consequences under each alternative is used to predict and compare the anticipated consequences of the studied alternatives. These scenarios cover a period of 25 years, which offers adequate time scale for cumulative impacts to occur and be identified. Additionally, the scenarios are built on the "worst-case-scenario" approach where no improvement in other related PPPs and activities is expected to occur. Data used in the scenarios are mainly based on 1997 data, while projections are built on official published projections and rates, or on assumptions based on current practices in developed countries and experts recommendations.

- **System thinking and analysis approach**, which is applied in order to integrate and achieve a comprehensive perspective of the different parameters, effects and interactions expected to occur under the studied scenarios. Thus aiding in understanding their interactions and relations to other PPPs and activities, and further facilitating their analysis.

The selection of the best alternative is based upon the comparison of the different environmental situations anticipated for each alternative, while mitigation measures and monitoring plans are suggested for the chosen alternative. Risk and uncertainty, and linkage to sustainable development are also discussed to conclude the case study.

Reflections on currently available SEA methodologies, and the effectiveness of the proposed simplifications in the procedure, are mainly based on literature survey, experience gained and results obtained from conducting the case study. The problems that the author encountered while conducting the case study, which can be identified as potential barriers hindering the practice of SEA are also presented and discussed. Furthermore, the barriers stated in literature to be

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*It is important to note, that at the time of selection, the proposed Biogas Program was still under study by the government of Jordan and still not approved or signed. While conducting the SEA study, the government decided to approve the program and it was signed. Therefore, although the results obtained from the SEA study will not change the decision to accept or reject the proposed program, it is hoped that the mitigation measures suggested are considered when projects are initiated under this program.*
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hindering the prevalence of SEA as a commonly used tool and discussed and commented upon. Finally, recommendations are suggested to help overcome all these barriers and obstacles, thus helping in promoting the practice of SEA at high level decision making.

I.5 Limitations

Several limitations were involved and interfered in the course of preparing this paper. These are:

- **Only one case study was conducted**: Reflections made on SEA effectiveness and problems are mainly based on conducting one case study. If several case studies were conducted, then results would have been more substantiated.

- **Lack of publications on SEA theory and practise**: Difficulties were faced while searching for published information and literature concerning SEA theory, process and procedures.

- **Lack of funding**: This acted as the main obstacle against conducting seminars and surveys in the scoping and screening process of the case study.

- **Lack of author’s expertise in several areas involved in the case study**: This was one of the main difficulties encountered in predicting and assessing indirect and cumulative impacts in the case study.

I.6 Paper Outline

The paper is presented in four sections. Section I, includes the introduction and objectives of the paper, and presents the hypothesis which the paper is aiming to prove. The methodology used and limitations faced during the preparation of the paper are also presented in this section.

Section II, discusses the concept behind SEA, its definitions and uses as a tool for sustainability integration into the decision making cycle. Current available methodologies and procedures, links to project level EIA, and the problems and barriers facing SEA prevalence are presented. Finally, the section concludes by illustrating SEA situation in the international arena.

In Section III, an SEA case study is conducted and presented, using a currently available SEA methodologies, with simplifications made in the environmental analysis, which is mainly based on qualitative rather than quantitative impact assessment and the use of several tools and techniques to help reduce the complexity and detail of the analysis. The case study assesses the proposed program of “Biogas Production from MSW and Collection from landfill sites” for the country Jordan. Scoping is presented, description of study boundaries presents the regional and sectorial boundaries limiting the study, while links to relevant PPPs are also presented. Environmental data is built and presented under the description of the current situation, presenting information regarding all related issues, in addition to the description of the environmental situation within the study area. Later on, alternatives are selected, and presented using the scenario approach. Three alternatives are identified and studied; No Action, Proposed Biogas Program, and MSW Composting Program. Each scenario is presented using system thinking approach, where different parameters and effects are inter-linked, and impacts are identified. A comparison is made under the subsection entitled Comparison of Alternative, and based on the results, the best alternative is selected, and mitigation measures and monitoring and feedback are suggested. Risk and uncertainty, and sustainability tests are also addressed. Finally, results and implications of the proposed program are discussed.

The final section of the paper, Section IV, reflects on the results obtained form conducting the case study, and links them to the currently available SEA methodologies and problems. It addresses the possible effectiveness of current and proposed simplifications in procedures and methodologies. In addition to highlighting other possible problems identified to be hindering the prevalence of SEA in higher level policy making, and suggesting possible ways to overcome these obstacles.
Section II: Strategic Environmental Assessment - Theory and Practice

In the last two decades, environmental impact assessment (EIA), has become very much practised and well developed. This is a process for predicting and evaluating an action’s impacts on the environment, aiming to prevent environmental degradation by giving decision-makers better information about the consequences that a development action could have on the environment. Nevertheless, it has been mainly carried out on individual projects, and therefore its currently available methodologies deal with these best. Early discussions suggested that EIA should also be applied to the earlier, more strategic tiers of decision making which include policies, plans or programs. This has lead to Strategic Environmental Assessment, which mainly addresses environmental considerations at the higher levels of the planning process.

II.1 Definition

Strategic Environmental Assessment (SEA) is a systematic procedure for evaluating and predicting the consequences of decisions taken at an early stage. Thus ensuring that environmental considerations and alternatives are addressed the earliest possible, when decisions are made concerning a policy, plan or program.

"SEA is a systematic process for evaluating the environmental consequences of proposed policy, plan or programme initiatives in order to ensure they are fully included and appropriately addressed at the earliest appropriate stage of decision making on par with economic and social considerations."

Source: (Sadler B., Verheem R., SEA Status, Challenges and Future Directions, 1996)

Therefore, SEA can be considered as a decision aiding process rather than a decision making one. Similar to all the PPPs it is applied to, it can be considered as an instrument or a tool for development through more comprehensive policy making, planning and programming where all stakeholders (environmental, social and economic) are taken into consideration.

II.2 SEA and EIA: similarities and differences

Since SEA and EIA are based upon common principles, their components are basically similar. Similarities can be clearly evident when PPPs are already well structured and established and consequently initiate projects and activities. Here, EIA methods can be applied and have proven to work relatively well with a few modifications needed to account for the great degree of generality and uncertainty involved in policy and plan making. In 1992, a report prepared by the United Nation Economic Commission for Europe (UNECE) Task Force on Application of Environmental Impact Assessment to PPPs presented several recommendations on SEA procedure and practices to the participating governments. The report proposed that SEA should reflect the principles of project level EIA. The recommended procedure include the primary elements found in an EIA as presented below:

**SEA Procedural Steps - Recommended by UNECE Task Force (1992)**

- **Initiation**: determine the need for and type of SEA, by means of a list, a screening mechanism or both.
- **Scoping**: identify alternatives and impacts to be assessed, exclude irrelevant information.
- **Outside review**: seek input and advice of other governmental agencies, independent experts, interest groups and the public during scoping and after completion of the SEA
- **Public participation**: involve the public in the SEA process, unless limited to legitimate confidentiality or timing requirements.
- **Documentation**: present the information, either in a separate document or a chapter or paragraph or the policy proposal.
- **Decision making**: take SEA conclusions and recommendations into account.
- **Post decision**: identify follow up measures of overall impact of projects and measures resulting from the policy, plan or program.

Source: (Sadler B., Verheem R., SEA Status, Challenges and Future Directions, 1996)
Nevertheless, detailed differences between SEA and EIA still exist. These can be categorised under procedural and methodological issues. In the case of procedural issues, these are largely attributed to the fact that SEA is normally applied at an earlier stage in the planning process than that for EIA. For the methodological issues, significant differences in the detail of the assessment tasks exist. This can be mainly attributed to the following reasons:

- The scale of an SEA is greater than in an EIA. This is mainly justified since SEA is normally related to a range of activities in a geographic area.
- The time interval between the planning of an action and the implementation of the specific activities which give rise to environmental impacts is usually much longer in the case of SEA. Consequently, the content of the action is known in less detail, but is more likely to change at later stages in the planning process, while impact predictions are liable to greater uncertainty. These major scale and time differences clearly show the complexity of relating SEA to EIA\(^2\).

II.3 The importance of SEA

Many reasons are given for introducing SEA as an instrument or a tool in decision making for PPP, these can be summarised in the following three main objectives:

- **Strengthening project level EIA:** Currently, EIA is well established in most countries. This can be mainly attributed to the widely acknowledged fact that EIA process is quite effective in process planning and decision making, which was very much stressed upon in Principle 17 of the Rio Declaration on Environment and Development\(^3\). Nevertheless, it is also well recognised that EIA is constrained by certain limitations and weaknesses, which are primarily related to EIA’s implementation in decision making at a relatively late stage, where important questions of whether, where and what type of development should take place, have been already decided earlier without any significant incorporation of environmental considerations or alternatives. Henceforth, SEA process comprehends and solves those weaknesses in project level EIA, in addition to establishing an integrated policy framework of goals, objectives and principles\(^1\). This helps to make project EIA more comprehensive, since it does not only react to development proposals as an acceptance or rejection tool, but as an environmental tool which helps to anticipate and steer EIAs away from environmentally sensitive areas, while reducing the time and effort needed for conducting them\(^3\).

- **Addressing cumulative and large scale effects:** The environmental impacts of human activities are now occurring at a regional and global scale, examples are loss of biodiversity and global warming respectively. Over the last 10 years, effort has mainly been concentrated on extending EIA-based framework to encompass some forms of cumulative effects, which include\(^1\):
  - Additive impact of development such as small scale project that do not require EIA according to existing legislation;
  - Synergistic impacts where several projects total impacts is considered quite significant in comparison to the summation of their individual impacts;
  - Threshold/saturation impacts where the environment seem to be resilient up to a certain level of impacts, but rapidly degrades when this level is exceeded;
  - Induced and indirect impacts where one development project can result in the initiation of several development projects in the same area;
  - Time crowded / space crowded impacts where the environment is granted enough time or space to overcome the impacts of one project before it is subjected to the next one\(^3\).

Nevertheless, most of the above listed forms of cumulative effects still escape assessment due to the narrow scope of project EIA. SEA manages to fill this gap as it can be used as an

\(^{b}\) Principle 17 of the Rio Declaration: “Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority”.

(5)
"early-warning" system for predicting, managing and mitigating cumulative impacts on a local, regional and global scale. Furthermore, SEA helps in identifying development alternatives which can minimise cumulative effects, while establishing a framework that monitor these effects in later stages.

- **Incorporating sustainability considerations in decision making:** Sustainable development has become widely accepted as the ultimate goal for all environmental policies and development. However, its implementation is still considered quite complicated as it requires a comprehensive approach that involves a wide range of human activities and environmental factors, where sustainability can be made an intrinsic factor of all policies, and then "trickled down" through plans, programs and finally projects.

### II.4 SEA practice and methodologies

SEA has been considered mainly on the theoretical level rather than on the practical level. Therefore, SEA methodologies are found to be not sufficiently developed nor commonly agreed upon. However, a few officially acknowledged methodologies exist. These include the SEA manual prepared by the US Department of Housing and Urban Development (USHUD), the UK's guidebook on policy appraisal reviews techniques for assigning monetary values to environmental assets and impacts, the Canadian guidelines for SEA preparation, and the proposed EC directive which lists methods of SEA broken down into their functions. Additionally, several computer models have been prepared such as "Strategic Environmental Assessment System" and other methodologies suggested by academic researchers.

Although various SEA systems are available in different countries, they all basically include most or all of the items requested by the USHUD task force. Differences can be found in their scope, detail, and inter-relationship, which can be attributed to variances in policy making processes in different countries.

Based on the USHUD manual for SEA of policies, plans or programs, and recommended methodology by literature and practitioners, a combination of items have been integrated, which encompass most of the components needed in an SEA, thus giving the following procedure:

- **Determining the objective(s) of the proposed PPP:**
- **Description of the need and feasibility of the proposed PPP:**
- **Defining the scope of the SEA:** this mainly involves:
  - The identification of the study (boundaries) regional or sectorial, which form the limits to the SEA study;
  - The impacts to be addressed in the SEA, including a statement explaining why other impacts or issues will not be addressed;
  - Possible alternatives to the proposed PPP which can fulfil the stated objective(s), more or less effectively, by the proposed PPP. These should be realistic, representing range of likely approaches to objectives stated, and should fulfil the constraints identified. Alternatives are generally selected through discussions between experts, or using cost-benefit analysis or goals achievement matrixes;
  - Links other relevant PPPs and environmental requirements, in addition to public and relevant organisations' view on the issue.
- **Environmental analysis:** This includes the following:
  - Establishing an environmental database: The success of an SEA mainly depend on the availability of a data basis, which is accessible and of a nature and scale that is suitable to the area being studied. Therefore, the establishment of a database is essential to help deal with the large amount of information during impact analysis, synthesis, evaluation and monitoring for all proposed alternatives. Furthermore, knowledge of the baseline situation is an essential reference point in order to be able to predict, monitor and compare any environmental change that might occur. Existing environmental data should be collected at...
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the earliest stages of the study, while gaps in information can be identified. Monitoring systems, special surveys, and expert consultation, can be further used to meet the remaining deficiencies.

⇒ Impact prediction: Several techniques and tools are available for impact predictions where cumulative, secondary and indirect impacts are needed to be addressed. Some of these techniques include environmental indicators, aerial photography, computer models, national and regional forecasts (relating to issues such as population, energy use, pollution levels and traffic), mapping and overlay methods, resource and waste efficient analysis and many others.

⇒ Impact valuation and analysis: This is usually based on criteria such as compliance with relevant environmental standards, carrying capacity, and sensitivity to local residents' views. Checklists, scaling and weighting systems, overlay methods, consultation with environmental agencies, screening procedures, resource depletion, diffusion and damage analysis, and landscape assessment techniques are all existing methodologies which can be used in valuating the magnitude and significance of environmental impacts;

⇒ Proposed mitigation measures: Mitigation measures should be proposed to eliminate the negative impacts which have been identified earlier. Some of these mitigation could includes changing part of the PPP's scale or general location, improved public outreach and participation, changing the objectives of the PPP, or even some sort of compensation.

• **Recommendations:** Recommendations should be based on the results found in impact evaluation for all alternatives. They may include the identification of the preferred alternative, proposed mitigation measures for the selected alternative in order to minimise adverse impacts, and monitoring measures that may be necessary.

• **Monitoring and feedback:** Monitoring is required to evaluate the effects of the PPP over time and space. It also helps to detect any modifications needed during implementation, and feedback into future decision making. Monitoring techniques could include the application of evaluation criteria, use of guidelines, consultation and public participation, and environmental monitoring systems.

Additional SEA techniques recommended in literature, which consider some additional parts to be essential in an SEA study are;

• **Dealing with uncertainties at the strategic level:** this is of significant importance as in most SEA studies, there will be a significant uncertainty factor to deal with in the analysis. Several techniques are used to reduce this uncertainty, these include; clarifying assumptions, stating predictions in terms of ranges rather than precise figures, basing predictions on different scenarios, using worst-case-scenario based on the precautionary principle, and carrying out sensitivity analyses.

• **Analysis of cumulative impacts:** One of the main advantages of SEA is that it deals with PPPs in the appropriate space and time scales at which cumulative impacts can be expressed. Several approaches have been used for analysing these cumulative effects based on linking the three elements; sources, effects and processes. Matrix methods and network analysis can be quite useful for this purpose.

• **Analysis of effect on sustainable development:** Suggested methods to incorporate the environmental sustainability test include the incorporation of appropriate environmental indicators which can indicate if policy options are leading in the right or wrong direction with regards to sustainability. Several sustainability rules exist, including the “rule of renewables” and the “rule of non-renewables”, “rule for outputs”, “rule for conversion” and the “rule for opportunity costs”.  

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*Environmental indicators include; state-of-the-environment indicators which measure the present environmental baseline, impact or pressure indicators which measure human impacts on the environment, and action indicators which measure whether or how agents carry out specific actions.*
II.5 Problems with SEA

Several difficulties have been identified in literature which are considered to be hindering SEA implementation at a wider scale. Following is brief summary of these problems:

- The vague nature of proposals at the policy and plans level, and the fact that decisions regarding PPPs are usually made in a fragmented and not completely formulated form;
- The problem that involves the system boundary and the analytical complexity which can be mainly attributed to the large number of decisions that flow from a higher-level decision, in addition to the large number of possible alternatives to be considered at the different levels of policy making;
- Uncertainty and lack of precision in impact prediction which is a result of the lack of information about existing and projected future environmental conditions in relation to nature, scale and location of future development proposals;
- The lack of publications and shared experience concerning the application of SEA for PPPs;
- Uncertainty over public involvement in the policy-making process which can be mainly attributed to the need for confidentiality at policy levels and to the difficulties facing public participation at this broader level of decision making;
- The political nature of the decision making process mainly characterised by low priority given for environmental consideration in decision making. In addition to the lack of clear objectives regarding environmental goals to be integrated into decision making, and the fact that emphasis is mainly on economic development.

II.6 SEA in the international arena

Presently, SEA is much less widely understood and used than EIA. Nevertheless, since the early 90's, SEA studies and applications have been increasing. A few countries and organisations have established formalised and mandatory SEA provisions containing several features corresponding to those in EIA. Several countries incorporated some elements of environmental evaluation (EE) into their planning procedures. Others either have proposals, or are presently carrying out studies for the introduction of some form of SEA into their systems.

In the European Union, formal requirement for assessing the environmental impacts of certain PPPs exist. This can be found in Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom. Currently, the European Commission is in the process of developing a proposal for a new directive for environmental assessment (EA) applications to PPPs. The USA has conditions for “programmatic” EIAs under the directions of the National Environmental Policy Act (1969). In Canada, there is a commitment by the Federal Cabinet to assess the environmental impact of its policy decisions, and a formal procedure has been established and is in operation for this purpose. Both Australia and New Zealand have legal requirements for more strategic forms of EA, but they are not frequently used. A number of aid agencies now accept that EA procedures should be applied at the programme and project level. But their use at the higher level is much less developed (e.g. World Bank).

Developing countries show very little interest in SEA, as most of them are still working on their capacities building for project level EA. Although, EIA regulations and guidelines exist in south America and Asia, their effectiveness is limited by the need to support economic development. The process is normally hindered by institutional and financial problems. Africa, although needs EIA and SEA most, unfortunately does not offer the political stability needed to support the incorporation of environmental considerations into decision making. In Jordan, attention is mainly given to capacity building at project level EIA. Occasional attempts have been performed by local NGOs and individual consultants in response to international donors requests. At the policy level, an SEA was conducted for the agricultural sector resulting in the recently approved Agricultural Policy. Other studies include the Gulf of Aqaba Environment Management Plan and the Wadi Mousa Environment Management Plan. Nevertheless, the assessment of environmental impacts remains to be at a very low scale, especially in the absence of binding regulations.
Section III: Case Study - “SEA Study for the Program of Biogas Production from MSW and Landfills in Jordan”

The case study is conducted using the currently available and acknowledged methodologies and procedures for SEA which are presented in Section II, and are followed step by step. The simplifications proposed by the hypothesis are mainly introduced in the environmental analysis subsection, which is based on qualitative rather than quantitative impact prediction and analysis, in addition to the application of different tools and techniques to help reduce any complexity and to clarify the interrelation between parameters, impacts, and activities. These tools and techniques include; impact or pressure indicators, and scenario and system thinking approaches.

III.1 Identification of the purpose of the proposed program and the need for the SEA

With growing concern regarding the negative environmental impacts of the increasing amounts of generated SW in Jordan in the past few decades, it becomes essential to consider other possible means and methods for handling and disposal of this waste, while making sure that negative impacts are minimised or eliminated.

The proposed program of Biogas Production from Municipal Solid Waste comes in line with national policies and commitments for decreasing its GHG emissions, promoting local energy sources and reducing the environmental impacts from MSW handling and disposal activities. Additionally, the concept of electricity generation from methane gas collected from SW landfill sites incorporated with its production from MSW offer significant advantages and positive environmental and socio-economical impacts. The strategy suggested for the biogas production from MSW, is presented mainly for Jordan, and proposed for its neighbouring countries in the Middle East region, where the concept of “waste-to-energy” can be illustrated, in addition to building up the needed technical capacities to ensure the proper transfer of this technology.

Although the proposed program seems to present several environmental advantages in comparison with the current SW management system. Nevertheless, it is important to consider other possible alternatives which can fulfil, more or less, the same objectives expected from the proposed program, and to assess the negative impacts that might arise from accepting this proposal. Therefore, an SEA should be conducted to assess the proposed program before a final decision is taken.

III.2 Scoping

One of the main elements of environmental assessment studies is the scoping process. Scoping helps to identify the study area, main critical issues, potential alternatives and technical needs. In addition to making sure that public involvement is achieved continuously during the whole assessment process.

Due to time and funding limitations, there was no possibility for involving the public through seminars and sessions. Nevertheless, limited scoping was attained through the participation of several active institutes in the country such as the Royal Scientific Society (RSS), General Corporation for Environmental Protection (GCEP), Department of Statistics, Greater Amman Municipality (GAM), United Group Co. (Private consultancy), UNDP-Jordan, NEPCO, and Biogas Co. of Jordan through using published data and conducting interviews. Additional technical scoping was attained in Sweden where the report was written and finalised. This was mainly achieved through expert consultation in Biogas technology through BIO-Mill AB, and several meetings conducted with experts from different sectors for the completion of the environmental assessment and impact predictions.
The establishment of environmental basis was achieved using published data, and through meetings and interviews leading to helpful discussions concerning related issues. Additionally, collected data through site visits and interviews with workers at landfill sites were also acquired. Furthermore, key issues were identified through the scoping process for the present situation and the proposed program including; key stakeholders, key resources, administrative and geographic boundaries, related policies, key activities and interactions.

**III.2.1 Identifying Alternatives**

Scoping results lead to the identification of three main alternatives that need to be studied in relation to the objectives of the proposed program. These alternatives are; No Action, the Proposed Biogas Program, and MSW Composting Program.

It is essential, for the integrity of the SEA study, to present the reasons behind excluding SW incineration as an alternative. This can be attributed to the following reasons:

1. **Financial limitations:** incineration technology involves high capital investment and stringent maintenance requirement, which Jordan, a young developing country cannot afford to invest in at the time being.

2. **Technical limitations:** MSW in Jordan as in most developing countries, contains a high percentage of moisture content reaching up to 60%, which makes the incineration efficiency relatively low. This puts additional costs for the process as there will be requirement for de-watering facilities before incineration.

3. **Environmental regulations:** it is important to note that incineration as an alternative mainly offers a reduction in the volume of SW reaching landfill sites. Nevertheless, incineration processes involve the release of toxins (mainly dioxins) and gaseous emissions and disposal of solid residue containing high concentrations of heavy metals, which must be handled and reduced to environmentally acceptable minimum. Therefore, this alternative does not apply with, or help in supporting the country’s environmental regulations and commitments.

**III.2.2 Identifying Impacts**

A detailed discussion of the environmental setting within the studied area is presented later in the report. This has mainly lead to distinguishing the aspects and effects which are of serious environmental concern, using impact or pressure indicators which are measure human impacts on the environment such as amount of air pollutants and landfill leachate emissions, and land lost. These environmental effects have either direct impacts such as soil and water pollution and threats to archaeological heritage, indirect impacts such as health hazards and effect on biodiversity and ecosystem, and cumulative impacts such as climate change and threat to land and water resources.

Impacts which are selected not to be considered, are the negative impacts of connecting the proposed Biogas program to the national electricity network, and CO₂ emissions from burning methane for power generation. This can be justified when considering that under all studied scenarios, there will still be a need to expanding the electricity network, therefore the connection needed for the Biogas plants generating units will not present any additional impact. Regarding CO₂ emissions for electricity generation from methane, it is important to note that methane, when burned, produces less amount of CO₂ than fossil fuel. Since under scenarios other than the proposed biogas program, the increase in electricity generation will be mainly supplied by fossil fuel, then these scenarios are expected to produce even larger amounts of CO₂ emissions per GWh generated than that produced from the Biogas scenario.
III.3 SEA boundaries

Boundaries that limit the SEA study can be presented under two categories, these are mainly regional and sectorial boundaries. For this case study, regional boundaries can be easily defined as they are mainly enclosed in the Middle East region in general, Jordan in specific. Sectorial boundaries intersect in several ministerial jurisdictions including; Ministry of Municipalities, Rural Affairs and the Environment (MMRAE) which is the main body responsible for SW handling and disposal in the country, Ministry of Health, Ministry of Planning mainly responsible for the study and approval of all development programs and projects, The General Corporation for Environmental Protection (GCEP) as it is the government body responsible for all environmental issues on the national and global scale, and the Ministry of Energy and Mineral Resources (MEMR) with the responsibility of promoting renewable energy resources.

III.4 Relation to other relevant PPP’s and environmental requirements

The objectives of the Biogas program can be easily linked to several environmental national policies and plans, where reduction of the adverse environmental impacts of SW disposal in landfill sites, and the emissions of GHGs is promoted, these include:

The National Environment Strategy for Jordan (NES) (1991), is the first official national document addressing all environmental issues including reduction of GHG emissions and fossil fuel dependency, and promotion of renewable energy sources.

"The objective of safe waste disposal is to ensure that wastes are dealt with in a manner which protects human health and the environment, and which minimises burdens placed on future generations"

"Current policies on alternative energy: There is a policy to promote the use of alternative energy, such as biogas, solar and wind energy, and encouraging private sector to participation in their development"

"Air is ...an important resource that has no geographic boundaries; therefore, conservation of this resources is both a national and an international responsibility"

Source: (Jordan’s National Environmental Strategy, 1991)

The National Environmental Action Plan (NEAP) (1996), is the first official document to prioritise the main environmental issues, and suggest plans for environmental action. Several sections discuss issues and actions in relation to the scope of this SEA.

"None of the existing waste disposal sites is properly designed and their locations are grossly undermining the objectives set for a safe environment. The health of the people living near these sites and groundwater are at risk"

"The ministry of Planning in association with the ... municipalities of Greater Amman and Irbid {should} look into finding long term solutions to the management, treatment and recycling of solid waste in northern Jordan"

Source: (Jordan’s National Environmental Action Plan, 1996)

In relation to the protection of the atmosphere, Jordan ratified the Montreal Protocol in 1989. Additionally, the London Amendment (1990) was ratified, while the Copenhagen Amendment (1992) was signed in 1995. The latest report to the Montreal Protocol Secretariat was prepared in 1996.

Moreover, the country has ratified the United Nations Framework Convention on Climate Change (UNFCCC) which specifies that parties publish, formulate and update national programmes to mitigate climate, in addition to promoting sustainable management and developing national policies and take actions and measures (that demonstrate leadership role). The country’s latest report to the UNFCCC Secretariat was submitted in 1997.
Addressing the Barriers Hindering the Practice of Strategic Environmental Assessment

III.5 Environmental analysis

This chapter presents the environmental analysis for the proposed program and the selected alternatives. This is mainly achieved through initially building up the data base and terms of reference, through describing the current situation and its environmental implications. Scenarios are used to compare the projected consequences of the selected alternatives, mainly No Action, the proposed Biogas Program and MSW Composting Program. Time scale chosen for the scenarios is 25 years, which should demonstrate adequate time for cumulative impacts to occur and therefore be considered. System thinking approach is applied for providing a more comprehensive and integrated perspective of what the interactions of different parameters, issues and impacts could be.

III.5.1 Description of the current situation

Solid waste in Jordan

Solid waste issues are receiving increasing attention and importance in Jordan. This is mainly attributed to the growing volumes of solid waste generated and the serious impacts of the current disposal system. In the last decade, high population increase and industrial development, associated with changes in consumption patterns, have all resulted in the generation of large amounts of solid waste. Following is a brief description of the situation in the Jordanian SW sector.

Sources and amounts: Sources of SW generated in Jordan can be classified into: Residential, institutional, agricultural, commercial, municipal activities, and industrial sources. Daily productions of SW usually fluctuate depending on income and education level, custom beliefs, geography of the site, climate, season, times of collection during the week, and methods of collection and disposal (use of grinders). In terms of quantity per capita and constituents, the waste generated in Jordan is comparable to that of most semi-industrialised nations. Jordan's total estimated production of SW was 3,586 ton/day in 1996 (population of 4,444,000) giving about 0.81 Kg/day/capita as an average.

Disposal Sites: Solid waste generated is collected in containers, dumped or transported to an intermediate dump station, where it is thereafter transported for disposal. Disposal occur in several forms including open dumps, open burning cites or controlled landfills. There are 30 final disposal sites (FDS) in Jordan, of which 10 are unauthorised. Table (1) in Appendix presents the main 11 disposal sites and their characteristics.

Medical and hazardous Waste: Jordan's present SW collection system does not differentiate between the different sources of solid waste such as municipal, industrial or medical waste. This establishes SW reaching landfills to be highly contaminated. Recently, industries have been forced to deal with their hazardous and chemical waste. Therefore, most industries treat their liquid waste on-site, but few do it properly. On the other hand, hazardous wastes are disposed of in MSW landfills. Recently, a licence system has been established by MGA, where companies must have an agreement before they are allowed to dump the waste in landfills. Nevertheless, in the absence of alternative disposal facilities, rejection of applications has not been practised. Medical waste is also a problem, hospitals are forced to incinerate all hazardous waste and deal with radioactive material. The later is not properly handled or treated and therefore represents another source of concern.

Recently, the MGA has allocated a landfill site at El-Swaqah, 60 km south of Amman, which is being prepared to be used as a hazardous waste FDS. Until this site is ready for use, hazardous waste will continue to reach MSW landfill sites.

Ruseifa landfill: This is the largest FDS in Jordan, serving about 54% of the country's inhabitants (2,383,300) living in the capital Amman and the second largest city Zarqa. The
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landfill receives more than 70% of the total SW in Jordan in all its types (municipal, industrial, medical, hazardous, etc.) from both cities and from the industrial estate of Sahab, the largest in the country. The site has been in operation since 1987 and is operated by the MGA. It is an exhausted phosphate mine in the form of a hole 20-25 m deep and an area of 70 ha. The entire site is expected to meet disposal needs until 2003 if no major waste processing projects are established before that time. It is important to note that this large FDS is situated in close proximity to a residential area and was not properly designed for its present use. Therefore, it has recently become a major cause of concern.

Key Actors: Solid waste disposal and handling is the responsibility of the local authority represented in the local municipality. The Municipality of Greater Amman (MGA) manages all activities and stages of SW disposal in the capital Amman (including collection, transportation, and handling in FDS). In other areas, local municipalities are normally responsible for the collection and transportation activities, leaving the operation of the FDS to the Combined Services Councils CSC’s.

Private sector participation in SW handling and disposal activities is limited and confined in areas where municipalities contract the private sector for clean up of specific areas such as certain congested areas in Amman, Zarqa, Aqaba port and Petra Reserve.

Composition: MSW in Jordan is characterised by a high organic content. Combustible matter consists mainly from plastic, paper, and kitchen garbage, reaching about 90% of total waste, while water content is approximately 60% by mass. The average density of household SW (free condition) is about 0.317 ton/m³, reaching to about 0.60 ton/m³ on truck. Furthermore, some disposal sites also receive quantities of non-urban solid waste including industrial, medical, hazardous wastes in addition to liquid waste.

Status of Recycling: Currently, SW sorting at source is not practised, and no significant recycling of recoverable material is conducted on site. All activities aiming at recycling material are being conducted on an individual basis by the private sector and NGOs. No involvement of the municipalities or governmental authorities is present. On the whole, the percentage of recycled products does not reach more than 4-5% at best conditions.

Although the present collection system does not differentiate between the different solid waste. Other types of solid waste, including building material, bulky items (refrigerators and furniture) are transported to other disposing sites than landfills. Apart from these few exceptions, all solid waste, goes into the containers where it is mixed and then sent to the FDS.

Urban areas and population concentration: It is important to note that the percentage of urban population is 78.2% of total country inhabitants. These are primarily concentrated in 4 large cities, mainly Amman (the capital), Irbid, Zarqa and Balqa.

Amman and Zarqa cities are growing at a very high rate of 5% annually, which can be mainly attributed to high population growth rate (3-3.5%), migration to cities, in addition to the rapid movements of industrialisation and tourism in these cities.

Energy and electrical power sector in Jordan

Energy Sector and Electric Power Sub-sector: The energy sector in Jordan is mainly supervised by MEMR. Several other agencies work in this sector and report to MEMR, such as The Natural Resources Authority responsible for the exploration and development of domestic primary energy and mineral resources and Jordan Petroleum Refining Company responsible for refining, storage, transport and distribution of petroleum products. The National Electric Power Company (NEPCO) has the main responsibility of generation and transmission of electric supply to the public. While the two main distributing companies are Jordan Electric Power Company (JEPCO) and Irbid District Electric Company, and these are private enterprises where public has a
majority shareholding and ownership. The private sector is also active in other activities, including oil and gas exploration, refining, storage, transport and distribution of petroleum products through sub-contracting, in addition to private electricity generation by major industries.

**Power System**: The electrical system in Jordan comprises a few main generating power stations using different energy sources but with the majority operating on fuel oil imported from Iraq, since the Gulf war in 1991, by land trucks. Additionally, a few private power stations exist for the major industries. These private power stations are not connected to the main distribution network, and therefore only serve their owners requirements, contributing 5.4% of total electricity generated.

**Electricity demand**: Electricity consumption is directly related to gross national product GNP. Table (2) in Appendix presents the changes in electricity consumption for the last 10 years in correspondence to GNP increase.

Overall electricity consumption by sectors is mainly dominated by the industrial, domestic, commercial, and water pumping sectors as presented in Figure (1).

![Electricity Consumption for 1997 (GWh)](image)

**Figure 1. Overall electricity consumption by sectors for 1997**
Source: (NEPCO Annual Report, 1997)

**Poverty Issues and Economic Development**: According to Jordan’s NES, drafts of Agenda 21 and several other governmental documents, economic development and poverty alleviation have been given the top priority if sustainable development and environmental protection are to be achieved in the near future. This can be mainly attributed to the fact that the per capita income from national product in 1994 was estimated at 1015 JD/capita/year (1500 $US) with an unemployment rate of 12%. In 1997, statistics showed that the percentage of population living under poverty reached 18.3%, while 6.6% of the population were living under severe poverty.

Several issues related to economic development and poverty alleviation can be linked to promoting local and renewable energy sources, thus reducing dependency on fossil fuel, currently imported from neighbouring countries, and resulting in political and economic instability. In 1997, the quantities of energy consumed in electricity production was about 4.7 Million Tons of Oil Equivalent (TOE), corresponding to $US 420 Million.

**Description of the environmental setting within the study area**

In order to be able to describe the environmental setting within the study area represented by the country Jordan and all its FDS’s, it is suggested to consider the Ruseifa landfill with its
environmental setting as an example for all landfills in the country. This is mainly justified by the fact that this landfill serves more than 50% of the population and receives more than 70% of total SW generated in the country. More importantly, considering that this specific FDS is presently a source of serious environmental concern to neighbouring communities and environmental groups and that the first project in the program series is suggested to be constructed on this landfill.

Following is a brief description of the primary environmental aspects, effects and impacts which are considered as the main causes for environmental concern in relation to the current situation.

Aspects
There are several activities involved in the current system of SW management and landfill operations causing serious environmental impacts. These include the transportation of SW from urban and industrial centres to remote landfill sites, in addition to the activity of large uncovered vehicles on dust roads inside the landfill cites which are major sources of dust, particles, CO$_2$, NO$_x$, SO$_x$ gases and litter.

The activity of SW disposal into landfills itself, is a major cause of geophysical impact on soil structure, while aerobic and anaerobic activities on SW in landfills are major sources of GHG emissions, particularly CO$_2$ and CH$_4$. In addition to the fact that it is a direct source of fires, explosions, and offensive odour.

Moreover, leachate emitted is a source of soil pollution and endangers water resources in the area. The presence of insects, vectors, rodents, noise, and particulates and gases in the atmosphere are all considered as health hazards to the neighbouring communities.

The above aspects are further aggravated by the current electricity generating system, mainly based on non-renewable resources such as fossil fuel, principally diesel fuel and natural gas.

Impacts
Impacts are mainly results of aspects (sources), and can be of concern either on the short or long term depending on their types. This can be determined based on the fact that these impacts are either temporary, fading with disappearing causes, or permanent ones, having continuing effect even after the aspects have ceased to exist.

Following is a brief description of the major socio-economic and environmental impacts identified to be related to the current situation:

Water
- Groundwater: Currently, FDS under use in the country have not been pre-designed for their specific use. Landfills are not pre-lined and therefore, the risk of leachate infiltrating through the soil until it reaches groundwater is considered to be relatively high. This is further enhanced by the high percentage of moisture content in MSW (60%), thus resulting in high emissions of leachate from the anaerobic biodegradation in the FDS for an expected period of 10-30 years from SW disposal. Groundwater pollution mainly involves high nitrate and heavy metals concentrations.

For the Ruseifa landfill, it is estimated that about 160 m$^3$/day of leachate is emitted from the site. Under normal conditions, the time required for this emitted amount of leachate to reach groundwater level exceeds 250 years. Taking into consideration that the landfill was not pre-lined, and that grooves and channels exist and are very deep, this decreases the time needed for the leachate to reach underground water levels, increasing the risk of its pollution.

- State of wadies and streams: The Ruseifa landfill is located in the Zarqa river basin and the Amman aquifer, with several natural valleys and water ways in the area. Similarly, other landfill sites in the country such as Akaider, Kufirin and Humra sites have been placed in close proximity to waterways. Most landfills in the country are located in areas characterised
by dry and hot summers, and winters are moderate with 275 mm average rainfall\textsuperscript{16}. However, it is important to note that although rainfall in the area is low, it usually comes very strong and for a very short time, thus creating streams and floods which therefore present pollution threat to nearby surface water resources by landfill leachate running with rain water.

Furthermore, the Ruseifa Landfill is located in an area subjected to earthquakes with an intensity of up to 6-8 degrees according to Mercalli scale. Thus increasing the potential of leachate reaching waterways and underground water levels and therefore augmenting the risk of water pollution\textsuperscript{16}.

\textbf{Atmosphere}

- \textbf{Air pollution:} This can be considered as one of the main impacts related to the current situation. Impacts listed under air pollution include;
  \begin{itemize}
  \item \textbf{greenhouse gases (GHG) emissions:} Greenhouse gases are one of the most serious environmental issues of the time and landfills are considered one of the main sources of these gases. GHG from FDS are emitted mainly as a result of the biological activities in FDS, specifically the anaerobic biodegradation of organic matter. Gases emitted comprise of high concentrations of methane (45-50\%) and carbon dioxide (about 35-40\%) which have been identified as the two main greenhouse gases\textsuperscript{16}. In the case of the Ruseifa landfill, considering that the landfill already contains more than 6 Million tons of SW and receives 2100-2500 ton/d. According to the RSS study, every ton of SW produces 360 m\textsuperscript{3} of gas, then the expected production of methane gas would be about 200,000 m\textsuperscript{3}/day, and 130,000 m\textsuperscript{3}/d of CO\textsubscript{2}\textsuperscript{16}
  \item Additionally, the present electricity production system, based on fossil fuel, is one of the major sources of GHG emissions as the current production of 6,264 GWh corresponds to 4.7 million TOE\textsuperscript{15}
  \item The latest GHG inventory in 1994 estimated anthropogenic emissions by sources, and removal by sinks. Results reached show that about 93\% of the country’s CH\textsubscript{4} emissions are from MSW management, while 87\% of total net CO\textsubscript{2} emissions are from fuel combustion as an energy source\textsuperscript{7}.
  \item \textbf{Air pollutants such as CO, NO\textsubscript{x} and SO\textsubscript{x} gases and particulates} which are mainly produced from oil-fired power stations, diesel vehicles and fuel combustion, in addition to waste incineration in landfill sites as a result of fires and occasional explosions. These pollutants have been identified to exist at high concentrations in FDS as a result of their activities and transporting vehicles. In addition to their emissions from the generating electrical power stations, mainly operating on fuel oil. Furthermore, secondary pollutant such as tropospheric ozone which is formed from the presence of volatile organic compounds (VOCs) and NO\textsubscript{x} in the atmosphere, is another pollutant which presents another source of health hazard to the neighbouring communities and their inhabitants.
  \item \textbf{Dust} from FDS due to transporting vehicles: In case of the Ruseifa landfill site, trucks transporting the solid waste across the 0.5 km road from the main road to the disposal site, are one of the main causes of dust occurrence in the area. Although not considered a major air pollution problem, this is one source of air pollution in the area that can be eliminated\textsuperscript{16}. Other disposal sites are placed far away from the main roads, therefore, dust from SW transporting vehicles does not occur in the FDS only, but also along the roads reaching it.
  \item \textbf{Offensive odour:} several sources of offensive odours exist in the landfill site, these are mainly attributed to the fact that the SW is usually dumped in open air for at least an hour before it is covered. Additionally, odour from hydrogen sulfide H\textsubscript{2}S gas emissions and from the occasional burning of the waste due to fires caused by methane gas emissions. Furthermore, serious offensive odour caused by landfill leachate produced from anaerobic biodegradation of SW\textsuperscript{16}.
  \end{itemize}
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- **fires**: The occurrence of fires in landfill sites is directly related to the presence of methane gas in concentrations above 5% (v/v). The main effect of these small fires is directly related to air pollution. This is a result of the emissions of CO$_2$, VOC’s, halogens, hydrogen sulfide H$_2$S, ashes and particulates from SW incineration in open air\textsuperscript{16}.

- **Congestion due to transportation to the site**: This is mainly related to the environmental impacts due to the emissions from vehicles transporting the SW to landfill sites. These vehicles are mainly operated on diesel fuel, therefore emitting large amounts of CO$_2$, SO$_x$, NO$_x$, and causing congestion and pollution along the roads leading to the landfill sites. Currently, the Ruseifa landfill site receives about 300-350 vehicles per day operating on Diesel fuel\textsuperscript{10}.

With low humidity and rainfall in the area, atmospheric pollutants are not returned to the ground but are allowed to stay in the air where they persist and accumulate, migrating to surrounding areas and increasing the size of areas affected.

Macroclimatic changes have been directly linked to the increase in GHG emissions. These act as strong absorbers of outgoing terrestrial infrared radiation, thus contributing to global warming. Global warming in its turn, changes the position and intensity of weather systems, therefore changing the regional wind, temperature and precipitation patterns. On a global level, global warming has been identified as one of the main reasons behind global sea level rises as a result of glaciers and ice sheets melting, in addition to thermal expansion of sea water. These are linked to loss of land to the sea, river floods, tsunamis and hurricanes and droughts, as a consequence of the extra energy which is locked in the earth’s atmosphere and not allowed to escape\textsuperscript{17}.

**Land**

- Soil pollution from landfill leachate: Leachate generated from SW in landfills has a direct effect on the soil quality around landfills. This is attributed to the fact that toxic waste is not pre-sorted from organic waste before disposal in landfills. Thus the leachate emitted from the landfill contains toxins such as mercury, zinc and other metals leading to pollution of the soil in landfill site areas and in areas surrounding it.

- land loss for SW disposal purposes: Jordan is relatively a small country by size, with increasing population and SW generation rates. This puts high pressure on increasing the sizes of landfills, thus leading to a loss of land for disposal sites close to urban areas. These lands are usually characterised as relatively productive lands with good soils which should be used productively instead of being lost for SW disposal.

**Nature and biodiversity**

- Natural environment, temporary and permanent damage: Ruseifa landfill site was earlier used for phosphate mining and was left as a large hole in the ground before it was used as a landfill. Therefore, the permanent change that has occurred in the natural environment in the area can be directly linked to the previous activities in the area and not only to its present use as a solid waste disposal site\textsuperscript{16}. Nevertheless, this cannot be said about all the country’s landfill sites, as in most, damage in the natural environment occurs as a result of the disposal activities and therefore must be considered as one of the impacts incorporated with using waste disposal sites and landfills. In the cases where toxic and radioactive waste is disposed of improperly, this temporary damage escalates to persistent pollution of soil and water in the area, thus creating the potential of permanent damage to the natural environment as the change in the wildlife and vegetation cover in the area is directly effected.

- **Loss of biodiversity and introduction of new species**: Landfill activities are direct causes of changing soil geophysical structure, and therefore a change in eco-structure and biodiversity. This is mainly due to the fact that the change in the vegetation cover effects the change in fauna thus changing the biodiversity. Additionally, the disposal of SW is directly related to
the introduction of new species in FDS such as mosquito, flies, rats and others. For the Ruseifa landfill case, due to the intensive past activities of phosphate mining and industrial activities in the area, the natural environment has been seriously affected and changed\[^{16}\].

**Human-Cultural**

- **State of sanitation and health**
  - Vectors and insects: For the Ruseifa landfill, vectors such as rats and small animals, insects such as flies and mosquitoes exist and are a cause of continuous complaint from neighbouring communities. The effect of the presence of these vectors is directly related to the state of sanitation for the landfill area thus affecting the labour force working in this FDS and its close-by inhabitants. Similar conditions exist in most landfills operated in the country\[^{16}\].
  - Health problems and hazards: Due to the offensive odour, dust and different gases emitted from the landfill, it has been noticed that the inhabitants living in close proximity to the Ruseifa landfill site have a high percentage of different respiratory track problems such as asthma and allergies\[^{16}\]. Furthermore, medical waste poses great health risks to the workers in landfill sites and those who are in direct contact with the SW.

- **Noise**: According to the RSS study, no high degrees of noise have been recorded due to the Ruseifa landfill activities. This can be assumed to apply for most landfills in the country as most of them are situated far away from urban areas, or are surrounded by a hilly or mountainous terrain which act as natural barriers\[^{16}\].

- **Aesthetics**: According to the RSS study, there are no problems related to visual intrusion in Ruseifa landfill as it is placed far from the main road and is surrounded by wired fence which makes the view much less offensive. Nevertheless, litter in the form of plastic bags and paper are transferred by wind from the landfill before it is covered. In most cases the fences surrounding the landfill sites are not high enough to capture this litter and therefore the areas surrounding the sites are usually filled with it\[^{16}\].

- **Radiation**: Currently, most FDSs are receiving medical waste, which includes radioactive waste. Although, no research has been performed on this issue on any landfill site in the country, nevertheless, the author expects that significant radiation exist in these areas which can be considered as a serious environmental impact expected to persist on the long run.

**Socio-Economic impacts**

- **Economic loss due to health problems**: An increase in health problems is usually identified for inhabitants living in areas close to landfill sites, as more visits to physicians have been cited per capita in these areas. This can be directly linked to economic losses due to the increase in the family’s budget lost for medical care, in addition to the reduction in workers productivity in these areas as a result of such health problems.

- **Land devaluation**: Currently, the environmental conditions in areas surrounding landfill sites do not favour economic activity and urban expansion due to odour problems, noise from landfill activity, insects and vectors and several other health hazards. This has directly lead to the devaluation of land surrounding landfill sites and therefore have indirectly lead to economic losses for the owners of these lands.
III.6 Alternative scenarios

This section discusses proposed alternatives separately, by building scenarios for each alternative for a period of 25 years (1998-2023), where the expected environmental situation under each scenario is presented and discussed. System thinking approach and causal loop methods are applied for interconnecting involved parameters and issues. Thus presenting a clearer and more realistic scenarios. Projections used in the scenarios for the studied period are either based on 1997 data, or obtained from existing published projections.

The scenarios are built on the “worst-case-scenario” approach. This is reflected through the assumption that no positive changes are expected to occur in other related sectors, which might effect the outcomes of the scenarios. Thus no changes with time in the percentage of waste sorting or recycling is incorporated, nor in the percentage of energy supplied from renewable resources (solar, wind and hydropower). Furthermore, the introduced technologies, mainly Biogas Production and MSW Composting, are built on the assumption that in 25 years period, Jordan will be able to reach the efficiency which is currently reached in developed countries such as Denmark and Sweden.

Following is a presentation of the basic data which the three studied scenarios are built upon:

**Solid waste generation for the next 25 years**

In 1996, based on a population of 4,444,000 the total production of SW was estimated to be 3,586 ton/day, thus giving about 0.81 Kg/day/capita as an average per capita, of which only 0.465 Kg/day/capita are of municipal origins. Solid waste generation is expected to significantly increase, considering the country’s high population growth rate of 3.3%, where population is expected to reach 14,878,000 capita by the year 2024. In addition to changes in lifestyle, production and consumption patterns. A study prepared for UNDP-Jordan in 1993, estimated the increase in SW generation to be around 4-5% annually.

For the purpose of this study, an annual growth rate of 5% will be accepted and used as a basis for the projection of SW generation for the period under study. Figure (2) illustrates the projections for the total amounts of SW generated in the country for the period 1998-2023, based on 1997 numbers and using the accepted 5% annual growth rate.

![Figure 2. Projected increase in SW generation ton/day for the period 1998-2023.](Image)
Energy and electricity projected demand

A DEMAND model was created by GCEP for the purpose of predicting the energy and electricity requirements for the period between 1994-2023, while taking into considerations the social and economic developments and objectives. The main socio-economic factors that were identified as influencing were: population, gross domestic product (GDP), governmental policies and assumptions for future development.

Results show that the average annual growth rate of energy demand during the model’s study period is about 4.9%, reaching up to 16 million TOE by 2023, see figure (3). The average annual growth rate of electricity demand for the same period is projected to be 6.1%.

![Figure 3. Projected demand in Total Energy and Electricity for the period 1998-2023.](image)

*Total energy demand represents LPG, Kerosene, Diesel, Fuel Oil, Gasoline, Jet fuel, and Asphalt.*

Source: (GCEP initial communication report for UNFCCC, 1997)

Note: When comparing the projected electricity demand for the year 1997 from the module at 5285.7 GWh with the actual electricity consumption for that year of 5281 GWh, it is clear that the model’s estimations are quite accurate and therefore will be used in this study.

Risk and uncertainty

In most SEAs, a significant uncertainty factor is involved in impacts identification, prediction and analysis. This is further magnified when addressing indirect and cumulative impacts. This is mainly due to the high level of abstraction found in policies, plans and programs in comparison to project level EIA.

In this SEA study, several sources of uncertainty are identified, these include:

- Projections for the 25 year period No Action scenario are all built on data published by governmental agencies, which include some uncertainty (population growth, SW generation, and energy and electricity demand).
- Assumptions used in building up the Biogas and Composting Scenarios, are based on currently available technologies and efficiencies in developed countries (Sweden and Denmark), which have different physical, social, economic and political conditions than those in Jordan.
- Predictions of direct, indirect and cumulative impacts of different activities, normally considered to have the highest uncertainty in an SEA study as several interactions interfere, including the future state of the environment, other related PPPs and projects, and changes in future technology and political and economic priorities.

Several adaptive methods are applied through the assessment of the three alternatives, which are used to reduce this uncertainty, these are:
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⇒ Use of scenarios: Used to reflect different possible future events and conditions;
⇒ Clarification of assumptions: To clearly identify that the results obtained are mainly based on assumptions, so that any changes in assumptions are expected to reflect on the SEA outcomes;
⇒ Expert qualitative judgement: addressing uncertainty by drawing on experience and knowledge from professionals, cases and the results of similar actions;
⇒ Using “worst-case-scenario” based on the precautionary principle: Where changes are only assumed to occur in MSW management and landfill gas emissions, and based on present technology efficiency, and the fact that in 25 years Jordan will be able to reach current technological efficiencies available in developed countries. Additionally, no assumptions were made to include other renewable resources, changes in technological efficiency, nor the introduction of combined heat and power (CHP) technology.

III.6.1. No Action Scenario

This scenario describes the expected environmental situation for the period (1998-2023) under the situation where the current SW management system is maintained without any substantial changes. Therefore, SW in general, and MSW in specific, will continue to be disposed off in landfills which were not pre-designed for their use purposes.

The scenario discusses the economic, social and environmental impacts expected to exist and those which are predicted to escalate as a result of increasing generated amounts of MSW reaching landfill sites. These increases are mainly in correspondence to population growth and anticipated changes in consumption and production patterns with social and economic development.

Description of the expected No Action Scenario- System thinking

In order to compose a comprehensive idea of how the situation is expected to be under the No Action scenario, it is important to link all issues involved and display how they interact together, thus affecting the social, economic and environmental situation. System thinking approach, and causal loop methods are applied for the interconnection of all parameters and issues as presented below.

In relation to the purpose of the study, it is important to initially identify the main parameters involved. These can be identified as mainly sustainable development, population, solid waste generation and energy demand.

Taking population to be the starting point for building up this scenario, the following rationale is anticipated.

With the projected increase in population and expected changes in lifestyle, production and consumption patterns, and economic development called upon by all governmental strategies and policies, there are two main issues to discuss;

- Projected increase in the amounts of MSW generated: It is important to link this increase in SW generation to its management and treatment systems which will continue under this scenario. Since no serious attempts of recycling or reuse of waste material is considered, then the increasing amounts of SW generated will lead to an increase in the fleet of vehicles necessary for its transportation to the FDS. Additionally, an increase in the areas of land needed for SW disposal will occur, causing large areas of land to be lost for SW disposal. Moreover, land in the proximity of these landfills will continue to be devaluated and therefore negatively influence economic development. Furthermore, the negative impacts of increased emissions of landfill leachate will intensify, thus augmenting the deterioration of water and soil quality around these landfills.
Furthermore, with the expected high urban expansion rate associated with population increase, and the anticipated increase in NGO activities and public awareness concerning environmental issues, it is therefore justified to predict that the community will urge for moving landfills to remote areas where the impacts are less sensed by the inhabitants. This will consequently result in a further increase in land lost for SW disposal, while at the same time increasing the distances travelled by SW transporting vehicles to these remote sites. In addition to the high costs of SW management expected to burden the country’s economy.

- **The projected increase in demand for energy and production of electricity:** Under the No Action scenario, the projected increase in the demand for energy and electricity production will consequently increase the pressure for intensifying fossil fuel imports from neighbouring countries. This is expected to reflect negatively on the country’s political stability, while adverse socio-economic impacts of this fuel dependency will occur due to the misallocation of large amounts of currency in fossil fuel imports, instead of investing it in local development activities, which could help in alleviating poverty and unemployment.

Taking the whole system into perspective, it can be realised that the situation under the No Action scenario is expected to escalate and continue its deterioration. Hindering social and economic development, a situation which is further enhanced by political instability. Moreover, the adverse effects of these activities on the environment and ecosystem are all building up cumulatively and causing severe irreversible damage. The interconnection between all the above discussed issues are presented in Diagram (1) below. The positive and negative signs used, illustrate the relationship between various issues, where a positive sign indicates a directly related relationship (increase leads to and increase, and vice versa), while the negative sign indicates an inversely related relationship (increase leads to a decrease, and vice versa).

**Diagram 1. Relationship between different activities and their impacts.**
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Description of expected environmental settings - No Action Scenario

The No Action scenario presents the situation in which the existing problems will not be dealt with. Therefore, issues that are presently considered to be of minor or relative importance, will become of considerable impact, aggravating the situation and augmenting the effects. Moreover, the fact that the effects are now of persistent characteristics, occurring for a longer period of time, will lead to a change in situation where temporary damage to the environment becomes of a permanent\(^d\) form, and indirect and cumulative impacts become of serious concern.

**Water**
- Surface and groundwater quality: The danger of the increased amounts of leachate generated from landfill sites is mainly from reaching surface water in the vicinity, contaminating it with its high biological oxygen demand (BOD), nitrates, phosphate, sulphate, chlorides and high metal content (mercury, lead, and others) thus causing eutrophication and contamination. For ground water, the threat from leachate is mainly in increasing the nitrate and heavy metal content, rendering these precious water resources not suitable for human or animal consumption.

**Atmosphere**
- Air Pollution: These are mainly micro and macro level impacts.
  - *Micro* level impacts: These are mainly a result of the increase in air pollutants such as; SOx, NOx, VOC's, particulates and dust, which can be mainly traced to the transportation system, and energy and electricity generation system primarily based on fossil fuel. These pollutants have adverse impacts on plant growth and animals, in addition to the health hazards associated with them. Indirect impacts can be linked to the synergistic effect of SOx and NOx, and VOC's products in the development of secondary pollutants such as tropospheric ozone and photochemical oxidants which have adverse effects on vegetation growth\(^19\). Figure (3) presented earlier illustrate the amounts of electricity in TOE for the period under study under the No Action scenario.
  - *Macro* level impacts: These are principally attributed to the increase in GHGs (mainly CO\(_2\), CH\(_4\) and N\(_2\)O gases) causing climate change and global warming effects. Cumulative effects of global warming have been linked to water resources and rainfall patterns. Studies of climatic changes indicate that by the year 2050, and with the increase in GHG emissions, temperature on earth will increase by 4-5°C, with an increase of 1-2°C in the equatorial region and 3-4°C in the polar region. Thus, climatologists expect that precipitation would increase in the polar region. While evaporation would increase, and precipitation would decrease around latitudes 25° North and 35° South, where Jordan and most other Arab countries are located. This can be considered a catastrophic impact as the country cannot handle any decrease in the current low annual rainfall\(^7\)\(^\alpha\)\(^8\). Emissions of CO\(_2\) and N\(_2\)O are mainly linked with the energy and transportation systems in the country.

Jordan's methane emissions are mainly ascribed to the emissions from anaerobic biodegradation of MSW in landfill sites. Taking into consideration that every ton of MSW reaching landfill emits 360m\(^3\) of gas (45-50% methane), thus giving 180m\(^3\) of methane emitted per ton of MSW\(^16\).

Methane emission projections for the period under study, can be linked to the amount of SW anticipated to be reaching landfills as presented in figure (4).

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\(^d\) Permanent damage is a situation where the environment changes in characteristics to adapt with persistent effects. These changes are difficult to overcome, even when the cause has ceased to exist.
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Figure 4. Projections for methane emission from SW reaching landfill sites under the No Action scenario.

- Offensive odour, fires, and congestion due to transportation: With increasing amounts of SW generated, a corresponding increase in transporting vehicles number is expected to occur. Increase in offensive odour in relation to the increase in leachate emissions is expected, while increased risk of fires and explosions are mainly linked to the increase in methane emitted from MSW landfill sites.

**Land**

One of the main issues involved in the increase in SW generation and disposal is the impacts of these activities on land and soil.

- Soil pollution from landfill leachate: The projected increase in leachate emissions from landfill sites containing high concentrations of pollutants and toxins (nitrate, phosphate, sulphate, chlorides, and heavy metals such as mercury, lead, and others) will therefore increase the area contaminated and elevate the level of deterioration in soil quality. Further studies are recommended to be conducted on this issue.

- Land loss for SW disposal purposes: Large areas of land are required for SW disposal purposes which can handle 13,388 ton/day of SW expected to be generated by the year 2023. Additionally, detrimental effects due to changes in the geophysical structure of soil as a result of SW disposal activities can also be expected. Taking into consideration that every hectare takes about 70,000 tons of SW, then the projected loss of land for the next 25 year period can be linked to the amounts of SW reaching landfill sites as presented in Figure (5).

Figure 5. Annual Projections of land lost for SW disposal under the No Action scenario.

**Nature and biodiversity**

When assessing the effect on the natural environment, it is important to link the synergistic effect that can arise from the expected changes in land (soil and geo-structure), water quality and
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availability, and air quality, as these compromise the basic environment for living species to coexist and grow. Changes in soils geo-structure and increased concentrations of toxins and pollutants in soil, air and water, all these existing in a persistent manner will create a stressed environment where permanent damage has great potential to occur.

Expected changes in vegetation cover (flora) and therefore in wildlife (fauna) in stressed areas is expected to take place. These changes include the disappearance of some species including mammals. The introduction of new species such as plants and animals, in addition to the overgrowth of species that may find the environment suitable such as mosquitoes and other insects, rodents and vectors, and new plants species. The no separation of hazardous waste and radioactive material from MSW projects a risk of introducing new mutated species.

Since no specific studies are available regarding this issue in the country, it is recommended that further studies be conducted.

Human - Cultural

- State of sanitation:
  - Vectors and insects: Vectors and insects are expected to grow in number with increasing MSW reaching landfills and deteriorating environmental conditions, thus making it more difficult for the authorities to keep their numbers under control, therefore augmenting their adverse impacts on sanitation in these areas.
  - Health problems and hazards: Health problems for those working in landfills and nearby inhabitants are expected to escalate, as higher concentrations of pollutants are emitted with high exposure duration, thus increasing the number of people getting allergies, acute and chronic respiratory problems linked to landfill activities and fossil fuel as energy source.
- Noise: No significant impact.
- Aesthetics: Adverse effects on aesthetics are expected from the increase in SW transporting vehicles, increase in landfills and their related activities.
- Recreation: Adverse impacts are expected in relation to the loss of large areas of land for SW disposal instead for recreation.
- Archaeological heritage: Jordan is a country with great archaeological heritage, a great percentage of it has not been revealed yet. With the increase in land needed for SW disposal, this endangers these archaeological sites and their conditions.

Since no specific studies are available regarding these issues in the country, it is recommended that further studies be conducted.

Socio-Economic

- Promoting local renewable energy sources: No significant impact.
- Economic impacts: Expected increase in economic losses are mainly a result of health problems linked to the contaminated environment, adverse impacts of allocating large investment and funding for SW management and fossil fuel imports, in addition to the economic losses linked to the devaluation of land in proximity to landfill sites, and the loss of productive land for SW disposal.
- Social impacts: adverse social impacts of SW disposal activities on the quality of life of nearby inhabitants to landfill, poverty and unemployment rates, land loss and degradation of nature, biodiversity and ecosystem, which are all expected to intensify under this scenario.

Since no specific studies are available regarding these issues in the country, it is recommended that further studies be conducted.
III.6.1 The Biogas Program Scenario (Biogas production from MSW and landfills)

Program description

A program for developing a series of biogas production plants from MSW and collection from landfills to be used for electricity production, was proposed by UNDP-Jordan and has been approved by the Jordanian government. It is arranged for the first plant to be funded by GEF and DANIDA through UNDP and the Government of Jordan. The program involves a special fund, to be established from part of the revenues, which will be set aside for training, promotion of biogas and investment in replication projects.

The responsibility of the construction and operation of these plants will be shared by GAM and NEPCO. These two institutions have formed a joint venture called Jordan Biogas Company (JBCO) which is responsible for program implementation.

A Special Consultative Committee has been established under the project, which guides present and future activities aimed at utilising MSW for energy production. The main responsibilities of the committee is to assist with information exchange, co-ordination and training aspects, and advising on fund allocation.

Program Objectives

The suggested program, demonstrated in the series of biogas plants from MSW, has several objectives to be achieved on the short and long run, these can be summarised as follows:

- Promoting local and renewable energy resources: The production of biogas from MSW and landfills for electricity generation comes in line with Jordan’s NES and the NEAP documents where the government has clearly stressed the need to seek local and renewable energy sources by promoting the use of alternative energy sources such as solar, wind, biogas and others.
- Reducing dependency on imported fossil fuels: The country is currently dependent on imports for most of its energy sources. Thus, any local energy production, as expected from the biogas program, will help in relieving the country from this dependency.
- Protection of water resources: Jordan is one of countries in the world, expected to be facing a water shortage crisis in less than two decades. Therefore, the protection of its available water resources have the highest priority. Several of the present FDS are located above or in close proximity to major water aquifers, and since they are not properly lined they are leaching to the underground and close by waterways. The program offers one way of reducing the amounts of SW reaching landfill, and therefore reduction in leachate emissions threatening these water resources.
- Reduction of greenhouse gases emissions: MSW landfill sites in Jordan are the major sources of GHG emissions, mainly CH4. The program proposes one way to reducing these emissions through landfill gas collection and reduction in amounts of MSW reaching landfill sites.
- Reduction of health hazards: SW landfills are causing serious concern regarding health hazards in additional to fires and explosion risks. These problems cannot be ignored and must be addressed while they are of a magnitude that can be handled and overcome.
- Sorting, recycling, energy and fertiliser production: The program offers a demonstration of the concept “Waste to Energy”. Furthermore, the advantages of using the by-product as fertilisers help to illustrate a realistic example of the concept “Nutrients Recycling” and the benefits gained it.
- A demonstration for the Middle East (ME) region: One of the main objectives of this program is to demonstrate that it is technically and economically viable, to use MSW for biogas production in the ME region. The availability of human resources, high educational and
organisational level in the country, make Jordan an excellent choice for capacity building and technology transfer in the ME region.

Capabilities and key role actors - in Jordan and the Middle East region

Jordan is well known for its high educational level within Middle East standards, in addition to its well known expertise in most economic and technical branches. Several actors are expected to be involved in the implementation and development of the Biogas program locally and for its dissemination in the ME region. These actors are:

- **Governmental bodies**: The MGA and municipalities through MMRAE are the main bodies responsible for handling all waste generated in the country. While GCEP is the body responsible for implementing all environmental related regulations in co-operation with the Ministry of Health. The role of MEMR and NEPCO is mainly for providing the local expertise in the electricity production and distribution sector, thus helping to build a strong base for electricity generation and distribution for this new technology.

- **Jordan's Biogas Company (JBCO)**: The implementation of the Biogas program has been assigned to JBCO. The company is the main key role actor for the success of this program, as it will act as a link between all other role actors, making sure that the progress of the program is according to its objectives.

- **Academic institutions and research centres**: Jordan is well known for its academic institutions in the region. Academic institutes (such as The University of Jordan and the University of Science and Technology) are expected to play a prominent role in facilitating the transfer of technology and building capacities. Additionally, several other research centres such as RSS which is mainly concerned in applied research and has a very strong Arab and international linkages, thus making it a key role actor in the dissemination of the results of the Jordanian expertise in the ME region.

- **Non Governmental Organisations (NGOs)**: Jordan large and influential NGOs, including the Royal Society for the Conservation of Nature (RSCN), Jordan Environment Society (JES) and several others. These NGOs are very active in the protection of nature, environmental issues and the promotion of public awareness and benefits of recycling and reuse of waste. All this is expected to reflect on the success of the biogas program.

First Step: Proposed Biogas plant from MSW and landfill gas at Ruseifa FDS

The first step in the program is proposed to be constructed at Ruseifa landfill site. The project presently in the planning phase, and includes the construction of a combined landfill gas collection and a biogas plant. The landfill gas collection system comprises of 10 wells, and the biogas plant will have the capacity of handling 60 tons/day of organic waste. The combined facility will produce 1000 kWh (1 MWh) amounting to 8,000,000 kWh (8 GWh) per year. Since the selected location for the plant is at the same site of the current landfill, then waste will be transported to it by the same trucks that normally deliver the waste to the current landfill.

**MSW Biogas Plant**

The suggested biogas production plant system is very simple. Waste is initially discharged on a concrete plate at the receiving station where non degradable and potentially contaminating matters are sorted and separated. Thereafter, degradable material are sent to the receiving tanks while the undesired residues are disposed of at the dump site. Waste received is mainly from clean sources, such as slaughterhouses, food waste from restaurants, expired food, fat, oil, chicken manure, market waste, blood and sesame waste.

At the receiving tanks, three parallel pre-storage tanks are used since some industrial waste (blood waste), is readily biodegraded with a relatively high specific gas production rate compared with ordinary fruit and vegetable residues. Thus, the composition of the substrate to the digesters can be used to control the gas production rate.
A waste chopping system is included and the tanks are equipped with mixers to ensure that the SW is dissolved into the liquid (re-circulated liquid from the digested mater) to form a homogenous slurry. The slurry containing 10-12% Total Solids (TS), is dosed into the two digestion tanks using eccentric screw pumps. These are completely stirred tank reactors equipped with vertically mounted external mixers where the biomass is heated to 55°C using heating coils (heat collected from the water cooling system of the gas engines).

The gas is led through pipes, drained for condensate, and then led to a small low-pressure storage tank which is used to equalise the hour-to-hour variations in production and consumption for power generation.

The solid residue is considered as a very good fertiliser that can be used as soil conditioner due to its high nutrient and humus content. For the 60 ton/day of MSW, 4.6 m³ of slurry and 40 m³ of wastewater are expected to be produced. It is proposed to load this slurry into tank containers, which are later collected by trucks from farms. The nutrient rich wastewater is to be returned to the landfill, thus activating the biodegradation process in the landfill and increasing the rate of methane production. If the slurry is to be stored for a longer time, it is to be dried to 70% TS (giving 2.1 m³/day).

**Landfill Gas Collection**

The landfill gas extraction system consists of 10 wells, each of 20m suction radius and 25m depth. In the middle of each well, a perforated plastic pipe is mounted and surrounded by gravel which allows the gas to be sucked into the pipe. The pipe is connected to a horizontal suction pipe which leads to a pump container (screw compressor type), after which the gas is directed to the utilisation system through a transmission pipe.

**Power Production**

The gas produced from the MSW plant is fed into two gas engine generators, each of 500 kW electricity output. These are connected to the public grid, producing 250 kW for the plant operation and 750 kW for the network.

The utilisation of the collected landfill gas is proposed to be in a power production plant placed together with the MSW biogas plant. This can be achieved using a gas engine which is linked to a generator producing 500 kW of electricity with an expected energy utilisation ratio of 32%. The total extracted landfill gas from the first 10 wells is expected to produce 300-500 kW.

Although all three engines will be equipped with an air cooling system, unfortunately, there are no users for the waste heat in the vicinity. If this should change in the future, the heat can be supplied.

**Generation potential**

In 1994, the overall emission of methane resulting from MSW treatment in the country (mainly emitted from landfill sites) was estimated at around 371,000 tonnes per year, of which about 190,000 tonnes are from the Ruseifäa landfill site and is expected to increase at the same rate as MSW of 4-5% annually. This corresponds to a total generation potential of 28 MW (224 GWh annually) for the country and corresponds to about 5.2% of electricity demand for that year.

**Description of the expected Biogas Program Scenario - System thinking**

For comparison purposes, the No Action scenario rationale will be used as a base for the description of this scenario, while stress will be put on the areas and issues where interference, positive or negative, from the biogas program is expected to occur.
Assumptions

For the purpose of building this scenario, an assumption is made for the projected expansion of the biogas technology in the country. Therefore, it will be assumed that the production capacity will increase in the next 25 years where it reaches the maximum currently achieved in developed countries (Sweden and Denmark) at retrieving 80% of methane emissions from MSW by the end of the period\textsuperscript{13}. This can be mainly achieved partly through the expansion of the MSW biogas production plants, where they will handle up to 40% of the country’s total MSW generated (60% of MSW is of organic origin, and 70% is used in biogas plant). This assumption is mainly based on the fact that this percentage is currently achieved in developed countries. The rest of the methane will be collected through gas wells from landfill sites.

The program is suggested to start with 1 MW generation units (as in the first step program), reaching up to 250 MW at the end of the period, see Table (3) in Appendix.

An important point to be noted, is that since the biogas production technology is very simple, and does not require huge construction in buildings, then it will be assumed that the impacts arising from constructing these plants will be minor and not of any detrimental effect. The argument for the biogas collection wells from the landfills is also similar.

Using the same parameters of population, sustainable development, projection for MSW and electricity generation, and the system thinking and causal loop connections, below is a discussion of the main issues and a brief description of where the biogas program is expected to interfere breaking or enhancing the effects of these cycles.

- **Projected increase in the amounts of MSW generated**: Under this scenario, the biogas program will interfere to decrease the amounts of MSW reaching landfill sites. This will therefore positively effect the areas of land used for landfill sites since less land will be needed as part of the waste will go to the biogas plant and become fertiliser and biogas. Similarly, less areas of land will be devaluated as the areas of landfills will not increase immensely.

  Although the biogas program itself will not directly influence the SW transportation part, since MSW sorting is suggested at site, and not at source. Thus the same amount of SW generated will have to be transported either to the landfill or to biogas plant. Nevertheless, it might indirectly offer a positive effect, as a result of the reduction in the amounts of MSW reaching landfills, and therefore less negative environmental impacts and health hazards will be sensed from these landfill, then the need to move these landfills to more remote areas will decrease, thus reducing the journeys’ length of transporting vehicles and therefore the corresponding environmental impact. All of these advantageous effects of the program are expected to positively reflect on sustainable development.

  On the other hand, under the present suggested biogas production system which suggests to de-water the slurry, reuse a small part of the wastewater in the plant and return the rest into the landfill site, this may be considered appropriate for the first step where only 60 tons/day of MSW are treated which produce 40 m\textsuperscript{3}/day of process wastewater. But, with the expected expansion in the Biogas plant, the amounts of waste reaching the landfill site will decrease, thus increasing the life of the landfill, and the amounts of wastewater directed to the landfill will be more than the amounts of leachate emitted under the no action scenario. Thus increasing the threat of soil and water pollution from landfill leachate\textsuperscript{13}.

- **The projected increase in demand for energy and production of electricity**: Building on the No Action scenario, the electricity generated from the biogas program is expected to reach up to 8% of the country’s total electricity demand by the end of the studied period and as presented in figure (6), taking into consideration that 1 MWh of electricity generated requires 7800 m\textsuperscript{3} of methane\textsuperscript{16}. This will interfere in the fossil fuel dependency cycle which has a
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great effect on the political and economic stability in the country. This interference may not lead to break this dependency, but at least relieve it. In addition to illustrating a successful example, which is expected to further encourage investments in local renewable energy sources such as solar and wind energy.

![Figure 6. Projected Annual Electricity Generation from MSW under the Biogas program.](image)

Taking the whole system in perspective, it can be seen that the situation under the Biogas Program scenario is expected to help relieve some of the anticipated problems and impacts seen under the No Action scenario. Simultaneously, there are some activities involved which are expected to have their own impacts on the environment.

Description of expected environmental settings - Biogas Program Scenario

Under the Biogas Program scenario, several negative impacts will be relieved. Nevertheless, some of the activities of Biogas plants and technology have their own negative impacts which will create new problems or aggravate some of the current ones, enhancing their direct, indirect and cumulative impacts.

A detailed discussion of the main environmental impacts involved in this scenario is presented in the following pages.

**Water**
- Surface and underground water: Although the amount of MSW reaching landfills will decrease as a result of this scenario, thus decreasing in the amounts of leachate expected to be generated from this SW. Nevertheless, it is important to note that although negative impact from redirecting wastewater is not significant at the early stages of the program as the amounts of wastewater produced is not large. Nevertheless, these amounts of wastewater are expected to increase with increasing biogas plants capacities and lengthening of landfill life term as less amount of SW will be reaching it. Thus increase the danger of leachate reaching groundwater levels, and run off to nearby surface water sources, contaminating them with high nitrates, sulphates, chlorides and heavy metals.

**Atmosphere**
- Air Pollution: The most significant positive impact that can be anticipated from this scenario is the reduction in air pollutants on the micro and macro level.

⇒ **micro** level impacts: The expected reduction in pollutants such as SOx, NOx, particulates and others are mainly due to the potential reduction in the use of fossil fuel by renewable energy source represented by biogas. Additional reduction in fossil fuel consumption is
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attributed to the decentralisation of electricity generation units, thus reducing the losses in the distribution network. See figure (7).

\[
\begin{align*}
\text{Electricity (1000 TOE)} & 0 & 500 & 1000 & 1500 & 2000 & 2500 & \quad & \quad & \\
\text{Total Annual Electricity Demand (1000 TOE)} & & & & & & & & & \\
\text{Electricity Production from Biogas per year (1000 TOE)} & & & & & & & & & \\
\end{align*}
\]

Figure 7. Projected reduction in fossil fuel consumption for electricity generation under Biogas Program scenario.

\[ \Rightarrow \text{Macro level impacts: Primary positive impacts expected are the reduction in methane emissions and GHGs from landfill sites and therefore reducing the indirect and cumulative effects of global warming and climate change on the short and long term. Expected reduction in methane emissions is estimated and presented in Figure (8).} \]

\[
\begin{align*}
\text{Methane Emissions (ton/day)} & 0 & 200 & 400 & 600 & 800 & 1000 & 1200 & 1400 & 1600 \\
\text{Total methane emissions from SW ton/day (Biogas)} & & & & & & & & & \\
\text{Total methane emissions from SW ton/day (No Action)} & & & & & & & & & \\
\end{align*}
\]

Figure 8. Projected amounts of methane emissions from MSW under the Biogas Program Scenario.

- Offensive odour, fires, and congestion due to transportation: Positive impacts are expected from the Biogas Program on decreasing the impacts of these effects as less methane will be emitted, less congestion will occur since the Biogas plants will be situated in different areas around the country. Nevertheless, offensive odour will not be resolved as leachate problems are not solved under this scenario.

- Land
  - Soil pollution from landfill leachate: Adverse impacts mainly related to soil pollution caused by leachate emissions are expected to increase as a consequence of the redirection of wastewater extracted from the biogas slurry into the landfills.
  - Land loss for SW disposal purposes: Positive impacts are anticipated as a result of the reduction in the amounts of MSW reaching landfills, thus leading to a reduction in the areas
of land lost for SW disposal in comparison to the No Action scenario. Figure (9) presents this anticipated reduction in land loss.

![Graph showing the reduction in land loss for SW disposal annually between 1995 and 2022.](image)

**Figure 9. Projected land loss for SW disposal under the Biogas Program Scenario**

- Land lost for industrial facilities: No significant impact, since the biogas production process is relatively rapid and therefore does not require large reactors and tanks.
- Soil quality and productivity: Positive impacts on soil quality and productivity can be directly linked to the application of the by-product fertiliser and soil conditioner. This mainly helps to increase moisture, nutrients, and humus content, added to the soil through the by-product, in addition to improving soil structure and reducing salinity, soil erosion and aiding in the reclamation of arid and semi-arid land.

*Nature and Biodiversity*

The impacts expected on nature and biodiversity are mainly linked to the changes occurring in the land, soil, and water quality. Therefore, any reduction in the impacts affecting these parameters will reflect positively on nature and biodiversity in the areas under study, if not to improve it, at least by stopping it from increasing to a level where permanent damage is possible. Additional positive impact can be expected on the flora and green cover in the areas where the fertiliser product and soil conditioner is to be applied.

*Human and Cultural*

- State of Sanitation, Health problems and Risk hazards: A positive impact is expected as a result of the reduction in health hazards induced by air pollutants such as SOx and NOx, particulates, dust, ash, and tropospheric ozone concentrations and smog, mainly attributed to an energy system based on fossil fuel. Additional benefits are expected from the reduction of health hazards due to rodents, vectors, insects, fires, and explosions in landfill area as a result of reduction of SW reaching landfills and landfill gas collection system.
- Noise: Minor negative impacts regarding noise are associated with power generation from the biogas plants.
- Aesthetics: NO Impact. Negative effects of the biogas plants are mainly related to aesthetics interference of to the biogas plants facilities which require large tanks for the slurry storage. Since it is possible to have these tanks partly placed underground, this effect becomes insignificant.
- Recreation: Advantage that can be expected from using the slurry can be related to increasing green cover areas. In a country that is considered to have an arid or semi-arid climate with 80% of its land is desert, this can have a positive effect on increasing the areas for recreation which are urgently needed.
Archaeological heritage: the anticipated decrease in the amounts of SW reaching landfills, and the corresponding decrease in area of land needed for solid disposal under this scenario, reflect positively on the country’s archaeological heritage.

Socio-economic impacts

- Promoting local renewable energy sources: the biogas program is mainly involved in promoting local renewable energy sources, and the demonstration of the potential benefits and feasibility of renewable energy sources. In addition to the reduction in imported fossil fuel dependency thus supporting political and economical stability in the country. Electricity produced from the MSW biogas plants under this scenario is expected to reach up to 2,000 GWh by 2023, which corresponds to about 8% of the country’s total energy demand.

- Economic Impacts: Economic benefits are expected as a result of using the by-products as source of nutrients and soil conditioner, thus increasing land productivity and reducing the amount of chemical fertiliser needed. Additional advantages can be linked to the reduction in the areas of land lost for solid disposal and devaluation of areas around it. Nevertheless, expected negative environmental impacts are related to the increase in the risk of soil and water pollution as a result of redirecting the Biogas wastewater back to the landfill.

- Social Impacts: The transfer of new technology and capacities building are expected to help in creating employment in new fields which have great potential not only in Jordan but also in the Middle East region. This reflects positively on reducing unemployment rates and alleviating poverty with its negative social impacts. Additionally, the expected increase in land productivity should help in reducing unemployment rates and migration rates to cities, thus resulting in a reduction in urban density and congestion.

III.6.3 Alternative scenario - MSW Composting Program

This scenario describes the situation under an alternative technology for MSW handling. The scenario suggests a program of constructing a series of composting plants in proximity to SW landfills, where MSW is diverted to these facilities and composted thus reducing the amount of MSW reaching landfills and their corresponding negative environmental impacts, in addition to producing nutrient rich fertilisers and soil conditioning products.

Program objectives

The suggested alternative program has several objectives in common with the Biogas program, these are:

- Protection of water resources: As mentioned earlier, several of the present FDS are located above or in close proximity to major water aquifers, and are not properly lined, therefore leaching to pollute underground and surface water in the vicinity of these sites. The composting alternative offers one way of reducing the amounts of SW reaching landfill, and therefore reduction in leachate emissions which is one positive step for the ultimate goal of the country’s scarce water resource protection.

- Reduction of greenhouse gases emissions: SW landfills in Jordan are one of the major sources of GHG emissions, mainly CH₄. The composting alternative offers the potential of reducing total CH₄ emissions through the reduction in SW reaching these landfill sites.

- Reduction of Health hazards: The scenario help to alleviate health hazards from landfill sites by reducing the amounts of SW reaching them.

- Sorting, recycling and fertiliser production: The composting alternative offers a demonstration of the concept “Nutrient Recycling”. The advantages gained from using the compost as fertiliser and soil conditioner should help to illustrate a realistic example of the benefits gained from recycling and reuse.
Addressing the Barriers Hindering the Practice of Strategic Environmental Assessment

Capabilities and key role actors

Similar to the Biogas program, the MSW Composting alternative has several advantages which can help it in becoming a success in Jordan. These advantages are mainly the availability of high educational level and the expertise in economic and technical branches. Additionally, several actors would be involved in the implementation and development of this alternative. These actors are mainly governmental bodies, academic institutions and research centres, non-governmental organisations NGOs and the private sector represented in the farmers who will purchase and use the compost product.

MSW Composting Plant

Composting is one of the well acknowledged treatment and disposal methods for MSW which includes the elimination of methane emissions and the concept of nutrient recycling. The process involves microbial metabolic activities. These work on organic matter over a period of months, where exothermic reactions and the development of CO₂ occurs. These activities produce an organo-mineral soil conditioner and fertiliser containing sulphate and nitrate, cellulose and lignin from the humic substances. Simultaneously, any disease pathogens in the waste material are destroyed, and weed seeds are sterilised as a result of the heat produced from the aerobic biodegradation process. A typical MSW composting facility usually comprises of several units, these are:

Waste Receiving Area: The raw MSW waste is received and unloaded into a large receiving area, which is a fully enclosed waste pit. Liquid waste is unloaded into a tank which can then be used into the Bio-reactor as process water. The raw waste is then fed into the Bio-reactor.

Bio-reactor: This rapidly breaks down organic material into raw compost and is the key to the accelerated maturation process. The feedstock remains within the continuously rotating reactor for a minimum of three days, giving a mixture of biodegraded organic matter and non-compostable residues. Due to the high temperature in the reactor (70°C), the material becomes free from harmful pathogens.

Primary Refining and Sorting: After leaving the Bio-reactor, the composted organic matter is separated and transported to the Maturation Building for further processing. The residue, which contains non-compostable material, is directed to a sorting section where the non-organic material are separated and transported for disposal.

Maturation Building and Secondary Refining: The recovered compost is placed into windrows between concrete walls. The compost temperature and moisture content are controlled by forced aeration which is used to provide enough oxygen for aerobic reactions, water or waste water addition is applied to keep moisture content between 50-60%, and regular turning of the windrows is sustained. After several weeks (2-3 months), the compost is transported to the secondary refining area to produce a homogeneous compost, which can be easily mixed with soil.

Odour Control: An odour control system captures and conveys all air from inside the buildings to a bio-filter. This is mainly to remove ammonia, the most common odour that can be formed aerobically. Other anaerobic odours can occur as a result of anaerobic activities, these include reduced sulphur compounds, volatile fatty acids, aromatic compounds and amines.

Generation potential

MSW compost generation potential for Jordan is mainly linked to the amounts of MSW generated in the country, with a percentage of about 40% of total MSW generated can be used to produce compost. With the high moisture content in MSW in Jordan, it can be considered that every ton of SW can produce 0.3 ton of compost. Thus, for the year 1997, with 3765 ton/day of MSW generated, a potential of about 450 ton/day of compost could have been produced.
Description of the expected MSW Composting Scenario - System thinking

Similar to the system thinking approach used for the Biogas Program, the No Action scenario rational will be used as a base for the description of this scenario, while stress will be made on the areas and issues where interference, positive or negative, from the suggested MSW composting alternative is expected to occur.

This scenario is built on the same parameters of population, sustainable development, projection for MSW and energy demand, system thinking approach and causal loop connections. Following is a discussion of the main issues and a brief description of where the composting alternative is expected to interfere breaking or enhancing the effects of these relations.

- **Projected increase in the amounts of MSW generated**: Under this scenario, the MSW composting alternative will interfere to decrease the amounts of MSW reaching landfill sites and transforming it from waste to a valuable nutrient rich fertiliser and soil conditioning product.

  The reduction in MSW reaching landfill sites will positively reflect on the land used for landfills, since less land will be required for waste disposal, less areas of land will be devaluated as the areas of landfills will decrease, while environmental impacts related to landfill activities will also decrease. On the other hand, it is worth noting that the composting process requires a relatively long time for completion (2-3 months), therefore considerable areas of land will be needed for windrows need to handle the increasing amounts of MSW directed for composting.

  The conversion of the MSW into compost has its own effect. This can be mainly linked to the reduction in the amount of fertilisers imported for food growing, as the compost itself will provide a part of the nutrients needed. Additionally, if well marketed and used, the compost as soil conditioner and nutrients source, improves soil structure and productivity, and help in reclaiming large areas of productive land endangered to be lost due to salination.

  Similar to the Biogas Program, the composting alternative does not directly influence the SW transportation part, since the same amount of SW generated will have to be transported either to the landfill or to the composting plant. Nevertheless, it will have an indirect effect, which is a result of the reduction in the MSW amounts reaching landfills and their associated negative environmental impacts and health hazards. Therefore reducing the need to move these landfills to remote areas and the length of journeys’ for transporting vehicles.

  All of the above can be considered as advantageous effects, expected to reflect positively on sustainable development.

- **The projected increase in demand for energy and production of electricity**: Since the amount of energy produced from the composting process is in the form of heat at an average temperature of 70°C, which is considered low for energy use. Thus, this alternative will not interfere in the energy and electricity generation cycle.

  Nevertheless, some energy savings can be traced when comparing biological (irrigation from humidity content in compost), chemical (fertiliser from nutrient), and physical soil improvement (improvement of soil structure by conditioners), and the energy required for natural decomposition of organic matter. Taking all these into consideration, it appears that the use of compost is associated with considerable energy savings reaching up to 1.2 GJ/ton of compost.
Description of expected environmental settings - MSW Composting Scenario

Under this scenario, several positive effects are expected to occur thus relieving some of the problems anticipated under the No Action scenario. Nevertheless, the composting activities themselves have some impacts which need to be considered.

Water
- Surface and underground water: A reduction in the threat to surface and underground water pollution and contamination caused by MSW leachate is expected to result in correspondence to the reduction in the amounts of SW reaching landfills and therefore in the amounts of leachate emitted from these landfills. While no serious amounts of wastewater are associated with this technology, and therefore no significant impacts associated with it.

Atmosphere
- Air Pollution:
  ⇒ Micro level impacts: No advantageous impacts are expected from this scenario, as main micro pollutants are related to the energy and transportation sector. Some advantages are expected from energy savings in the agricultural sector from using the compost as a source of nutrients and soil conditioner, thus reducing the amounts of chemical fertiliser needed. Nevertheless, the labour and energy needed to spread the compost, and the energy need to turn the windrows in the production process are all energy consuming. Therefore, the situation under the composting scenario is expected to be similar to that under the No Action scenario. Negative impacts are mainly linked to the release of ammonia NH₃ from the composting process. This is not a stable compound, it reacts when in the atmosphere to form NOx products, thus indirectly forming another source of GHG²⁴. Figure (3) presented earlier illustrate the amounts of electricity in TOE for the period under study under the Composting scenario.

  ⇒ Macro level impacts: Expected positive impacts on the macro level are mainly connected to the reduction in the amounts of SW reaching landfill sites, which will therefore result in a reduction in the emissions of GHGs chiefly methane gas, see Figure (10).

![Figure 10. Methane emission reduction from MSW landfills under Composting Scenario](image)

- Offensive odour, fires, and congestion due to transportation: Positive impacts are expected from the Composting alternative on decreasing the impacts of fires as less methane will be emitted from SW landfill sites. Less congestion will occur since the Composting plants will be cited in different areas around the country. Nevertheless, offensive odour from landfills will persist and will not be reduced since leachate problems are not solved under this
alternative. Additionally, the composting process is well known to be associated with offensive odour since it large scale aeration units.

**Land**

- Soil pollution from landfill leachate: Positive impact caused by the reduction in soil contamination corresponding to reduction in landfill leachate as a result of directing a part of MSW to the composting plants.
- Land loss for SW disposal purposes: Positive impacts are expected involving the reduction in areas of land lost for SW disposal in correspondence to the reduction in volume of SW reaching landfills. Since the scenario is built based on the assumption that the same amount of MSW diverted to the composting plants as that for Biogas plant, then the area of land lost for SW presented in Figure (9) under the Biogas Program scenario should be the same as that under the Composting Program scenario.
- Land loss for industrial facilities: Minor negative impacts are mainly anticipated in correspondence to the areas of land lost for SW composting plants facilities. This is chiefly attributed to the slow composting process, requiring 2-3 months for completion, which will require large areas to place the windrows needed to handle the increasing amounts of MSW directed for composting, which will be reaching up to 1600 ton/day by the year 2023 (similar to the amounts directed to Biogas Plants under Biogas scenario).
- Soil quality and productivity: The most prominent advantageous impact of the composting scenario is on land quality and productivity. This is mainly a result of using the compost product as a fertiliser and soil conditioner providing nutrients and increasing humus content and improving soil structure. This positively reflect on land quality and productivity, in addition to helping in reclaiming land that is endangered to be lost for salination due to intensive cultivation and chemical fertilisation, reducing the risk of soil erosion, and helping in the reclamation of arid and semi arid land.

**Nature and Biodiversity**

Similar to those impacts from the Biogas Program, positive impacts are expected on nature and biodiversity from the composting scenario. These are mainly linked to the changes occurring in the land, soil and water resources in relation to SW disposal activities. Therefore, any reduction in the impacts affecting these parameters will reflect positively on nature and biodiversity in the areas under study, if not to improve it, at least by stopping it from increasing to a level where permanent damage is possible.

Additional positive impacts are expected in the areas where the compost will be used to ameliorate soil structure and quality. This will directly effect the micro fauna and the flora, which will indirectly positively reflect on the macro flora and fauna in these areas.

**Human and Cultural**

- State of Sanitation and Health hazards: Advantageous impacts are expected in relation to reduction of SW reaching landfills. These are mainly the reduction in health hazards caused by rodents, vectors, insects, fires and explosions in landfill sites. Regarding the impacts of air pollutants from the energy and transport system (fossil fuel use), the situation under the composting scenario is similar to that under No Action scenario.
- Noise: No significant impact is expected under the Composting scenario.
- Aesthetics: Negative impacts are mainly related to aesthetics interference of the composting plants facilities which require large areas for the windrows in the production of compost.
- Recreation: Similar to the Biogas program scenario, advantageous impacts are mainly expected form using the compost as a source of nutrient and soil conditioner, thus increasing green cover areas. This should have a positive effect on increasing the areas for recreation which are urgently needed.
Archaeological heritage: The decrease in areas of land lost for SW disposal, and the amounts of leachate emitted from landfill sites, this is expected to reflect positively on the situation of the archaeological heritage as less threat will be posed on it.

**Socio-Economic**
- Promoting local renewable energy sources: No significant impact.
- Economic Impact: Similar to the Biogas Scenario, economic benefits are expected as a result of using the by-products as source of nutrients and soil conditioner, thus increasing land productivity and reducing the amount of chemical fertiliser need. Additional advantages can be linked to the reduction in SW volume to be disposed of, and the areas of land lost for landfills, the risk of soil and water pollution and environmental impacts related to waste handling. All this reflect on the value of land around SW disposal sites and therefore decrease the potential of devaluation, of these lands. No advantageous impacts are expected from this scenario in connection to the energy production system and the amounts of fossil fuel to be imported.
- Social Impacts: The transfer of new technology and capacities building are expected to help in creating employment in new fields, thus helping in unemployment rates reduction and alleviating poverty and its negative social impacts. While the increase in land productivity is expected to help in creating more jobs in rural areas, thus helping in decreasing unemployment and reducing migration rates to the cities and leading to a reduction in urban density and congestion.

III.7 Comparison of Alternative Scenarios

A comparative analysis of all impacts associated with the three studied alternative scenarios is presented in this section.

**Water**
- Surface and underground water: The main concern involving water resources is the threat of leachate emissions from SW landfill sites. Under the No Action scenario, this threat is expected to intensify with the projected increase in leachate emissions associated with the increase of SW reaching landfill sites. The Biogas program scenario, although attempt to alleviate the problem by reducing the amounts of SW reaching landfill sites. Nevertheless, negative impacts are anticipated on the long term, as a result of the suggested redirection of wastewater into landfill sites, which offers an increase in leachate emission higher than that anticipated under the No Action scenario. The Composting scenario seems to offer a successful way for the reduction of leachate emissions from these landfills without posing any serious threat to water resources.

**Atmosphere**
- Air Pollution: these are mainly micro and macro level pollutants,
  ⇒ Micro level impacts: These mainly involve pollutants from the transportation and the energy system based on fossil fuel. Under the No Action and Composting scenarios, pollutants emissions are expected to intensify in correspondence to the increase in energy demand. The Biogas program scenario offers a mode to alleviate the projected impacts by providing a non-fossil fuel based electricity source. Figure (11) presents the amounts of fossil fuel required to provide the projected electricity demand under the three scenarios.
Addressing the Barriers Hindering the Practice of Strategic Environmental Assessment

Figure 11. Annual electricity demand projections in (1000 TOE) under the three studied scenarios

⇒ Macro level impacts: These are principally attributed to the increase in GHGs (mainly CO₂, CH₄ and N₂O gases) causing climate change and global warming. CO₂ and N₂O emissions are mainly linked with the energy and transportation systems in the country. Under the three scenarios, no major reduction in the emissions of these two pollutants is expected to occur except for some reduction of CO₂ emissions under Biogas scenario. This is mainly a result of the anticipated reduction in fossil fuel use for electricity generation.

For CH₄ emissions, under the No Action scenario this harmful GHG emissions are expected to continue increasing. The Biogas program scenario offers a feasible method of reducing the amounts of emitted methane from landfills, in addition to the reduction of the amounts of SW reaching landfills and thus indirectly reducing methane emissions from MSW reaching up to 80% by the end of the study period. The Composting scenario does not offer any way to reducing methane emissions from landfill sites, but addresses it on the long term indirectly by reducing the amounts of MSW reaching landfills. Figure (12) illustrates methane emission projections from the biogas and composting scenarios in comparison with the No Action scenario.

Figure 12. Methane emission projections from MSW landfills under the three studied scenarios.
Addressing the Barriers Hindering the Practice of Strategic Environmental Assessment

- Offensive odour: These are mainly attributed to landfill leachate run off. Under No Action scenario this is expected to persist and intensify with increasing amounts of MSW reaching landfill site. The Biogas scenario does not offer any advantages to reduce this offensive odour from landfill leachate if the wastewater is to be redirected back to landfills. The Composting scenario seems to offer a possible way to reduce this offensive odour by reducing the amounts of leachate emissions and run off, while some offensive odour problems are linked to the composting process.

- Fires and explosions: These are caused by landfill gas emissions containing methane gas. Under the No Action scenario, these impacts are expected to intensify with increasing amounts of MSW reaching landfill sites and correspondingly landfill gas emissions. The Biogas scenario offers a proper method of reducing the risk of these fires and explosions on the short and long term through the landfill gas collection system and the MSW biogas plants. The Composting scenario offers a reduction of these risks on the long term through the reduction of MSW reaching landfills.

- Congestion due to transportation: These are mainly attributed to the large number of vehicles required to transport MSW to landfill sites. The three studied scenarios do not offer a way to reduce this congestion on the short term, as the same amounts of MSW will still need to be transported to the FDS, whether it is a landfill, biogas or composting plant. Nevertheless, the Biogas and Composting scenarios may offer some positive effects on the long term to reduce congestion as these plants can be sited in different areas around the country, closer to industrial and urban areas.

Land

- Soil pollution from landfill leachate: This impact is expected to intensify under the No Action scenario where the current SW management is continued and landfills are not pre-designed for their use. Similarly, the Biogas scenario attempt to reduce this impact, but as a result of the redirection of wastewater back to landfill sites this is expected to aggravate. The Composting scenario offers a credible way of reducing this impact by reducing MSW from reaching landfill sites.

- Land loss for SW disposal purposes: Under the No Action scenario, this impact is expected to augment and escalate. Both Biogas and Composting scenarios offer feasible solutions to reducing the amounts of MSW from reaching landfill sites and therefore the corresponding areas of land lost. See figure 13.

![Figure 13. Projections in area of land lost for SW disposal under the three studied scenarios](image)

- Land loss for industrial facilities: This impact is mainly related to the Biogas and Composting technology and the area of land that would be required mainly for MSW handling and products storage. The Biogas scenario does not present any serious impact of land loss since
the biogas process is relatively rapid. The *Composting scenario* does offer minor impacts on land loss as the composting process is relatively slow and requires large areas to site the windrows.

- **Soil quality and productivity:** The *No Action scenario* presents a situation where soil quality and productivity continue to decline. Both *Biogas and Composting scenarios* offer advantageous effects on soil quality and productivity through the application of compost products as sources of nutrients and soil conditioners.

**Nature and Biodiversity**

Changes in nature and biodiversity are mainly linked to expected changes occurring in land, soil and water quality. Thus, under the *No Action scenario*, these impacts are expected to escalate. The *Biogas and Composting scenarios* offer positive impacts on flora and fauna, due to the advantageous effects they have on land, soil and water quality.

**Human and Cultural**

- **State of Sanitation and Health hazards:** These are mainly linked to the environmental situation in landfill sites and their attributed health hazards. Under the *No Action scenario*, these impacts are expected to intensify, causing serious concern and significant effects. Both the *Biogas and Composting scenarios* offer to alleviate these impacts by reducing the amounts of MSW from reaching these FDS. Impacts linked to pollutants from the energy generation system are similar under *No Action and composting scenarios*, where these pollutants are expected to intensify and persist. The *Biogas scenario*, by generating a percentage of the electricity demand from a non-fossil fuel source, offers an option of reducing emissions of these pollutants and therefore their impacts as health hazards.

- **Noise:** No major impacts on noise levels are expected to occur under the *No Action and Composting scenarios*. The *Biogas scenario* involves minor negative impacts concerning noise associated with power generation from these systems.

- **Aesthetics:** Negative impacts on aesthetics are anticipated under the *No Action scenario* due to the increasing number of SW transporting vehicles and landfill activities. No significant impacts are associated with the *Biogas scenario*. Minor negative impacts are associated with the large facilities required for the *Composting scenario*.

- **Recreation:** Negative impacts are anticipated from the *No Action scenario* mainly due to the degradation in soil, water and atmosphere quality. In addition to the areas of land lost for SW disposal and the negative effects on nature and biodiversity. Both the *Biogas and Composting scenarios* offer positive impacts regarding recreation associated with increasing greencover and nature and biodiversity as a result of applying the fertilisers and soil conditioning products.

- **Archaeological heritage:** Negative impacts are anticipated from the *No Action scenario* mainly due to the areas of land loss and SW disposal activities. Both the *Biogas and Composting scenarios* offer to reduce the threat on archaeological heritage as less land will be lost for SW disposal and less leachate emitted from landfill sites.

**Socio-Economic**

- **Promoting local and renewable energy sources:** Both *No Action and Composting scenarios* do not offer any advantageous impacts for this issue. The *Biogas scenario* successfully offers a feasible process for producing electricity from local resources (MSW) and illustrating the benefits of “waste-to-energy” concept.

- **Economic development:** Under the *No Action scenario* significant negative impacts are associated with the SW management systems and energy production mainly based on fossil fuel resources. The *Biogas scenario* addresses both systems and therefore successfully offers a beneficial way for reducing the impacts of both systems, nevertheless, negative economic impacts are associated with the redirection of process wastewater to landfills. The
Composting scenario succeeds to address the economic impacts of SW management systems, but fails to offer any advantageous solution to the energy system.

- Social Impacts: Significant negative impacts on society and social issues are expected to intensify under the No Action scenario. Both Biogas and Composting scenarios offer advantageous social impacts related to alleviating unemployment rates and poverty, in addition to the increase in land productivity, decrease in migration rate to cities and urban density.

Table (1) presents a summary of the comparative analysis of the three studied scenarios, where the No Action scenario is taken as the basis for reference.

Table 1. Summary of comparative impact assessment for studied scenarios.

<table>
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<th>Compost Program Scenario</th>
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<td>+</td>
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<td>0</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Social impacts</td>
<td>0</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

(+/-) low to medium positive impact, (+++) high positive impact, and (-/-) low to medium negative impact.

It is important to note that in line with the objectives of this paper for simplifications in details, no identification of impacts as reversible or irreversible is made, as such identification entails detailed testing of concentrations of contaminants emissions, type and quality of soil and water, identifying the threshold and carrying capacity of the environment and others.
III.8 Suggested mitigation measures for the selected scenario

Scenario Selection
In order to select the most suitable scenario, reference is made to table (1) which summarises the main environmental impacts expected under the three studied scenarios. It is therefore clear to state that the negative impacts associated with the No Action scenario are severe and difficult to overcome without significant changes in the existing conditions, and therefore this scenario does not offer a sustainable method for SW management.

The Composting scenario offers high degree of positive impacts, but fails to address impacts related to the energy system and GHG landfill emissions, which cannot be overcome without significant changes.

The Biogas scenario seems to offer significant advantageous impacts in comparison to the No action and Composting scenarios. Implementation of this scenario seems to eliminate or reduce most of the adverse impacts associated with the No Action scenario. Although it incorporates negative impacts which can be directly linked to the management of process wastewater, nevertheless this can be mitigated by careful planning and execution.

Some of the impacts associated with all the studied scenarios, such as noise from power generators, and adverse impacts of power lines, cannot be solved even under the Biogas scenario, and would probably require to be addressed under the energy system policies and plans.

- **Suggested mitigation measures for the Biogas program** to eliminate or reduce negative impacts.
  - **Effective use of biogas process wastewater:** To avoid the increase of leachate emissions with increasing wastewater directed to landfill sites, thus pausing significant negative impact on water resources, soil pollution and offensive odour, it is recommended to treat the process wastewater through wastewater treatment plants, and use this treated water for agriculture. Other suggestions include marketing this as a liquid fertiliser product with high nitrate concentration. Therefore, it is important to stress the need for well monitoring and control of liquid quality before permitting its use for the above suggested purposes.
  - **Selective location of new projects:** It is recommended that consideration is made when locating next projects for placing them closer to industrial areas and clean MSW sources, such as dairy plants and slaughterhouses. Thus benefits can be obtained by reducing transportation needed of MSW with high organic matter, supply these industries with their needs of heated water using CHP technology, and reducing electricity losses in the grid as users become closer to generating units.

- **Suggested measure to enhance and support the Biogas program effectiveness**
  - **Marketing plan for product fertiliser and liquid fertiliser:** The use of MSW as a source of fertilisers and soil conditioners have been known for a long time. Nevertheless, obstacles related to social or ethnic prohibitions are linked to the sales of these products, because the product is derived from MSW. Therefore, an effective marketing plan should be placed and commenced as early as possible to help overcome any expected obstacles, and before the first projects starts production. Thus avoiding any problems which might arise if the product fertiliser is not sold, related to handling and storage.
  - **Public involvement and awareness.** This is mainly concerning the positive impacts and benefits gained from biogas technology, which should help to overcome social inhibitions involving working in such facilities.
  - **Recycling and reuse of inorganic SW:** the first stage in the biogas plant is to separate organic material from inorganic. The later should cover about 60% of total SW, and since it would be separated, then instead of sending it to the landfill sites as is currently proposed, it would be more feasible and profitable if it is sold for recycling or reuse purposes as it is already sorted.
III.9 Monitoring and feedback

Program monitoring is essential for ensuring that the program is achieving its stated objectives and targets, that mitigation measures proposed in the SEA are well implemented, and for identifying any negative impacts needing remediation which might arise as a result of changes in related policies or plans.

Therefore a monitoring plan for environmental indicators related to water, atmosphere, land, nature and biodiversity, human and cultural and socio-economic situation in studied areas should be designed and performed on a periodic basis. This can be achieved through either using related monitoring data such as existing integrated pollution control requirements, biodiversity action plans, or through specific monitoring plans concerning the efficiency of landfill gas collection systems and the proper use and application of the product fertilisers.

Furthermore, for each stage in the selected biogas program expansion, it is essential to make sure that the suggested mitigation measures concerning the produced wastewater is well studied and considered in the designing stage or project level EIAs (whenever performed).

During implementation, several issues might arise that need to be addressed which have not been discussed in this study. These are mainly concerning related policies and plans or are mainly related to project level EIAs, they include: Site selections for following stages in the program; The decision to incorporating CHP units and the impacts of the district heating systems; The introduction of a national system for source sorting and recycling; And the introduction of new environmental regulations regarding the use of the fertiliser products in the country.

III.10 Testing for sustainability assurance

SEA as a tool for integrating sustainability into decision making, requires the selected program to be tested for sustainability assurance. Thus making sure it is in line with adopting a proactive and forward looking approach. In line with this, the Biogas program is in accordance with the "rule of conversion" test (a qualitative early indicator for potential cumulative loss and deterioration in land use, habitat and eco-structure) through proposing a reduction of land loss for SW disposal. Furthermore, the proposal of using the collected methane gas in power generation, is in line with the requirements of the "rule of non-renewables" (which specifies that the depletion rates of non-renewable resource should be equal to the rate at which renewable substitutes are developed).

III.11 Results and Implications

Reference to the previous sections where comparison of alternatives, selection of best scenario, proposed mitigation measure and monitoring plan, it can be concluded that for the period under study, and based on the environmental consideration, the proposed Biogas program offers a good compromise between feasibility (as presented in the program's proposal document), impacts on the environment which can be mitigated, and compatibility with existing environmental policy objectives.

The proposed program offers creating a local source of energy, a positive contribution to methane emissions reduction, and reducing areas of land lost for SW disposal. Furthermore, it offers a suitable demonstration of the concepts "waste-to-energy" and "nutrients recycling" which should encourage the development of other local renewable energy sources such as solar and wind, and the implementation of other methods for solid waste management including sorting and recycling.

However, these achievements are limited to the implementation of the suggested mitigation measures, and monitoring and feedback plans, which should be followed throughout the process
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of implementing projects under this program. This can assure that the program is fulfilling its objectives and that feedback into related policy and plans is successfully achieved.

Additionally, recommendations are made to conduct SEAs for Jordan’s solid waste management and energy policies. As these two policies have been identified through the process of conducting this SEA, to involve activities that do not support sustainable development or environmentally sound practices. Furthermore, the proposed mitigation measure for the Biogas program from this case study, should be inter-linked with these suggested SEA studies, which should help to reduce fragmentation in higher level decision making.

It is important to note that the author realises that the project was approved by the government of Jordan during the process of conducting this SEA. Nevertheless, it is still hoped that the results reached, suggested mitigation measures, monitoring and feedback plans, will be taken into consideration by the involved parties, whenever a Biogas project is initiated under this program.
Section IV: Analysis and Conclusions

IV.1 Analysis

The following analysis is made based on the results obtained from the case study, and the experience gained through conducting it is used to reflect on the proposed hypothesis and stated objectives of the paper.

I. The effectiveness of the suggested simplified SEA methodology as a tool for environmental consideration and sustainability integration into decision making, is reflected through the results obtained from the case study. Despite the simplifications made in the SEA procedure in the environmental analysis performed for the case study, where detail minimisation and the use of qualitative analysis and assessment in impact identification and prediction was applied, environmental consideration were successfully integrated throughout the case study. These can be mainly recognised through the incorporation of the carrying capacity and sustainability concepts throughout the case study, which are reflected by aiming to reduce land lost for solid waste disposal, environmental deterioration linked to the currently applied solid waste management system and electricity generation, and the negative social and economic impacts evolving from these practices.

The use of the different tools and techniques, such as scenarios and system thinking approach, contributed in achieving a more comprehensive view of the situation and inter-linking the issues and actions involved under each scenario, without any additional details to the process. Furthermore, they aided in portraying a more comprehensive view of what the social, economic and environmental consequences could be as a result of each alternative, in addition to helping in reducing the uncertainty normally encountered with future projections and estimations.

Moreover, even under the simplifications made, other main characteristic of SEA were still successfully incorporated in the case study. These are mainly the identification of cumulative impacts and synergistic effects from the studied alternatives with regard to the amounts of methane emissions on global warming and climate change, and the negative impacts of SW leachate emissions from landfills on soil, water and biodiversity on the short and long term. Although these impacts were identified qualitatively and were not quantified, the case study was still able to highlight the issues involved and needed to be considered in accepting or rejecting the proposed program. Therefore, it consequently became easier to identify the most suitable alternative to be selected, and the mitigation measures required for reducing these negative impacts, in addition to suggesting a suitable monitoring and feedback plan which should help to integrate these considerations in projects initiated under this program.

II. Through conducting the case study and the research regarding the available SEA methodologies, the author identified potential barriers hindering the prevalence of SEA practice which were not found in literature. These can be attributed to the following:

- **SEA current methodologies are hindered by existing project level EIA procedures:** This can be mainly attributed to the following reasons:

  ⇒ **Bottom-up versus trickle-down approach:** Since SEA has evolved from project level EIA, the main approach that is currently found to be used in literature and by practitioners, is to implement available project level EIA methodologies to PPPs assessment but using larger time and scale boundaries. This is called the “bottom-up” approach. Nevertheless, since projects are at lower tiers than PPPs, and therefore deal with a different level and types of issues, the effectiveness of EIA procedures at the project level do not necessarily assure
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their successfulness at higher level decision making. On the contrary, the author identifies these methods as actually obstacles hindering the development of SEA as an effective tool for higher level decision making, which needs to deal with larger time and space scales than project level EIA.

If SEA is to assume its right position as an effective tool for sustainability integration into higher level decision making, then the author identifies the need to develop special tools and methodologies for these specific purposes, independently from project level EIA tools and procedures which deal with a different time, scale and boundaries, and a completely different level of complexity. The research and development in SEA methodologies need to involve more strategic oriented techniques such as: use of scenarios, system thinking approach, modelling and others, and to be developed for use with higher tier PPPs. These tools and techniques are needed to help reduce the current complexity of SEAs and address the broader time and scale of studied PPPs.

Some of these techniques were used in conducting the case study, including the use of scenarios and system thinking and analysis approach, which aided in reaching a more comprehensive idea of what might happen under each studied alternative, in addition to integrating different issues and parameters for analysis and assessment.

Therefore, if this obstacle is to be approached and overcome, then the author identifies the need for developing two separate methodologies, where one can successfully deal with the broader concept of policies, plans and programs at higher tiers dealt with under SEA, and the other deals with details involved with lower tiers (similar to existing EIA procedures). These new methodologies, need to be based on the “trickle-down” approach, where higher tiers encompass lower tiers, ensuring that sustainability considerations are integrated from the highest to the lowest levels of decision making. Making sure that the connection between both separate methodologies is very clear and easy to follow, through well considered monitoring and feedback plans, and where mitigation measures from higher tier SEAs are considered and included in the EIAs prepared for projects.

⇒ Current SEA methodologies are too detailed, therefore time and money consuming:

Project level EIAs are well known to be detailed and time consuming and therefore similar drawbacks are found in SEA methodologies. Although this detail has not hindered EIA from becoming quite commonly practised, the author identifies this issue as one main barrier hindering the prevalence of SEA practise. This can be justified, as SEA deals with larger boundaries than EIA, and therefore greater information and data are involved in SEA studies, thus making it extremely complex and difficult to deal with the immense amounts of information and details involved. This all leads to turning SEA studies into time and money consuming processes, which in turn the author believe is hindering SEA from becoming more commonly recommended and used tool by politicians and decision makers.

The literature reviewed state that decision makers generally have lower expectations regarding details and assumptions at the broader levels of government planning. Therefore, a comparative analysis of alternatives, which can successfully highlight the potential environmentally problems anticipated for a proposed PPP, is usually considered adequate for decision makers.

In line with this, the author stresses the need to develop a simpler, less detailed, and therefore less time and money consuming SEA methodology, which can achieve the incorporation of environmental considerations into higher level decision making. If this simplified methodology is not enough to address all involved issues and problems, then it is suggested that part of the mitigation measures should be to refuse the proposed PPP until further studies are conducted concerning the issues requiring more detail. Otherwise,
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details should be left for the initiated lower tier projects assessment, which can handle addressing details, as they are more specific and have less broader perspectives. With this simplification, the author believes that SEA should have a better chance of becoming more practised, which should help in the development of new methodologies and tools that are not limited to EIA current procedures as mentioned in the previous notes. At the same time, it is important to stress that these proposed simplifications in SEA methodologies, are achieved without pausing any danger of reducing the effectiveness of SEA as a tool for identifying all issues and parameters involved and related to a proposed PPP.

- **Problems with sustainability and sustainable development concepts**: It is well identified that SEA is the tool for incorporating sustainability into the decision making process. Therefore, any problems associated with the sustainability concept are expected to reflect on SEA as an effective tool.

The main issue which the author identified through conducting the case study, was the fact that sustainability and sustainable development concepts are still not very common or properly comprehended amongst the general public, politicians and decision makers. Public knowledge and familiarity with these concepts are still at the early stages in several developed and most developing countries. The author noticed that most of the time these concepts are mixed with economic or social development without any consideration of environmental considerations or the carrying capacity concept.

Since public participation (direct participation or through public representatives and active NGOs) is one of the main links to sustainability, and the later is one of the main parameters in an effective SEA process, it can be clearly justified that the lack in public participation, causes the weakness of SEA. Therefore, the author identifies the urgent need for promoting and explaining the sustainability concept to the public, politicians and decision makers. As these are the parties expected to participate in the decision making process and incorporate these concepts in their decisions.

III. Based on the experience gained from conducting the case study and the literature survey conducted earlier, following are the author’s comments, on some of the barriers identified in reviewed literature to be hindering the practice of SEA as presented earlier in Section II.

- **Vague nature of proposals at the PPP level and the fact that they are most fragmented and not available in formulated form**: The author believes that it is one barrier that might always exist and therefore should be addressed by using tools and techniques that can address it.

Therefore, the use of special tools and techniques, as mentioned earlier, include using modelling, scenarios and system thinking and analysis approaches and many others, may offer to reduce this fragmentation and aid in the integration of various issues. Therefore, making the analysis process less complicated and fragmented while at the same time making sure that the connection between various issues and activities at higher tiers is well established. Thus aiding in establishing the relationship between SEAs dealing with related issues (e.g., for the case study these can be waste management and energy policies). This should further facilitate the inter-linking of new SEAs to existing ones, and relate PPPs to each other. The author also believes that properly prepared mitigation measures, and monitoring and feedback plans, which relate to other PPPs can act a major role in reducing this fragmentation at the lower levels of decision making.

- **Problems with system boundaries and analytical complexity (regarding decisions and alternatives involved)**: Although this maybe correct, nevertheless, it can be argued that usually, for the stated objectives of a proposed PPP, there will not be that many alternatives to be considered, which can fulfil the requirements or objectives. Additionally, through using the different scenario approach, modelling techniques (e.g. system analysis models and
"Strategic Environmental Assessment" computer model, and different tools (e.g. life cycle analysis, and full cost analysis) this barrier can be overcome to some extent.

- **Uncertainty and lack of precision in impact prediction**: This maybe true, but based on literature statements that decision makers have lower level of expectations regarding assumptions, predictions, uncertainty and precision at higher level of decision making\(^8\). A comprehensive environmental analysis which can successfully highlight the main issues, should be adequate at higher levels of decision making. This can be achieved using the simplified methodologies suggested earlier under point I, which can address the broader time, scale and boundaries encountered in higher level decisions while assuring that all involved parameters and issues are well identified and addressed.

- **Lack of application and shared experience**: This is a barrier that the author identifies to be very true, as one of the main difficulties which were faced during conducting the case study, was obtaining published information and studies concerning SEA. Therefore, limiting the author from gaining more knowledge and insight concerning SEA's theory and practice, which could have helped in strengthening the arguments when discussing the results.

- **Uncertainty over public involvement**: Since one of the main objectives of SEA is the incorporation of public involvement in the higher decision making levels, therefore, the author finds it quite strange that there is an uncertainty regarding this involvement. Although it is quite understandable that great difficulties can be faced in trying to involve the public directly at such high levels of decision making, and the confidentiality expected in some higher policies. Nevertheless, the author believes that it should be well accepted for indirect public participation to be achieved through the involvement of public representatives such as different institutes, NGOs, private sector, which can help to reflect the general public’s opinions and view regarding a proposed PPP.

- **The political nature of the decision making process characterised by low priority given for environmental considerations**: Although this maybe be currently true, the author identifies vast changes which are occurring in the political arena concerning environmental issues. This is especially true with increasing public awareness regarding environmental issues. Therefore, politicians are becoming more aware of their role as environmental advocates, and environmental parties are emerging, increasing the need for environmental influence in decision making. Furthermore, with the suggested simplification in SEA methodologies, rendering them less time and finance consuming, and the promotion of the sustainability concept, this should enhance political support for SEA application into higher level decision making.

Finally, it is important to note that the author realises that the above analysis and results are mainly built on conducting one case study for a proposed program. If time limitation did not exist allowing for several case studies to be conducted, then results and analysis could have been built on a much stronger basis as a larger scope and issues could have been covered. Additionally, it is well known that several differences exist between policies, plans and programs, as each represents a different tier and involves different scope and characteristics. Therefore, the author recognises that the results obtained from conducting an SEA for a program, do not precisely apply for policies and plans. Nevertheless, it can be argued that the approach used in the analysis, which deals with the general characteristics of SEA, manages to cover issues existing in all high decision making tiers, thus enabling it to cover policies, plans in addition to programs.
IV.2 Conclusions and recommendations

The results obtained from conducting the case study show that the use of a simplified SEA methodology with qualitative assessment, which does not entail great detail, and mainly addresses the broader concepts and major issues related to the studied PPP, can be effectively used to identify the main issues needed to be addressed, and identify and anticipate impacts in their various forms: direct, indirect and cumulative. This is achieved, while still making sure that the sustainability and carrying capacity concepts are successfully integrated in the course of the assessment, and the decisions reached are mainly built on the integration of these concepts into the decision making cycle.

This therefore justifies the hypothesis proposed by the author, where simplifications made in currently available SEA methodologies to reduce the complexity of the environmental analysis, integrated with the use of tools and techniques that are mainly developed to deal with the broader perspective of issues involved in higher tiers decision making, can successfully be used to integrate environmental consideration in the decision making process. Thus, achieving a reduction in time and money costs, and reducing the risks and uncertainty involved with detailed impact predictions associated with currently available methodologies.

Methodological barriers were identified through conducting the case study, which the author believes are hindering the prevalence of SEA as a more practised tool are mainly attributed to the fact that currently used methodologies are limited with project level EIA procedures from which they evolved. Therefore, the author identifies the need for practitioners and researchers to change their view of SEA and project level EIAs, as one concept and procedure which applies to different tiers. Practitioners should start looking at these as two separate methodologies, which complement each other. The first to be developed in such a way that can deal with the broader perspective of the policy, plan or program, identifying the main issues involved and the problems anticipated, and setting the general path for initiated lower tiered plans, programs or projects. The later, since it is can be more specific, can tackle the details, taking into considerations the mitigation measures suggested by higher tier SEAs.

Each methodology should also develop different techniques and tools, which can handle the issues attacked, and overcome the problems encountered with each tier of decision making.

Other barriers which the author identified while preparing this paper, involve the concepts of sustainability and carrying capacity, which SEA is considered an important tool for incorporating into the decision making cycle. The author noticed that these important concepts are not yet commonly known and understood by the public, and to an extent by decision makers. Therefore, recommendations are made to enhance the support for programs promoting public awareness regarding environmental issues and the sustainability and carrying capacity concepts, which should reflect positively on public participation and political support for SEA practice.

The author would like to conclude with a final note; SEA as a concept is a very effective tool for the integration of environmental consideration into decision making. However, it still has a long way to go and obstacles to be overcome, before it can become more commonly practised. Therefore, it is important to recognise that each and every SEA conducted, whether it entails great detail or prepared qualitatively and as simply as possible, should be considered as one step forward towards a more integrated and comprehensive decision making process. Therefore, it is important that SEA practice is encouraged and supported by decision makers, as every SEA conducted, adds to practitioners experience and SEA development. In addition to presenting a new piece in the large and complex puzzle of integrating environmental considerations into higher decision making. Thus helping to fill the void gaps and moving forward along the road towards achieving the ultimate goal of sustainability.
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References


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Appendix

Table (1) Characteristics of SW disposal sites in Jordan.

<table>
<thead>
<tr>
<th>Solid Waste Disposal Sites</th>
<th>Area (1000 m²)</th>
<th>Landfill Method/Type of Received Waste</th>
<th>Geographical Configuration</th>
<th>Soil Quality</th>
<th>Ground Water</th>
<th>Term of Landfill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akaider</td>
<td>606</td>
<td>Sandwich method/MSW, septage, industrial and medical waste</td>
<td>hilly or flat, no adjacent houses and facilities</td>
<td>sandy soil</td>
<td>Impermeable layer down to 300 m</td>
<td>2010</td>
</tr>
<tr>
<td>Mafraq</td>
<td>180</td>
<td>MSW and industrial waste</td>
<td>flat desert, no houses nor public facility nearby</td>
<td>sandy soil and basalt</td>
<td>300-400m deep</td>
<td>2046</td>
</tr>
<tr>
<td>Humra</td>
<td>275</td>
<td>Open Dumping /MSW and medical waste</td>
<td>on mountain slopes, no houses</td>
<td>clayey sandstone</td>
<td>200-300m down from the surface</td>
<td>2020</td>
</tr>
<tr>
<td>Tafila</td>
<td>454</td>
<td>Open Dumping /MSW and medical waste</td>
<td>Hilly, no houses or public facilities.</td>
<td>Sandy soil equivalent with limestone equiv.</td>
<td>150-200m</td>
<td>2050</td>
</tr>
<tr>
<td>Ma’an</td>
<td>503</td>
<td>Sandwich method/Septage</td>
<td>flat land, no houses</td>
<td>equivalent to debris containing sandy soil</td>
<td>200-300m</td>
<td>2033</td>
</tr>
<tr>
<td>Ianoon</td>
<td>500-600</td>
<td>Sandwich method/MSW</td>
<td>flat land in a hilly terrain, no houses</td>
<td>sandy soil containing debris</td>
<td>250-300m</td>
<td>2010</td>
</tr>
<tr>
<td>Aqaba</td>
<td>60</td>
<td>Open Dumping /MSW, industrial and medical waste</td>
<td>mid hilly terrain</td>
<td>Sandy soil with rock-bed least imaged from the mountain ground</td>
<td>Details are unknown</td>
<td>2510</td>
</tr>
<tr>
<td>Kufrinja</td>
<td>71</td>
<td>Open Dumping /MSW</td>
<td>flat surrounded by mountains</td>
<td>sandy soil equivalent</td>
<td>200-300m</td>
<td>1998</td>
</tr>
<tr>
<td>Kufrinja new</td>
<td>100</td>
<td>Open Dumping /MSW</td>
<td>not-so-mild mountains</td>
<td>calcareous clayey soil/marl</td>
<td>200-300m</td>
<td>2045</td>
</tr>
<tr>
<td>Madaba</td>
<td>50</td>
<td>Sandwich method/MSW, industrial, medical waste, &amp; airport waste</td>
<td>flat land with adjacent houses</td>
<td>sandy soil equivalent</td>
<td>200-00m under surface</td>
<td>1997</td>
</tr>
<tr>
<td>North-Shuneh</td>
<td>67</td>
<td>Open Dumping /MSW and medical waste</td>
<td>hilly land</td>
<td>sandy soil</td>
<td>approx. 680m</td>
<td>1998</td>
</tr>
<tr>
<td>Ruselfa</td>
<td>700</td>
<td>Sandwich method/MSW, industrial and medical waste</td>
<td>flat with faults</td>
<td>details unknown</td>
<td>major water aquifer &amp; many water wells.</td>
<td>2003</td>
</tr>
</tbody>
</table>

Source: (General Corporation for Environmental Protection GCEP of Jordan, Draft of Agenda -21, A plan of Action for Municipal Solid Waste management, 1997).
**Table (2) Energy consumption in relation to GNP for the period 1987-1997.**

<table>
<thead>
<tr>
<th>Year</th>
<th>GNP in current price (Million JD)</th>
<th>GNP growth in Real Terms (%)</th>
<th>Total Energy Demand (fuel 1000 tons)</th>
<th>Total Energy growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>211.0</td>
<td>1.0</td>
<td>3031</td>
<td>5.4</td>
</tr>
<tr>
<td>1988</td>
<td>2175.9</td>
<td>-0.5</td>
<td>3086</td>
<td>1.8</td>
</tr>
<tr>
<td>1989</td>
<td>2180.7</td>
<td>-19.8</td>
<td>3135</td>
<td>1.6</td>
</tr>
<tr>
<td>1990</td>
<td>2428.8</td>
<td>-4.1</td>
<td>3306</td>
<td>5.4</td>
</tr>
<tr>
<td>1991</td>
<td>2634.0</td>
<td>0.2</td>
<td>3272</td>
<td>-1.0</td>
</tr>
<tr>
<td>1992</td>
<td>3306.8</td>
<td>20.7</td>
<td>3770</td>
<td>15.2</td>
</tr>
<tr>
<td>1993</td>
<td>3652.0</td>
<td>5.1</td>
<td>3935</td>
<td>4.4</td>
</tr>
<tr>
<td>1994</td>
<td>4049.9</td>
<td>6</td>
<td>4152</td>
<td>5.5</td>
</tr>
<tr>
<td>1995</td>
<td>4537.8</td>
<td>9.5</td>
<td>4400</td>
<td>6.0</td>
</tr>
<tr>
<td>1996</td>
<td>5035.2</td>
<td>4.2</td>
<td>4607</td>
<td>4.7</td>
</tr>
<tr>
<td>1997</td>
<td>5453.0</td>
<td>5.1</td>
<td>4732</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Source: (NEPCO Annual report, 1997).

**Table (3) Projected capacities for Biogas program for the period 1998-2023 under the Biogas Scenario.**

<table>
<thead>
<tr>
<th>Year</th>
<th>MSW to Biogas Plants (ton/day)</th>
<th>Electricity Production from Biogas per year (GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td>1999</td>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td>2000</td>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td>2001</td>
<td>300</td>
<td>40</td>
</tr>
<tr>
<td>2002</td>
<td>300</td>
<td>40</td>
</tr>
<tr>
<td>2003</td>
<td>300</td>
<td>40</td>
</tr>
<tr>
<td>2004</td>
<td>600</td>
<td>120</td>
</tr>
<tr>
<td>2005</td>
<td>600</td>
<td>120</td>
</tr>
<tr>
<td>2006</td>
<td>900</td>
<td>240</td>
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<tr>
<td>2007</td>
<td>900</td>
<td>240</td>
</tr>
<tr>
<td>2008</td>
<td>1800</td>
<td>400</td>
</tr>
<tr>
<td>2009</td>
<td>1800</td>
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