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عمادة البحث العلمي والدراسات العليا
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A Preliminary Model for the Factors Affecting the Sustainability of Internationally Funded Water Desalination, Waste Water and Solid Waste Treatment Projects in Developing Countries

نموذج أولي للعوامل المؤثرة على استدامة مشاريع تحلية مياه الشرب ومعالجة الصرف الصحي والنفايات الصلبة الممولة دوليا في البلدان النامية

By

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إقـــــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

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A Preliminary Model for the Factors Affecting the Sustainability of Internationally Funded Water Desalination, Waste Water and Solid Waste Treatment Projects in Developing Countries

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سورة الرحمن: آية 1– 4

Dedication

To…

My lovely family, hoping that our relation is sustainable forever.

Doaa Abd Elraheem Safi

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.

Abstract

Purpose: In most of developing countries, many millions of dollars are invested by national governments and international donor agencies in water and waste treatment projects implementation**.** These projects require that their services be sustained over time to ensure a continued flow of outputs and hence achievement of the desired change which could be social, cultural or economic, however many of these projects fail to maintain the flow of expected benefits over their proposed lifetimes or decline in performance shortly after external support is withdrawn. Therefore, this study aimed to identify and model the main factors affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects in developing countries especially in Gaza Strip.

Design/methodology/approach: The research approach was a quantitative and qualitative survey research to measure the objectives. The research technique was shaped as questionnaires with semi-structured interviews. The first questionnaire was designed as pairs comparison one to be analyzed using Expert Choice software package (2000) based on the analytic hierarchy process (AHP). A pilot study was conducted to pre-test the survey and subsequently modified before a final version of the questionnaire was produced. This questionnaire was modified and distributed to only 10 respondents due to the nature of the AHP analysis method. Then semi-structured interviews were conducted to collect data and reports about local water and waste treatment plants. These interviews suggested four treatment plants to be taken as case studies in this research. For this application, another simple questionnaire was designed to obtain the importance score for each sub factors in four projects.

Findings: The study results indicated that the political factor is the most sustainability affecting main factor whereas financial factor comes later. Political stability, working at hot (dangerous) points in the political category, levels of operation and maintenance costs in the financial category and the plant's equipment/spare parts can be locally manufactured or imported in the technical category were found to be the most sustainability affecting sub factors on the internationally funded water desalination, waste water and solid waste treatment projects in Gaza Strip.

Recommendations: Based on these results, the study suggests several recommendations; the most important is to conduct the same methodology with taking into consideration the different policies of each donor that may affect the final results.

الملخـــص

غرض الدراسة: تستثمر الحكومات الوطنية والوكالات الدولية المانحة في معظم البلدان النامية ملايين الدولارات في تنفيذ مشاريع تحلية مياه الشرب ومعالجة الصرف الصحي والنفايات الصلبة. تتطلب هذه المشاريع أن تستمر خدماتها مع مرور الوقت لضمان استمرار تدفق مخرجاتها وبالتالي تحقيق التغيير المنشود الذي يمكن أن يكون اجتماعيًا أو ثقافيًا أو اقتصاديًا ، إلا أن العديد من هذه المشروعات يفشل في الحفاظ على تدفق الفوائد المتوقعة على مدى أعمارها المقترحة أو انخفاض في الأداء بعد فترة وجيزة من سحب الدعم الخارجي. لذلك هدفت هذه الدراسة إلى تحديد العوامل الرئيسية التي تؤثر على استدامة مشاريع تحلية مياه الشرب ومعالجة الصرف الصحي والنفايات الصلبة الممولة دوليًا خلال مرحلة التشغيل في الدول النامية خاصة في قطاع غزة.

التصميم / المنهجية / النهج: اعتمد البحث على المنهج الكمي والنوعي الاستقصائي لقياس الأهداف. اعتمد البحث على تقنية استخدام الاستبانات والمقابلات غير المنتظمة. تم تصميم الاستبانة الأولي كمقارنة بين ازواج العوامل على أساس عملية التحليل الهرمي (AHP) ليتم تحليلها باستخدام حزمة برنامج (Expert choice). قبل عملية توزيع الاستبانة، أجريت دراسة تفحصيه لاختبارها والتعديل عليها بما يلائم وضع المشاريع في قطاع غزة. ومن ثم تم توزيع الصيغة النهاية على 10 خبراء في مجال معالجة المياه والنفايات فقط بسبب طبيعة عملية التحليل الهرمي. تم تنفيذ المقابلات شبه المنظمة بعد ذلك لجمع البيانات والتقارير حول محطات معالجة المياه والنفايات المحلية. اقترحت هذه المقابلات أربع محطات معالجة تؤخذ كدراسات حالة في هذا البحث لذللك، تم تصميم استبانة بسيطة للحصول على مدى تطبيق/تأثير كل عامل على هذه المشاريع.

النتائج: أشارت نتائج الدراسة إلى أن العامل السياسي هو العامل الأكثر تأثيرا استدامة هذه المشاريع يتلوه في الأهمية العامل المالي. وكان الاستقرار السياسي و العمل في النقاط الساخنة (الخطيرة) من العوامل السياسية و مستويات تكاليف التشغيل والصيانة من العوامل المالية وامكانية تصنيع او استيراد معدات المصنع / قطع الغيار من العوامل الفنية هم أكثر العوامل الفرعية تأثيرا على استدامة مشاريع معالجة المياه والنفايات (الممولة دولياً) في قطاع غزة.

التوصيات: استناداً إلى هذه النتائج، قامت الدراسة بالعديد من التوصيات، وأهمها ضرورة اجراء منهجية البحث مع الأخذ بعين الاعتبار اختلاف سياسة كل ممول على حدا لتحديد العوامل المؤثرة على استدامة المشاريع.

List of Contents

List of Abbreviations

Abbreviation	The explanation
AHP	Analytic hierarchy process
UNDP	United nations development program
UN	United nations
MCM/Yr	Million cubic meters/year
WHO	World health organization
WWTP	Waste water treatment plant
PNA	Palestinian national authority
CRSWM	Country report on the solid waste management in occupied Palestinian territories
AR-CMWU	Annual report of Coastal Municipalities Water Utility
GIZ	German corporation for international cooperation
AFD	French development agency
EC	European commission
IDB	Islamic development bank
UNICEF	United nations children's emergency fund
ICRC	The international committee of the red cross
KFW	Bank credit for reconstruction
ANERA	American near east refugee aid
USAID	United states agency for international development
MSWM	Municipal solid waste management
SW	Solid waste
SWM	Solid waste management
BSc.	Bachelor of science degree
MSc.	Master of science degree
O & M	Operation and maintenance
Que.	Questionnaire

List of Tables

List of Figures

Chapter One

Introduction

Chapter one: Introduction

This chapter clarifies the background about the research. The problem statement of the study, research aim, objectives, key questions, research delimitations, as well as the outline of the thesis are included in this chapter.

1.1 Background

As the world is becoming more developed, and with populations quickly increasing each year, consumption levels are reaching extraordinary levels (UN, 2013). A foreseeable consequence of this growing consumption trend to the rapid increase in the amount of water demand and waste produced. Having effective and sustainable water supply and waste management systems in place will help order waste disposal , water providing and will help reduce some of the pressure consumption has put on the environment (UN, 2013).

For the insufficiency of operation and maintenance in several previous water and sanitation exertions, it is important to apply the more specific, function-oriented definition provided by (Tafara, 2013), which stated that sustainability is dependability in water and sanitation services which may be achieved through adaptive mechanisms. Therefore, environment, development, and long-term functionality and trustworthiness of service attend as the limits for purifying the key components of sustainability.

Every year, in developing countries, several millions of dollars are spent by national governments, international and local donor institutions similarly in water and waste treatment projects implementation. Implementation of these projects is useless if they fail after a short time. To make the investment in these projects effective, failure degrees of these systems should be condensed.

1.2 Problem statement

Projects are intended and implemented to meet specific goals and attain preferred change. Herroelen & Leus (2005) describe a project as a group of matched activities with a specific start and finish time, ensure a specific goal with restrictions on time,

scope and resources. Some projects such as water and waste treatment projects require their services be sustained over time to ensure continued flow of outputs. Implementation of many projects may be fruitful but their sustainability may stay a challenge. This matter has been taken concerns by many donors like as the World Bank and the bilateral aid agencies (Macharia et al., 2015).

In spite of continually increasing efforts to tackle the problem in developing countries, many water and waste treatment projects especially in Gaza Strip failed to sustain the flow of probable benefits over their proposed lifetimes or decline in performance shortly after external support is withdrawn due to varied affecting factors.

1.3 Research aim, objectives and key research questions

Research aim

The aim of this research is to identify and model the main factors affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects during operation phase in developing countries especially in Gaza Strip using the analytic hierarchy process (AHP) application.

Research objectives

1. To identify and prioritize the main factors affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects in developing countries.
2. To identify and prioritize the sub factors categorizing each of main factor affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects in developing countries.
3. To develop a decision support model based on the Analytic Hierarchy Process (AHP) including the sustainability factors affecting water and waste treatment projects with their priorities.
4. To obtain the sustainability of four real projects based on the model.

Key research questions

RQ 1: What are the main and top factors affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects during the operation phase in Gaza Strip?

RQ 2: What are the main and top sub factors affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects during the operation phase in Gaza Strip?

RQ 3: What is the sustainability index for given projects?

1.4 Structure of the thesis

The thesis write-up is divided into five chapters to create a flow. The structure of the thesis is therefore summarized as follows:

Chapter 1 (Introduction):

This chapter clarifies the background of the research. The problem statements of the study, research aim, objectives, questions, research delimitations, and the summary of the thesis are included in this chapter.

Chapter 2 (Literature review):

This chapter discusses briefly the definition of projects sustainability with a specific focus on the concept, water, waste water and solid waste in developing countries and especially in Gaza Strips. The international donors for these types of projects are identified. Also, the factors affecting the projects sustainability are identified according to previous studies. Finally, a summary of the analytical hierarchy process (AHP) was given.

Chapter 3 (Research methodology):

This chapter presents the detailed research design and methodology. This chapter also describes the technique used in the analysis and issues related to data collection

Chapter 4 (Results and discussion):

After results are analyzed, this chapter presents, discusses and connects them with the previous studies in this chapter.

Chapter 5 (Conclusion and Recommendations):

According to the final results, recommendations and conclusion of the research is discussed in chapter five.

References

Appendices

Chapter Two

Literature review

Chapter two: Literature review

This chapter presents comprehensive definitions for many points related to this study. This chapter consists of many sections. The first section is about infrastructure and heavy construction projects , secondly sustainability and its definitions, section three, four and five talk about water, waste water and solid waste in developing countries and especially in Gaza Strips. The international donors for these types of projects are shown in section seven. For achieving the main objectives, factors affecting projects sustainability were recognized according to the previous studies. Finally, analytical hierarchy process (AHP) was defined.

2.1 Infrastructure and heavy construction projects

There are several different types of construction projects. It can be categorized under residential, commercial, industrial, highway construction and infrastructure and heavy construction. Water and waste treatment plants are listed under infrastructure and heavy construction type.

Infrastructure and heavy construction projects are one of the major types of construction projects which include projects such as highways, tunnels, bridges, pipelines, drainage systems and sewage treatment plants (Elbeltagi & Eng., 2009). A large percentage of the investment both in developing and developed countries is spent for new infrastructure projects. Developing countries invest about $200 billion a year, however, developed ones add for about 11% of their gross domestic product.

Although the large investment in developing countries in these projects, infrastructure services are often of poor quality as over 1 billion people in that countries do not have access to safe drinking water, 2 billion lack adequate sanitation and cannot access to electric power, etc. sustainable infrastructure are needed to improve the living standards of the population and increase creativity efficiency (Merna & Njiru 2002).

During the past years, most of the infrastructure projects both in developed and developing countries have been funded by public exchequer or through a combination of public and foreign assistance (Merna & Njiru 2002).

2.2 Sustainability

The main objectives of project management are: costs, quality and time; as well as

performance and particular requirements for each project. But, it seems that these requirements are not enough paralleled to new challenges posed by society, which demand a change of project approaches (Rodríguez et al., 2010). There must be a strategic triple objective for the project based on the environment, society and economy as shown in Figure (2.1)

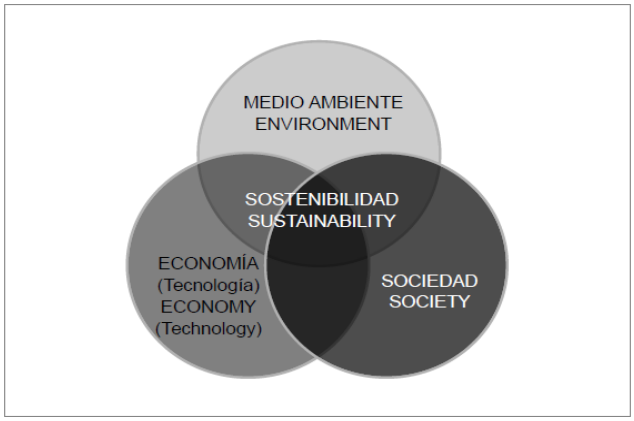

Figure (2.1): Sustainable engineering dimensions (Rodríguez et al., 2010)

Sustainability is one of the most over used and abused words in the development vocabulary (Tafara, 2013). Macharia et al. (2015) defines sustainability as, meeting the necessities of the present-day without bartering the ability of future generations to meet their necessities. Sustainable construction term is normally used in construction industry. Kibert (2005) defined sustainable construction as "*the responsible development and management of a healthy built environment, based on the proficient use of resources and on environmental principles*".

Sustainable term mentions to something which can be kept going. It also denotes to resource use and lifestyles which do not destruct resources or humanity. Sustainable development pursues to meet the needs of the present without bargaining the ability to meet those of the future (Tafara, 2013). "*Sustainability is a process of change in which the utilization of resources, trend of investments, orientation of technological development, and institutional change are made consistent with future moreover, present necessities*."(Tafara, 2013)

Hasna (2010) underlined that sustainable development mentions to the design of human and industrial systems to certify that humanity's use of natural resources do not lead to reduce quality of life due to fatalities in future economic chances or to opposing impacts on social situations, human health, and the environment.

The researcher believes that every one of the previous definition adds value to sustainable development in its own way, all of them enthused the researcher to define the projects sustainability as the ability of a project to initiate a process by which benefits are conserved.

2.3 Water in the developing countries

Water is the essential source for all forms of existence. It is a vital resource for the presence of living on the earth surface and is essential for economic and social development (Islam et al., 2018). Most of developing countries suffer from severe water scarcity, Lack of accessibility (0.9 billion people still lack access to safe drinking water), water quality drop, debility of financial resources, allocation and destruction of water management will be the world water, especially developing countries, challenges for the 21st century (Gutterer et al., 2009).

In the last century, water use has critically overtaken the population growth rate; people are using more water than ever before. By 2025, up to 1.8 billion people could face water lack. Water lack can take two forms: physical water scarcity, or low quantity of water, and economic water scarcity, or low quality of water (WHO & UNICEF, 2000).

Therefore, it is very important to find out the alternate and sustainable sources of fresh water to handle with the increasing demand. As a result, a solution such as salt-water desalination has occurred as the keys to sustaining future generations across the sphere (Islam et al., 2018).

2.3.1 Water in Gaza Strip

According to the annual report of Coastal Municipalities Water Utility (AR.CMWU, 2016), the only source for water in Gaza Strip is Gaza coastal aquifer. In recent years the aquifer had been over pumped at a rate of 200 MCM/Yr, which is four times higher than the safe yield. As a result of the high groundwater pumping amount, the water level within this aquifer is affected harmfully. Sewage and agricultural fertilizers infiltration have caused an aquifer water quality worsening and polluted 96% of the aquifer's water. This caused declining in water quality to be below the standards set by the World Health Organization’s (WHO) of safe drinking water. In 2014, only 4% of the water in Gaza was drinkable.

The urgency for the desalination facility has increased by the worsening water quality in Gaza Strip and with no alternative existing source of fresh water. Many plants were constructed to provide drinkable water with an acceptable quality and designed quantity, however some of these plants were forced to stop their works or have operated at a little percentage of their planned capacities (AR.CMWU, 2016).

2.4 Sewage and sanitation treatment in developing countries:

Unsuitable use and poor management of water resources have an increasingly negative effect on economic progress, on public health and on the world's eco-systems. For a long time, the necessity for proficient and sustainable wastewater treatment was discounted by many public authorities. As a result, the performance of existing treatment plants and the settings of sanitation facilities are relatively poor. At many sites in developing countries, the sewage is just drained to surface or ground waters without suitable management. In recent times, decision makers, planners, engineers and civil society stakeholders have launched multiple initiatives to answer the question facing many developing countries: How to confirm a good performance and a high coverage of wastewater treatment under difficult situations with financial restrictions and limited human and institutional capacities?(Gutterer et al., 2009).

Sewage treatment is not a cheap proposition. Public bodies have to think twice before making extensive investments particularly in developing countries where environmental concerns could not be given the priority due to financial restrictions.

In developing countries, the waste water treatment systems are not effective and therefore unsustainable. These systems were just copied from western treatment systems without bearing in mind the suitability of the technology for the culture, land, and climate which make it unreliable (Abdel-Halim, 2008).

2.4.1 Sewage and sanitation treatment in Gaza Strip

In Gaza Strip, the annual wastewater collected by sewage systems is around 41.27 MCM/year from which 37.62 MCM/year are partially treated before being discharged into the Mediterranean Sea. The wastewater treatment plants are: (1) Khan Younis intermediate treatment plant; (2) Rafah WWTP (3) North Gaza - Beit Lahia WWTP; (4) Gaza WWTP - Gaza Central WWTP (Isaac & Rishmawi, 2015).

The current wastewater treatment plants in Gaza are burdened and extremely inefficient and scarcely operational. These inadequacies had been related to the lack of appropriate operation and maintenance; the lack of sufficient and applicable infrastructure for wastewater collection and treatment; undependable electric source, and difficulties in the accessibility of spare parts as result of the closure on the Gaza Strip (Isaac & Rishmawi, 2015).

2.5 Solid waste in developing countries

Solid waste denotes to the useless and occasionally dangerous material with a low liquid content. It includes municipal garbage, industrial and commercial waste, sewage sludge; damage wastes, mining remains, and waste from agricultural, animal farming, and other activities (Guangyu, 2009).

Solid waste has become a perpetual problem in developing countries. It causes severe dangers to the human health and environment. Steady increase in population growth makes the state more critical and the municipalities, lacking financial resources, are unable to deal with the increasing amount of waste created from residential, commercial and institutional activities. Also, it is worth mentioning that the waste management cost in these countries is too expensive for the municipalities, taking of a high percentage of the municipality incomes, accounting for up to 50 per cent of the budget in some cases (Adebayo et al., 2011).

2.5.1 Solid waste management in Palestine

In Palestine, the dominant method of solid waste disposal is dumping in open, uncontrolled, unmonitored sites (50% of the generated solid waste). There are about 100 random dumpsites distributed in the West Bank and Gaza Strip; none of them were built or follow the environmental regulations (Isaac & Rishmawi, 2015). Typically, burning is the standard practice used for waste volume reduction in these dumpsites regardless of the negative impacts of burning on environment.

In Gaza Strip, the central sanitary landfills are Juher El Deek, Deir El Balah and Rafah (Sofa) landfill. These sites are currently exceeding their maximum capacity; therefore local authorities attempt to expand the existing ones as much as possible. In this regard, Rafah Municipality has been predicting to add 10 hectares for its sanitary landfill and to build a composting plant. The story is the same for Deir El Balah and

Juher Al Deek sanitary landfills, which are tried to expand their capacity. Unfortunately, no decision has been taken yet regarding such expansion. In addition the Juher El Deek and Deir El Balah dumpsites face troubles with the occupation border military due to their location within the buffer zone next to Israel.

The implementation of solid waste management is confronted with several challenges at the organizational, technical, environmental and financial levels. This situation is further complicated by the lack of statistical data needed for decision making, planning and effective operations (Isaac & Rishmawi, 2015).

2.6 Projects international donors

Donors play an essential role in the field of development of the water and waste management sector in Palestine. They started early their support since the establishment of the Palestinian National Authority. The donors mainly supported the fields of building the infrastructure like regional sanitary landfills, desalination plants and transfer stations, developing the capacities of the local authorities and developing the capacities in the national strategic planning. The donors started to act in a more organized and cooperating way since the establishment of the sector working groups by the Palestinian National Authority (PNA). The solid waste thematic sub working includes the main national stakeholders in addition to the donors of the sector. Unfortunately, this working group has not convened for the past two years (Country Report on the Solid Waste Management in Occupied Palestinian Territories CRSWM, 2014).

The main donors in this sector could be listed as mentioned in CRSWM, 2014 and AR-CMWU, 2016 as follows: GIZ, The World Bank, The Japan Government, AFD, UNDP, Italian Cooperation, EC, IDB, UNICEF, ICRC, KFW, EU, JICA, Islamic help, Muslim Hands, ANERA, SIF and other NGOs.

2.7 Factors affecting water and waste treatment projects sustainability

In developing countries, a number of water and waste treatment projects have been carried out in cooperation with external support agencies. Some projects succeeded to ensure continued and effective flow of outputs. However, many projects could not support themselves or expand after the external agencies withdrew their support. A

number of factors contribute to the failure to sustain the projects, and they vary from project to project (Ogawa, 2002).

Many researchers focused on these factors and listed groups of sub factors affecting the sustainability or success of construction projects in general and water and waste treatment projects particularly. The related previous studies are summarized below beginning from waste water, water and finally solid waste related studies:

Kampa (2009) studied the constraints affecting wastewater treatment and reuse in Mediterranean Partner Countries .This study classified the constraints to six main groups as shown in figure (2.2) and listed many sub constraints under every main factor as shown later in table (2.5).

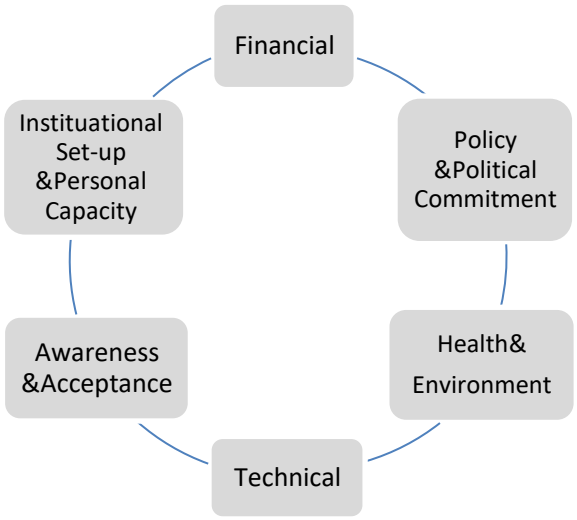

Figure (2.2): Factors affecting wastewater treatment (Kampa, 2009)

Sbeih (1995) referred in his study to the obstacles that face the treatment plants in Palestine and he commented that wastewater collection and treatment projects are considered the "forgotten infrastructure projects" as a result of many obstacles. He concluded that funding is the main obstacle for these infrastructure projects. High cost of investment desired. Since municipalities bear the responsibility for sewage collection and treatment, it is very difficult for the individual municipality to raise the required funds for the capital cost which is needed for such projects.

Isaac & Rishmawi (2015) summarized the challenges and limitations facing the Palestinian water and wastewater sector as follow :(1) The Political Situation, (e.g.

Israeli difficulties, Israel stopped/ didn't approve several water and wastewater projects and conditioned aids to political situation (USAID cancelled Hebron wastewater project in 2006 as consequence of election results), (2) Financial aspects , (e.g. limited availability of fund and citizen affordability), (3) Technical aspects, (e.g. operation & maintenance costs related to water and wastewater infrastructures and selection of suitable systems and technologies that fit the particularity of Palestine), (4) Institutional,(e.g. Legislations: Enforcement of laws and standards), (5) Social and environmental aspects.

On the same side, Tafara (2013) focused on water projects (desalination and supply) and identified the factors affecting their sustainability. The determinant factors for the sustainability were categorized into two main groups. These were pre implementation factors and post implementation factors. The pre-implementation factors include community participation, technology selection, site selection, demand responsiveness, construction quality, population and training and post-implementation factors are technical support, community satisfaction, institutional and financial management, training and willingness to sustain the water projects.

Yukalang et al. (2017) focused on defining the barriers of effective municipal solid waste management (MSWM) in a rapidly urbanizing area in Thailand. In-depth interviews with individuals and focus groups were conducted with key informants including the municipality staff, residents, and external institutions. The main factors affecting waste management were categorized into six aspects: social-cultural, technical, financial, organizational, and legal-political barriers and population growth.

McAllister (2015) studied the factors influencing solid waste management in the developing world and he divided them into three main groups culture, education, and microeconomics, infrastructure and technology and policy, institutions, and macroeconomics and listed major constraints under every group. He commented that solid-waste management is a multidimensional issue that incorporates political, institutional, social, environmental, and economic aspects. Improving SWM in developing countries requires efforts to raise public awareness, increase funding, build expertise, and invest in infrastructure.

Asit Nema (2005) focused in his study on the risk factors associated with solid waste treatment**.** A case study of 11 municipal solid waste treatment plants and one disposal facility from across India was carried out with the objective of assessing the sustainability dimension of technology options**.** The study has helped in identifying a very wide range of risk factors which undermine sustainability of solid waste treatment plants under Indian conditions. These risk factors could be classified under fourteen broad categories which were project development, political aspects, administrative aspects, contractual agreement, promoter background, location of plant, collection and transport system, waste quality, waste quantity, plant design, operation and maintenance, climatic factors, market and environmental and social impacts.

Assessment of the current status of solid waste (SW) sector in the Palestinian Territory was discussed in Solid Waste Management Strategy 2010-2014 Report. This assessment resulted in the identification of a number of key issues, indicating the problems and challenges facing this sector. The assessment involved institutional, technical and financial aspects. Many challenges were listed under each issues as shown in table (2.2).

Table (2.2): Assessment issues with related challenges face SW sector in Palestine

Assessment Issues	Challenges affecting SW sector
Institutional and organizational issues	Absence of effectiveness and update of the legislative framework leading the SWM sector
	Lack of developed specifications and standards for various stages of SWM
	The indistinctness of general institutional frame for SWM and overlap and conflict in roles and authorities.
	Insufficiency of financial, human, and organizational capacities of institutions involved in management of the SW sector
	The lack of a wide-ranging system for authentication and analysis of data and the inadequacy of monitoring and evaluation systems.
	Lacking of participation of the private sector in SWM
	Lacking of public awareness in SWM issues

Assessment Issues	Challenges affecting SW sector
Technical issues	Limited initiatives and proficiency in the areas of waste reduction, reuse and recycle
	The necessity for suitable mechanisms to collect and treat special wastes
	Inadequacy of legal, organizational, and institutional frameworks for handling hazardous waste
	The limited experience in reducing gas emissions from landfills or recycling these gases
Financial issues	Reliance on external funding to cover SWM expenditures and variety of funding channels
	Insufficiency of current financial systems to provide necessary financial data
	Incapability to recuperate SWM costs threatens service sustainability

Enshassi et al. (2016) studied factors affecting sustainable performance of construction projects during project life cycle phases, a total of 53 sustainable factors (economic, social, and environmental groups) were identified during wide literature review and confirmed by experts' interviews and a pilot study. These factors are grouped with respect to the project life cycle stages; inception phase, design phase, construction phase, operation phase, and demolition phase. For the operation phase, seven sub factors under the main groups were identified for achieving the mean of project sustainability as shown in table (2.3).

Table(2.3): Sustainable Factors Affecting Operation Phase in Construction Projects (Enshassi et al., 2016)

Sustainability main factors	Sustainability Sub factors	Description
Economic sustainability factors	Training costs	Training courses accompanied for employees to increase the quality of human resources.
	Local economy	The project benefits

		economically the local economy.
Social sustainability factors	Provision of services	Necessities for improving living standard to local communities were considered.
	Provision of facilities	Beneficial spaces and facilities were saved to involve in the development of local communities.
Environmental sustainability factors	Chemical wastes	Chemical wastes and organic pollutants did not release to water ways.
	Water pollution	Projects releases of chemical wastes and organic contaminants to water were curing.
	Waste generation	There are no adverse influences from projects operations to flora, fauna, and ecosystems.

The main factors affecting water and waste treatment projects as mentioned in the previous studies are summarized and listed in table (2.4).

Table (2.4): The main factors affecting water and waste treatment projects

Publication Title	Main factors	Authors
Waste factors influencing solid management in the developing world	1. Culture, education and microeconomics	Jessica, 2015
	2. Infrastructure and technology	
	3. Policy, institutions and macroeconomics	
Barriers to Effective Municipal Solid Waste Management in a Rapidly Urbanizing Area in Thailand	1. Internal factors	Yukalang et al., 2017
	1.1. Insufficient waste management infrastructures	
	1.2. Organizational barriers	
	1.3. Communication	
	1.4. Staff	
	2. External factors	
	2.1. Social –cultural barriers	
	2.2. Legal and political barriers	
	2.3. Physical barriers	
Systems approaches to integrated solid waste management in developing countries	1. Environmental context	Marshall & Farahbakhsh, 2013
	2. Political context	
	3. Institutional context	
	4. Social context	
	5. Cultural context	
	6. Technical context	
	7. Economic context	
Risk factors associated with solid waste treatment technology options in the Indian context	1. Project development	Asit Nema, 2005
	2. Political aspects	
	3. Administrative aspects	
	4. Contractual agreement	
	5. Promoter background	

Publication Title	Main factors	Authors
	6. Location of plant	
	7. Collection and transport system	
	8. Waste quality	
	9. Waste quantity	
	10. Plant design	
	11. Operation and maintenance	
	12. Climatic factors	
	13. Environmental and social impacts	
	14. Market impacts	
Sustainable Solid Waste Management in Developing Countries	1. Technical constraints	Ogawa, 2002
	2. Financial constraints	
	3. Institutional constraints	
	4. Economic constraints	
	5. Social constraints	
Sustainable municipal waste water treatment systems	Problems and constraints are:	Balkema et al., 2002
	1. Government/state monopoly of the water and sanitation sector	
	2. Lack of awareness/access to information	
	3. Ineffective government policy	
	4. Overall poor state of economy of the people and government	
	5. Lack of local capabilities to promote these systems	

Table (2.5) summarized the main and sub factors affecting water and waste treatment projects as mentioned in the related previous studies that will be considered in this study and checked in the pilot study as will discussed later in chapter 3.

Table (2.5): The main and sub factors affect water and waste treatment projects according to the previous studies

Main Factors	Sub Factors
Technical Factors	Staff knowledge and experience in solid waste management
	Overall plans for solid waste management at the local and national levels
	The existence of research and development activities
	Communication between consultants provided by the external support agency and the local counterpart in the developing country
	Validity of treatment plants design and construction for treatment purposes
	Plants location suitability
	Availability of storage basins for treated solid and water for reuse when needed
	Availability of monitoring equipment at the project
	Levels of services required for protection of public health and environment
	Levels of decent attitude and experience of external consultants in working with officials of developing countries
	Availability of industry manufacturing for solid waste equipment and spare parts and foreign exchange for importing such equipment/spare parts
	Availability of sufficient infrastructure for treating, conveying and distributing waste for reuse
	Availability of natural resources in the country
Financial Factors	Financial basis of local governments
	Users' ability & willingness to pay for the services
	Good financial management and planning
	Sector's priority for support for the donor
	User's ability and willingness to pay for the services related to water and waste management
	O & m costs, e.g. For electricity, equipment maintenance of treatment systems

Main Factors	Sub Factors
	Existence of political commitment and supporting laws
Political Factors	Government and political stability
	Closure
	Unstable security circumstances (wars)
	Working at hot (dangerous) points
Institutional Factors	Coordination among the relevant agencies in the same country
	Availability of legislation for water and waste management
	The priority given to these projects at the level of institutions
Social/cultural Factors	Social norms, public culture, levels of public participation in waste management
	Awareness & acceptance of civil society on benefits of treatment and reuse
	Availability of industry to receive and process recycled material
	Awareness & acceptance of the end users (e.g. industrial /agricultural users) to use treated water/solid
	Exchange rate fluctuation
	Export and import regulations

2.8 AHP as a research analysis method

The Analytic Hierarchy Process (AHP) is an effective decision-making tool that permits the decision maker to model a composite problem in a hierarchical structure showing the relations between goal, criteria, sub-criteria and alternatives (Agha, 2008). It reflects both quantitative and qualitative approaches to research and combines them into a single empirical analysis.

It has become quite popular in research because it provides a realistic description of the problem. With this method, a problematical system is transformed to a hierarchical system of elements. In each hierarchical level, pair-wise comparisons of the elements are made by using a nominal scale. These comparisons create a comparison matrix. To find the weight of each element, the eigenvector of this matrix is calculated. The consistency of the pair-wise comparisons is calculated by using a consistency ratio. If it is below a predefined level, the comparisons are either revised by the decision-maker or omitted from the calculations (Qureshi & Harrison, 2003).

2.8.1. AHP procedure

AHP method involves six essential steps (Saaty, 1977)

1. Define the unstructured problem
2. Develop the AHP hierarchy
3. Perform p air-wise comparison
4. Estimate the relative weights
5. Check the consistency

First Step: Define the unstructured problem, in this step the unstructured problem with its characters will be recognized and the objectives will be specified obviously.

Second Step: Breaking down the decision problem into a hierarchy of interconnected decision elements as shown in figure (2.3). This hierarchy consists of at least three levels, the decision problem's goal is at the highest, the second level includes the criteria affecting the decision, and the last level in this study comprises the sub criterions

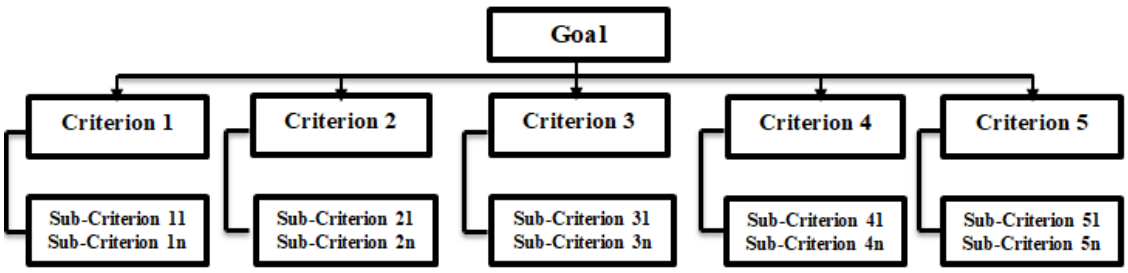

Figure (2.3): Three-level AHP Hierarchy

Third Step: Pair-wise comparison**;** after the hierarchy has been built, the decision maker initiates the prioritization procedure to determine the relative importance of the element in each level of the hierarchy. Elements in each level are pairwise compared with respect to their importance in making the decision under concern. The comparison takes this form: How important is element **1** when compared to **2** with respect to a specific element in the closely higher level? **(**Mustafa & Al-Bahar, 1991). As shown in Table (3.3), the comparisons depend on a scale ranging from 1 to 9 (Saaty's scale), correspond to the level of dominance or contribution to the project.

Table (2.6): Pairwise Comparison Scale (Alharthi et al., 2015)

Rating	Description
1—Equal	Both alternatives have **equal importance.**
3—Weakly	One of the alternatives is **weakly more important** than the other one.
5—Strong	One of the alternatives is **strongly more important** than the other one.
7—Very Strong	One of the alternatives is **very strongly important** compared to the other one.
9—Extreme Importance	One of the alternatives is **strictly superior** to the other one.

All of the associated elements in the same level are compared in pair-wise comparison matrices as follows:

$$A = \begin{bmatrix} 1 & \frac{w_1}{w_2} & \dots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & 1 & \dots & \frac{w_2}{w_n} \\ . & . & . & . \\ . & . & . & . \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & . & 1 \end{bmatrix}.$$

Where A = comparison pair-wise matrix,

w_1 = Weight of element

w_2= Weight of element

w_n= Weight of element n

The number of needed comparisons for (n) criteria is given by n*(n-1)/2

Fourth step: Calculating the relative weights

The priority weights of the factors represent the importance of these factors. Priority weights have two types: local priority weights and global priority weights. The local priority weights represent the relative weights of the factors within a group of factors with respect to their categories. The local priority weights are derived from each set of pairwise comparisons in each level. The global priority weights are obtained by multiplying the local priorities of the factors by the global priority of their corresponding categories. In this process, the importance of each local factor is balanced by the importance of the category to which it belongs.

The relative weights (W) of matrix A

$$A \times W = \lambda max \times W \dots\dots\dots\dots\dots\dots\dots\dots \textbf{Eq.2.1}$$

Where: λ_{max} = The largest eigenvalue of matrix A,

Fifth step: Checking the consistency

In this step, the consistency property of matrices is checked to confirm that the judgments of decision makers are consistent. For this test, consistency ratio (CR) is obtained from following equation:

$$CR=CI/RI \dots\dots\dots\dots\dots\dots\dots\dots \textbf{Eq.2.3}$$

Where:

CI: A random index of a randomly generated reciprocal matrix. It is calculated by:

$$CI = \frac{\lambda max - 1}{n-1} \text{ ……..Eq.2.4}$$

RI: A random number index. Table (2.7) shows its varied values.

Table (2.7): RI reference values

N	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

If CR < 0.1, then the pair comparisons are said to be consistent, otherwise, lack of inconsistency reasons should be examined, and logic is used to revise the comparisons until CR is acceptable.

Fortunately, there is no need to implement the fourth and fifth steps manually. Professional commercial software, Expert Choice, is available on the market which simplifies the application of AHP steps and automates many of its calculations (Al-Harbi, 2001).

2.8.2. AHP method justification

AHP has been broadly used to reflect the importance, or relative weights, of the factors associated with priorities. Many outstanding studies of the AHP have been conducted, including application of the AHP in different areas in construction management such as contractor selection (Jaskowski et al. 2009), risk assessment (Aminbakhsh et al., 2013 and Al Barqouni, 2015), project complexity (Alexandre et al., 2011), contractor prequalification as studied by (Al-Harbi, 1999), Safety risk assessment (Aminbakhsh et al., 2013) study as an example and many other fields.

The technique appears to achieve better than depending only on experts' assignation of the absolute priorities of each criteria or depending on qualitative analysis alone. Additionally, by using this technique, the level of importance of each attribute can be compared to the others. According to experts, making comparisons between criteria appears to be an easier way to adjust their importance (Alharthi et al., 2015).

Mulder (2011) stated that AHP is a certified multi criteria decision Analysis technique which has many advantages as it is flexible as there are different formats available, easy to use for the respondents due to the pairwise comparisons and the mathematics behind the analysis are theoretically acceptable and assumption free.

Chapter Three

Research methodology

Chapter three: Research methodology

This chapter discusses the methodology which was used in this research. The research methodology was chosen to fulfil the research aim and objectives which help to achieve this research study. This chapter included information about the research plan/strategy, data collection technique, questionnaires design and development, pilot study, final content of the questionnaire, and analytical methods of data.

3.1. Research Aim and Objectives

The aim of this research is to identify and model the main factors affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects during operation phase in developing countries especially in Gaza Strip.

In achieving this aim, four main objectives have been outlined which includes:

1. To identify and prioritize the main factors affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects in developing countries.
2. To identify and prioritize the sub factors categorizing each of main factor affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects in developing countries.
3. To develop a decision support model based on the Analytic Hierarchy Process (AHP) including the sustainability factors affecting water and waste treatment projects with their priorities.
4. To obtain the sustainability of four real projects based on the model.

3.2. Research plan/strategy

In order to investigate the research questions and achieve the whole goal of the study a quantitative and qualitative survey were adopted. The research techniques were chosen as questionnaires and unstructured interviews research to measure the objectives.

3.3. Research framework

The research design consists of seven main steps as shown in Figure (3.1). These steps are:

First: Problem definition

Firstly, the problem was defined, the objectives were identified and the research plan was developed.

Second: Literature review

A number of previous related studies were reviewed to have the overview of the state of the art research to collect needed data for this study. Group of factors were listed after this step.

Third: Pilot study conducting

A pilot study was conducted through consulting five experts in treatment projects; academic, operating plants' professionals to pre-test the factors and consequently modified. A final version of factors was produced.

Fourth: Pair wise comparison questionnaire development

After the pilot study was conducted and the final version of factors produced, pair wise questionnaire was developed and distributed to the target group. This questionnaire was used to make importance comparisons between each pair of criteria and sub criteria.

Fifth: Semi-structured interviews

After pair wise comparisons questionnaire distribution, semi-structured interviews were conducted to collect necessary data about local water and waste treatment projects. Four implemented treatment projects were suggested by the interviewees as case studies in the next step.

Sixth: **Sub criteria score questionnaire development**

Four operation managers of the previous suggested projects were interviewed and asked to score each of the sub criteria by how much did their project achieved them?

Seventh: Results and discussion

Data was collected by the pair wise comparison questionnaire were analysed using pairs comparison tools of Expert Choice software (2000) to obtain the relative weights of the criteria and sub criteria.

The results of the pair wise comparison analysis were inputted in a manual Excel model built by the researcher with the sub criteria scoring collected by sub criteria score questionnaire to obtain the sustainability index for each project.

Eighth: Conclusion and recommendations

This phase of the study includes the conclusions and recommendations.

Ninth: Documentation

The final phase of the study includes editing the final text, formatting and spelling and grammatical review.

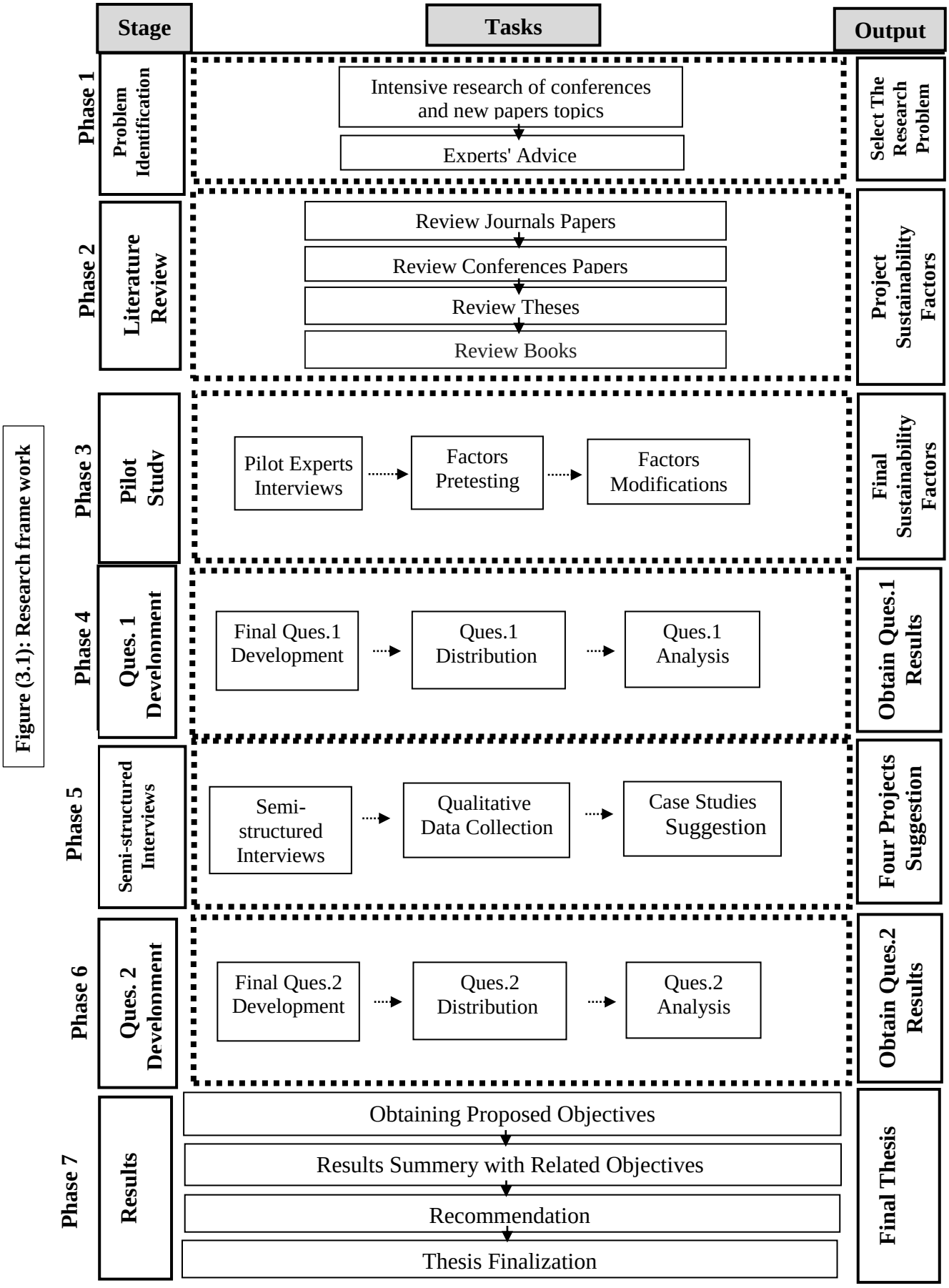

Figure (3.1): Research frame work

3.4. Research period

The study started in September 2017 after the proposal was approved. The literature review was completed at the end of February 2018. Piloting and questionnaires distribution and collection were completed at the beginning of May 2018. The analysis, discussion, conclusion and recommendations were completed in July 2018.

3.5. Research location

The research was carried out in Gaza Strip which consists of five governorates: the Northern, Gaza, the Middle, KhanYounis and Rafah governorate.

3.6. Sampling procedure

There is lack of agreement on how to identify stakeholder groups, and how to select samples or representatives from them in AHP analysis method (Qureshi & Harrison, 2003). Mulder (2011) mentioned that when the sample size increases, the results became more inconsistent. So that, a sample consists of ten experts (working in water desalination, waste water and solid waste treatment sector) were selected.

3.7. Research techniques/Data collection

In this research, the problem was divided into three levels, goal, criteria and sub-criteria. The elements of each level were identified through literature review and semi-structured interviews. Two questionnaires and semi-structured interviews were used to collect the necessary data.

3.7.1 Literature review

Literature review is performed to collect data. Parameters were found from literatures were mentioned in chapter 2. These parameters are divided into main five categories but a validation test questionnaire and pilot study is performed after that to validate and eliminate the sustainability factors and sub factors to cope with the present conditions in Gaza Strip.

3.7.2 Pilot study

By a pilot study, a trial run for the questionnaire can be done, which includes test for wording of the questions, identifying unclear questions, examination for the techniques that used to collect the data, measurement of the effectiveness of the standards invitations to respondents (Al Barqouni & Alhallaq,2015).

In this study, a pilot study was conducted in order to validate and eliminate the sustainability factors and sub factors to cope with present conditions in Gaza Strip before using them in the main study. It was conducted by inviting five professionals each with more than 10 years in water and waste treatment projects. The qualification level of those experts and their occupation is presented in table (A) in appendix I.

Minor modifications were made to the sustainability criteria and sub criteria. Some of them were repeated or deleted due to their effectiveness. Other factors are modified to suit Gaza Strip conditions. All modifications and final factors are shown in table (3.1) as follows:

Table (3.1): Selected and modified factors

Item	Projects sustainability factors	Action	Modified sub factors
TF	**Technical factor**	Selected factor	**Technical factor**
TF1	Staff knowledge and experience in water and waste management	Selected factor	**Local** staff knowledge and experience in water and waste management
TF2	Availability of communication between consultants provided by the external support agency and the local counterpart in the developing country	Not an important factor (deleted)	……
TF3	The existence of overall plans for water and waste management at the local and national levels	Modified and categorized under national /institutional factors	National/institutional capacity to implement overall plans for water and waste management
TF4	The existence of research and development activities related to water and waste projects	Categorized under national /institutional factors	Availability of research and development activities related to water and waste projects
TF5	Validity of treatment plants design and construction for treatment purposes	Selected factor	Validity of treatment plants design and construction for treatment purposes

Item	Projects sustainability factors	Action	Modified sub factors
TF6	Plants location suitability	Selected factor	Plants location suitability(e.g. Proximity to source of waste or water)
TF7	Availability of storage basins for treated solid and water for reuse when needed	Selected factor	Availability of storage **places** for treated solid and water for reuse when needed
TF8	Availability of monitoring equipment at the project	Selected factor	Availability of monitoring **plans and equipment** at the project
TF9	Levels of services required for protection of public health and environment	Selected factor	Taking public health and environmental guidelines into consideration during design and construction phases
TF10	Levels of decent attitude and experience of external consultants in working with officials of developing countries	Not an important one (deleted)	…….
TF9	Availability of industry manufacturing for solid waste equipment and spare parts and foreign exchange for importing such equipment/spare parts	Modified factor	The plant's equipment/spare parts can be locally manufactured or imported
TF10	Availability of sufficient infrastructure for treating, conveying and distributing waste for reuse	Categorized under national/institutional factors	Availability of sufficient infrastructure for treating, conveying and distributing waste for reuse
TF11	Availability of natural resources in the country	Selected factor	Availability of natural & **power** resources in the country

Item	Projects sustainability factors	Action	Modified sub factors
FF	**Financial Factor**	Selected factor	**Financial Factor**
FF1	Financial basis of local governments	Selected factor	Financial **capacity** of local governments
FF2	Degree of good financial management and planning	Selected factor	**Availability** of good financial management and planning
FF3	Sector priority for support from the donor	Selected factor	Financial policy of the Donor (willingness to continue the funding)
FF4	Existence of national /inter agency to complete the operation costs after the end of donor's fund	Added factor	Existence of national /inter agency to complete the operation costs after the end of donor's fund
FF5	User's ability and willingness to pay for the services related to water and waste management	Selected factor divided into two factors	User's ability to pay for the services related to water and waste management
			User's willingness to pay for the services related to water and waste management
FF6	O & m costs, e.g. For electricity, equipment maintenance of treatment systems	Selected factor	**Levels** of O & m costs, e.g. For electricity, equipment maintenance of treatment systems
PF	**Political Factor**	Selected factor	**Political Factor**
PF1	Existence of political commitment and supporting laws	Selected factor	Existence of political commitment and supporting laws
PF2	Government and political stability	Merged to one factor	Political instability (closure, wars, Governmental stability and confliction)
PF3	Closure		
PF4	Unstable security		

Item	Projects sustainability factors	Action	Modified sub factors
	circumstances (wars)		
PF5	Working at hot (dangerous) points	Selected factor	Working at hot (dangerous) points
IF	**Institutional Factor**	Modified factor	**National & Institutional Factor**
IF1	Coordination among the relevant agencies in the same country	Selected factor	Coordination among the relevant agencies in the same country (gabs and interferences)
IF2	Availability of legislation for water and waste management	Selected factor	
IF3	The priority given to these projects at the level of institutions	Selected factor	The Institutional/national priority given to these projects
IF4	Availability of motivation laws to encourage the involvement of private sector in these projects	Added factor	Availability of motivation laws to encourage the involvement of private sector in these projects
SCF	**Socioeconomic/cultural Factor**	Selected factor	**Socioeconomic/cultural Factor**
SCF1	Social norms, public culture, levels of public participation in waste management	Deleted(General factor consists of other factors)	……
SCF2	Awareness & acceptance of civil society on benefits of treatment and reuse	Selected factor	Acceptance of civil society on benefits of treatment and reuse
SCF3	Availability of industry to receive and process recycled material	Replaced by two factors	Private sector Awareness on the interest of waste recycling / Ability to

Item	Projects sustainability factors	Action	Modified sub factors
			Ability to persuade the private sector to invest in recycling sector
SCF4	Awareness & acceptance of the end users (e.g. industrial /agricultural users) to use treated water/solid	Selected factor	acceptance of the end users (e.g. industrial /agricultural users) to use treated water/solid
SCF5	Exchange rate fluctuation	Deleted	…….
SCF6	Export and import regulations	Selected factor	Export and import regulations

A final version of projects sustainability criteria and sub criteria modified after the pilot study are shown in table **(**3.2)**.**

Table (3.2): Final version of projects sustainability criteria and sub criteria 1

Main Factors	Sub Factors	Abb.
Technical Factors	Local staff knowledge and experience in water and waste management	SKE
	Validity of treatment plants design and construction for treatment purposes	VDC
	Plants location suitability(e.g. proximity to source of waste or water)	PLS
	Availability of storage places for treated solid and water for reuse when needed	ASP
	Availability of monitoring plans and equipment at the project	AM
	Taking public health and environmental guidelines into consideration during design and construction phases	HEG
	The plant's equipment/spare parts can be locally manufactured or imported	EMI
Financial Factors	Financial capacity of local governments	FCG
	Availability of good financial management and planning	AFM
	Financial policy of the Donor (willingness to continue the funding)	FPD
	Existence of national /inter agency to complete the operation costs after the end of donor's fund	ENA
	User's ability to pay for the services related to water and waste management	UAP
	User's willingness to pay for the services related to water and waste management	UWP
	Levels of O & m costs, e.g. For electricity, equipment maintenance of treatment systems	OMC
Political Factors	Existence of political commitment and supporting laws	EPC
	Political stability (closure ,wars, governmental stability and confliction)	PI
	Working at hot (dangerous) points	WD
National & Institutional Factors	Coordination among the relevant agencies in the same country (gabs and interferences)	GI
	Availability of legislation for water and waste management	AL
	Institutional/national priority given to these projects	INP
	National/institutional capacity to implement overall plans for water and waste management	CIP
	Availability of motivation laws to encourage the involvement of private sector in these projects	MLP

Main Factors	Sub Factors	Abb.
	Availability of research and development activities related to water and waste projects	ARD
	Availability of sufficient infrastructure for treating, conveying and distributing waste for reuse	ASI
	Availability of natural and power resources in the country	ANR
Socioeconomic/cultural Factors	Acceptance of civil society on benefits of treatment and reuse	AAC
	With private sector awareness on the interest of waste recycling	PSA
	Ability to Persuade the private sector to invest in recycling sector	APP
	Acceptance of the end users (e.g. industrial /agricultural users) to use treated water/solid	AAE
	Export and import regulations	EIR

3.7.3 . Pair wise questionnaire design

The questionnaire is a main mean that is used for data collection for conducting surveys. It is widely used for descriptive and analytical surveys to find out facts and opinions. It enhances confidentiality; facilitate analysis and supports validity (Al Barqouni & Alhallaq, 2015).

The final version of the sustainability criteria and sub criteria was inputted for pair wise comparison questionnaire design in order to obtain the local and global priorities of the criteria and sub criteria affecting the sustainability of water and waste treatment projects.

Pair wise comparison consists of three parts as follow:

Part one: Personal information of respondent who is filling the questionnaire.

Part two: Projects sustainability criteria comparison, this part concerns about pair wise comparison between the projects sustainability criteria.

Part three: Projects sustainability sub criteria comparisons, this part concerns about pair wise comparisons between the projects sustainability sub criteria.

Pair wise comparison questionnaire with its final form was distributed to ten experts. They were carefully interviewed in order to make pair-wise comparisons among criteria and sub criteria using Saaty's scale as discussed in chapter 2. The comparison took this form: How important is element **1** when compared to **2** with respect to a specific element in the immediately higher level.

3.7.4 . Semi-structured interviews

After the pair wise comparison questionnaire had been distributed, unstructured interviews with four experts, with qualifications as shown in table (B) in appendix I, were conducted as open questions. The aim of the interviews was to collect data about treatment plants on Gaza Strip, operation situation, funding institutions, operating institutions, plants problems and other important data. These interviews suggested four treatment plants with different donors, location, treatment type (water or solid) and operation situation to be taken as case studies in this research. For this application, Sub criteria scoring questionnaire was built.

3.7.5 Sub criteria score questionnaire design

Sub criteria score questionnaire was developed to ask about how much the four projects achieve the sustainability sub criteria in order to obtain the sustainability index for four implemented projects using the results of the first questionnaire analyses.

This questionnaire consists of two parts as follows:

Part One: Name and location of the plants. Other information about the plants was collected at the interviews as shown in table (3.4).

Part Two: Sub criteria scoring**,** this part consists of a table to score sustainability sub criteria based upon the question form: how much do your project achieve this sub criteria?

A sub criterion scoring varies from 5 to 1 as shown in the table (3.3).

Table (3.3): Sub criteria score

Score	Description
5	Very strongly achieved /has high positive effects
1	Very strongly not achieved / has high negative effects
2,3,4	Intermediate values between the two adjacent judgments

Both questionnaires were discussed with the supervisors and amended according to their advices and attached in Appendix II and Appendix III

3.8. Questionnaires analysis methods

3.8.1. AHP as a research analysis method in the pair comparison questionnaire

In this research, AHP analysis method was proposed to implement pair wise comparison analysis as discussed in chapter 2. Expert Choice software package (2000) based on the principle of AHP has been used to obtain relative weights of the five sustainability criteria (technical, financial, political, national/institutional and socioeconomic/cultural) and their sub-criteria, and to test for inconsistency between preferences within individual stakeholder groups. The hierarchy used for this study is shown in figure (3.2).

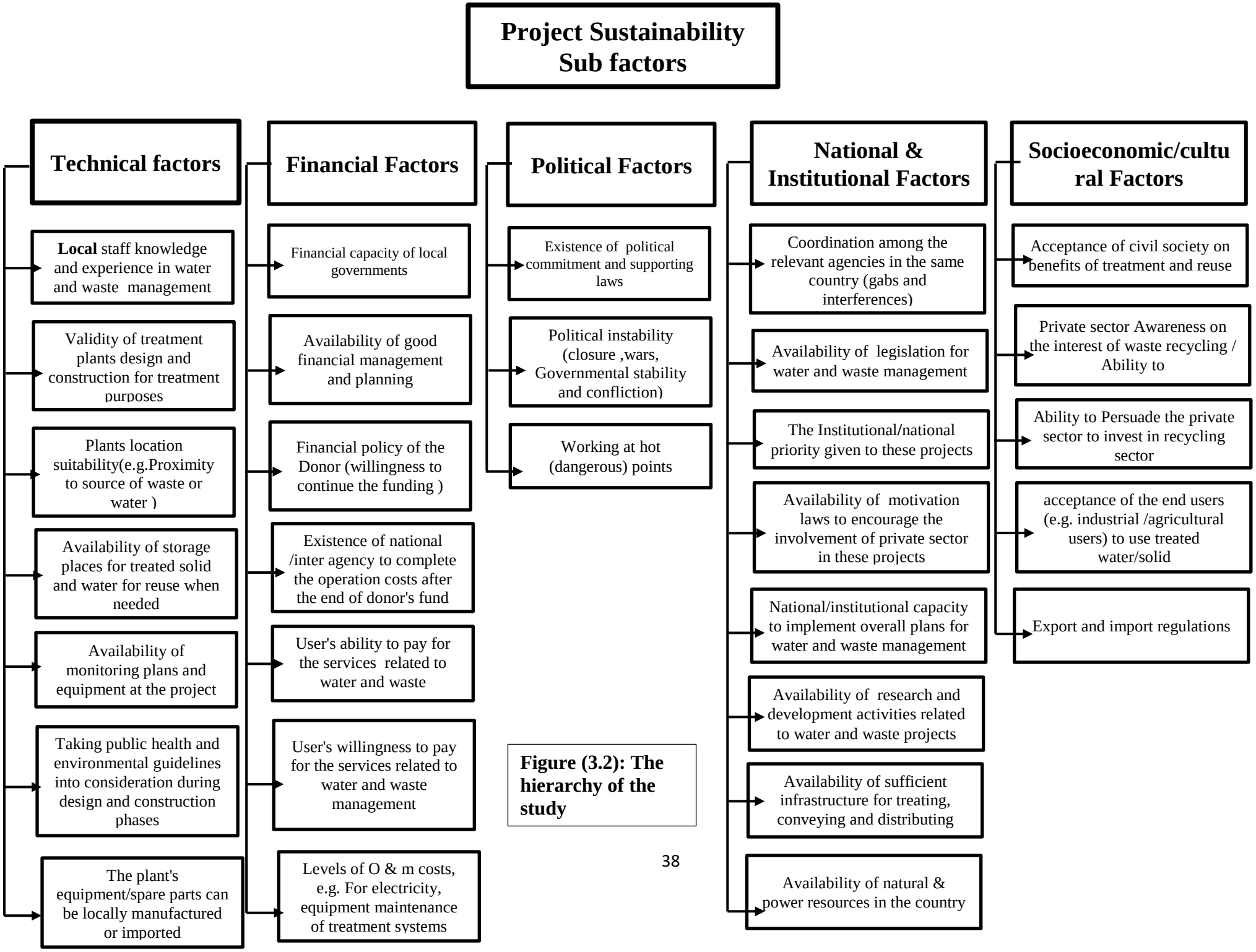

Figure (3.2): The hierarchy of the study

3.8.2. Excel built model for the Sub criteria score questionnaire analysis

Collected data by the sub criteria score questionnaire with the results of pair comparison of sub-criteria were inputted to a simple excel equation built by the researcher to calculate the sustainability index of the four case studied projects. This equation is as follows:

Project sustainability index = $\sum(SS \times GP)$ ……..**Eq.3.1**

Where:

SS: sub-criteria score, it varies from 5 to 1 as shown in table (3.3)

GP: global priority for each sub-criteria resulted from Expert Choice analysis.

3.9. Application of Project sustainability factors on a case study

As a final step of this research, the results of AHP analysis were applied to four real projects as case studies. The researcher chose four treatment projects through the interviews. The main three criteria that were considered during projects selection were donors, type of treatment and operation levels differences. Table (3.4) summarizes those projects with small description about each one.

Table (3.4): Four projects description

Project No.	Project Name	Plant Location	Donor	Description
Project A	Shiekh Ajleen WWTP(Waste water treatment plant)	Shiekh Ajleen (Gaza City)	KFW	Established in 1979 upgraded in 1996 to increase its capacity to 12,000 m3/d, upgraded again in 1998 to reach a treatment capacity of 35,000 m3/d, currently overloaded, under rehabilitation & Expansion through an Emergency Project to reach a design capacity of 50,000 m3/d
Project B	NGEST(North Gaza Emergency Sewage Treatment	Jabalia(Eastern area)	AFD & World Bank for construction, JV(TME Italy &MACC Palestine) for operation	The only waste water full treatment project in Gaza Strip and the biggest in Palestine. It is constructed in 2010 and operated in March 2018.
Project C	Sea water desalination plant for Middle Area	Deir albalah-Albasa Area	IDB	The plant was operated to treat 2600 m3/day sea water and turning it into drinkable water to serve 30,000 inhabitants of the Middle area residence (Deir Al Balah &Al Zawaida cities). Currently, this plant is under expansion to reach 6000m3/day by

Project No.	Project Name	Plant Location	Donor	Description
				USAID fund
Project D	PEF-waste separation and composting unit	Deir Al Balah	UNDP	Palestinian Environmental Friends Association waste separation and composting unit. It's work was stopped completely

3.10. Sensitivity analysis

The consequences of the variation of the weight of a criterion can be investigated by sensitivity analysis. With this analysis, it is possible to measure the strength of the solution and determine the criteria that have more significance on the final result and it is accomplished with an interactive graphical interface, where the input data are slightly modified in order to perceive the impact on the results. If the ranking does not change, the results are said to be strong (Al Barqouni & Alhallaq, 2015).

In this research, the sensitivity analysis is carried out to investigate the sensitivity of the sustainability indexes results of the mentioned four projects to changes in the priority of the high weight criterion. This will be explained in details in Chapter 4.

3.11. Summary

Table (3.5) summarizes the method chart which was used in this study.

Table (3.5): The method chart

Methodology Purpose Outcome	Methodology Purpose Outcome	Methodology Purpose Outcome
Proposal	❖ Identify the problem ❖ Define the problem ❖ Establish aim, objectives and key research questions ❖ Develop research plan/strategy (outline methodology) • Deciding on the research approach • Deciding on the research technique	• Research problem Fail/ stop of many water desalination, waste water and solid waste treatment projects during operation phase in Gaza strip. • Research aim To identify and model the main affecting factors on the sustainability of water desalination, waste water and solid waste treatment internationally funded projects during operation phase in developing countries especially in Gaza Strip using the analytic hierarchy process (AHP) application. • Research Objectives ✓ To identify and prioritize the group of main factors affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects in developing countries. ✓ To identify and prioritize the sub factors categorizing under each of main factor affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects in developing countries. ✓ To develop a decision support model based on the Analytic Hierarchy Process (AHP) including the sustainability factors affecting water and waste treatment projects with their priorities. ✓ To obtain the sustainability index by which the sustainability criteria were achieved for four real projects. • Research plan/strategy The research approaches were quantitative and qualitative to measure objectives. The research techniques were questionnaires and unstructured interviews.
Literature Review	Collecting existing knowledge on the subject, reading and	• The following factors have been compiled and summarized from the previous studies: 5 main factors affecting projects sustainability and 33 sub factors which categorized under

Methodology Purpose Outcome	Methodology Purpose Outcome	Methodology Purpose Outcome
	note-taking from different sources such as: • Refereed academic research journals • Refereed conferences • Dissertations/theses • Reports/occasional papers/ white papers • Government publications • Books	the main factors. ✓ They factors were reviewed in chapter (2) in table (2.4), (2.5).Some of those items have been modified; other items have been merged; or have been deleted through the process of questionnaires development as well as some items have been added.
Questionnaires development and semi-structured interviews	❖ Questionnaires have been widely used for descriptive and analytical surveys in order to find out facts, opinions and views on what is happening, who, where, how many or how much. (Two questionnaires were used) ❖ Semi-structured interviews were conducted to get necessary data about the field of study	❖ Que. 1: Pair wise questionnaire ✓ It aimed to to obtain the local and global priorities of the criteria and sub criteria affecting the sustainability of water desalination, waste water and solid waste treatment projects. ✓ It consists of three parts: **Part one**: Personal information of respondent who is filling the questionnaire. **Part two:** Projects sustainability criteria comparison, this part concerns about pair wise comparison between the projects sustainability criteria. **Part three**: Projects sustainability sub criteria comparisons, this part concerns about pair wise comparisons between the projects sustainability sub criteria. ✓ The final form of this questionnaire was distributed to ten experts. They were carefully interviewed in order to make pair-wise comparisons among criteria and sub criteria using Saaty's scale. ❖ Semi-structured interviews

Methodology Purpose Outcome	Methodology Purpose Outcome	Methodology Purpose Outcome
		✓ Unstructured interviews with four experts were conducted as open questions to collect data about treatment plants on Gaza Strip, operation situation, funding institutions, operating institutions, plants problems and other important data. ❖ Que. 2: Sub criteria score questionnaire ✓ It was designed to to ask about how much the four projects (which are suggested during the unstructured interviews) achieve the sustainability sub criteria in order to obtain the sustainability index for four implemented projects using the results of the que.1 analyses. ✓ It consists of two parts: **Part One**: Name and location of the plants. **Part Two:** Sub criteria scoring**,** this part consists of a table to score sustainability sub criteria based upon the question form: how much do your project achieve this sub criteria?
Analysis and Presentation of the Results	❖ Analyse the results of the collected data to determine the direction of the study ❖ Choose the analysis instrument ❖ Present the results	❖ Analysis instrument ✓ Expert choice software (2000) for que.1 analysis. ✓ Microsoft Excel for que.2 analysis. ❖ The quantitative measures/analysis for que.1 1. Local and global priorities for criteria and sub criteria (results can be presented in the form of tabulation or a bar chart). 2. Inconsistency determination. ❖ The quantitative measures/analysis for que.2 1. Project sustainability index.

Chapter Four

Results and discussion

Chapter four: Results and discussion

This chapter includes analysis and discussion of the results that have been obtained from field surveys using two questionnaires. Data in pair wise comparison questionnaire was analysed using expert choice software(2000) as mentioned in chapter 3 while using Microsoft Excel in sub criteria scoring questionnaire analysis.

4.1 Pair wise comparison results

The pair wise comparison questionnaire consists of three parts, simple manual calculations was used for part 1 analysis while expert choice software was used for part 2 and 3 analysis as explained in chapter 3.

4.1.1 Personal information of respondents analysis: (part 1 of the questionnaire)

Table (4.1) designates that 70% male and 30% females who are filling the first questionnaire. Their qualifications varied between master and doctoral degrees with 60% and 40% respectively. The majority (50%) of the respondents was civil engineers with different qualification degree and the rest varied as 30% environmental, 10% electrical and 10 % were mechanical engineers. Most of the respondents had more than 10 years' experience and only 20% of them had less experience.

Respondents for this study had a good practical and scientific experience in water and waste treatment projects and could thus provide reliable answers to the questionnaires.

Table (4.1): Personal general information analysis

Personal general information	Categories	Frequency	Percentage %
Gender	Male	7	70
	Female	3	30
	Total	**10**	**100**
Qualification Level	Bachelor	0	0
	Master	6	60
	Doctoral	4	40
	Total	**10**	**100**
Specialization	Environmental	3	30
	Civil	5	50
	Electrical	1	10

Personal general information	Categories	Frequency	Percentage %
	Mechanical	1	10
	Total	**10**	**100**
Work Experience	Less than 10 years	2	20
	10 to less than 15 years	4	40
	More than 20 years	4	40
	Total	**10**	**100**

4.1.2 Pair wise comparisons results (part 2 and 3)

4.1.2.1 Criteria (groups) comparisons results

Table (4.2) and figure (4.1) show the global priority weights of each criterion resulted from the pair comparisons. It is seen that political factor (global priority weight = 0.325) is found to be the most important in the second hierarchy level than the other ones whereas financial factor comes later (global priority weight =0.267) whereas technical has 0.222 global priority weights while NIP and SCF rank the lowest among these criteria as they both have 0.186.

Table (4.2): Global priority for criteria

Criteria	Global priority	Rank
Technical Factor (TF)	0.222	3
Financial Factor (FF)	0.267	2
Political Factor (PF)	0.325	1
National & Institutional Factor(NIP)	0.091	5
Socioeconomic/cultural Factor (SCF)	0.095	4

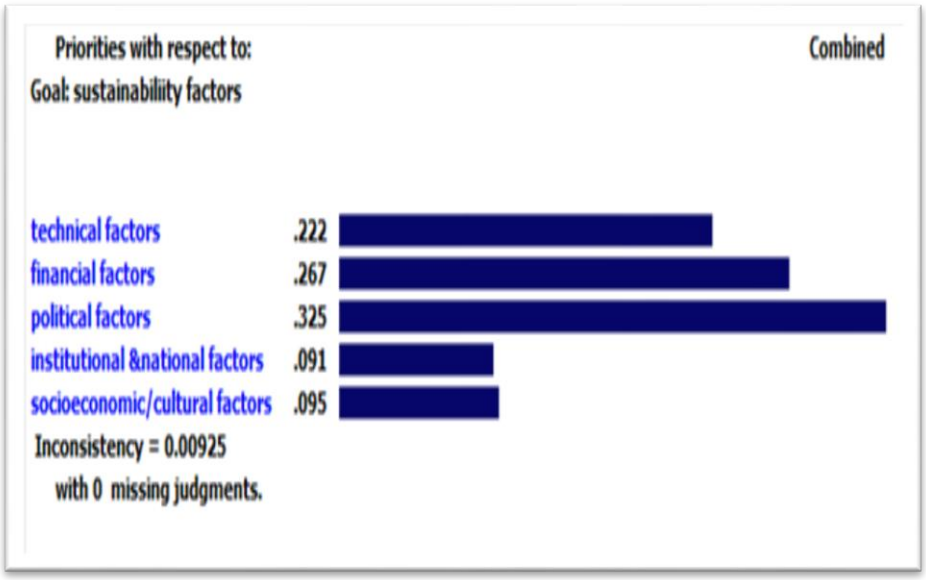

Figure (4.1): Global priority weights for criteria

4.1.2.2 Sub-criteria Comparisons Results

Pair comparisons at the third level of the hierarchy were used to determine the relative of each sub-criterion with respect to its corresponding criterion and the goal (local and global priority respectively) as shown in table (4.3) and figure (4.2).

Table (4.3): Relative weights for sub- criteria

Groups	Sub factors	Local priority	Global priority	Rank
Technical	SKE	0.116	0.026	14
	VDC	0.162	0.036	10
	PLS	0.106	0.023	17
	ASP	0.077	0.017	19
	AM	0.173	0.038	8
	HEG	0.165	0.037	9
	EMI	0.201	0.045	5
Financial	FCG	0.088	0.024	16
	AFM	0.176	0.047	4
	FPD	0.177	0.031	11
	ENA	0.156	0.042	7
	UAP	0.104	0.028	13
	UWP	0.111	0.030	12
	OMC	0.247	0.066	3
Political	EPC	0.136	0.044	6
	PI	0.577	0.188	1
	WD	0.287	0.093	2
National & institutional	GI	0.074	0.007	27
	AL	0.105	0.010	26
	INP	0.133	0.012	25
	CIP	0.141	0.013	23
	MLP	0.075	0.007	27

Groups	Sub factors	Local priority	Global priority	Rank
	ARD	0.059	0.005	29
	ASI	0.255	0.023	17
	ANR	0.157	0.014	22
socioeconomic/cultural	AAC	0.153	0.015	21
	PSA	0.141	0.013	23
	APP	0.180	0.017	19
	AAE	0.269	0.026	14
	EIR	0.257	0.025	15

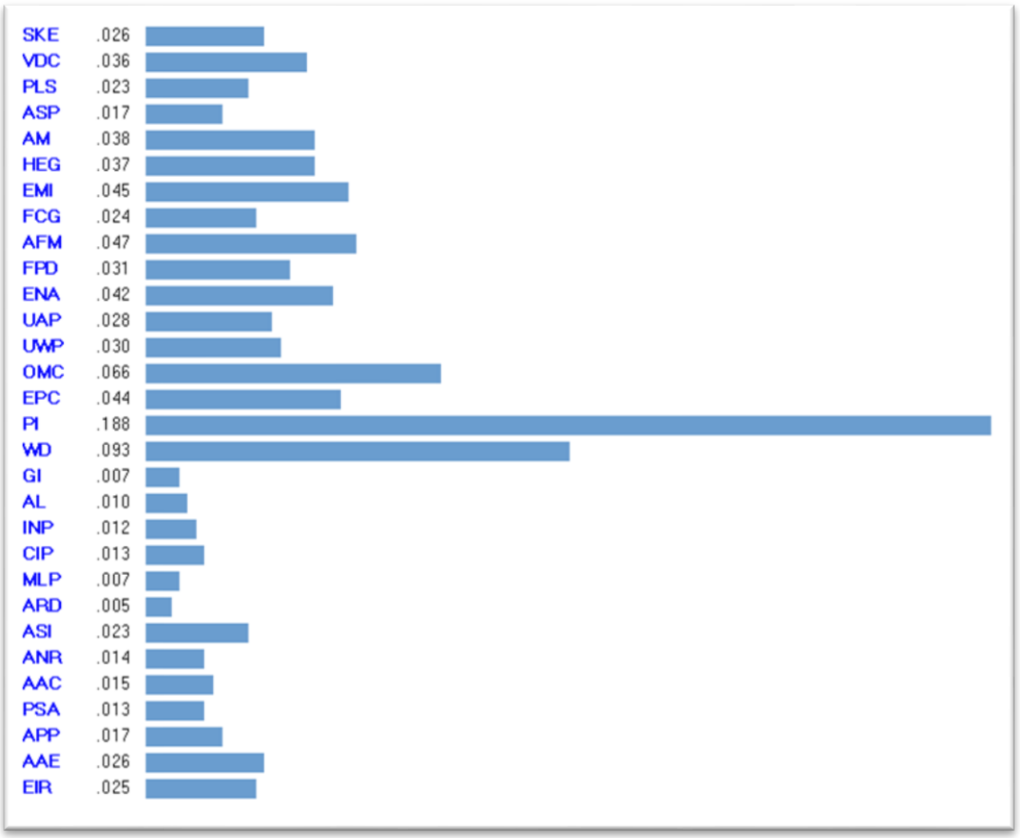

Figure (4.2): Global Priority weights for sub-criteria

Table(4.3) and figure(4.2) show that the top five factors related to the sustainability of water and waste treatment projects are as follows: political stability (PI)(global priority weight =0.188) in the political category, working at hot (dangerous) points (WD)(global priority weight = 0.093)also in the political category, levels of O & m costs (OMC)(global priority weight = 0.066) and availability of good financial management and planning (AFM)(global priority weight = 0.047) in the financial category and the plant's equipment/spare parts can be locally manufactured or imported (EMI) (global priority weight = .047) in the technical category.

The aforementioned results in the table 4.2 and 4.3 fully match the experts' statements during the semi-structured interviews. The expert's statements mentioned that:

Expert A: Stated that, "Despite the availability of financial support and qualified technical staff, but it was not possible to start the operation of the plant only after the political approval and commitment of the government."
Expert B: Stated that "The political situation in the Gaza Strip is the most important reason to bring donor institutions to support these projects."
Expert C: Stated that "The financial and political situations are the most important factors in the operation of these projects. Solutions can be developed for any shortage of other factors, such as technical like, development and training of a professional staff or provide the equipment and spare parts in advance."

Conclusions of three local reports also agree with the above results, these conclusions are summarized as:
Isaac & Rishmawi (2015) concluded that, "The treatment inadequacies had been attributed to lack of proper operation and maintenance; unreliable electric supply, and difficulties in the availability of spare parts as result of the Israeli closer on the Gaza Strip." This means that political situation is the dominant factor which has large effects on all other factors like technical and national/institutional factors.

AR.CMWU (2016) commented that, "The main and major obstacles in waste management development is the closure forced on the Gaza commercial borders which prevents importing the required spare parts to operate and continue the works. Gaza strip is suffering from terrible shortages and unreliability of electricity power supply which has severely and adversely affected the whole pumping and treatment systems of water and wastewater services in addition to the high operation and maintenance costs."

CRSWM (2014) highlighted that, the political situation in the West and Gaza Strip has been the main cause of poor waste management. With reference to this report, there have been two attempts for composting in municipal waste in Gaza Strip and both failed and stopped operating. These are:

- ✓ The first plant was in Deir Al Balah and due to the limited compost market and unavailable private sector, the plant was stopped.

- ✓ The second plant was built by the end of 2011 in Rafah. A NGO (Palestinian Environmental Friends Association) was running the plant, and the rest of the operations were fully subsidized by UNDP from December 2012 till June 2013. As soon as UNDP funding stopped, the plant operating stopped. The NGO could not sell the compost to the farmers so operational costs of the facility are not available.

4.1.3 Consistency results

It is clear from the figure (4.1) that the inconsistency index for the whole pairs comparison is 0.00925and it is less than 0.10, so all the judgments of the respondents are consistent as mentioned in chapter 3.

4.2 Sub criteria score analysis

As mentioned in chapter 3, the results of the pair wise comparison questionnaire analysis were used in a built excel model for analysing the other questionnaire data for four projects. Tables below show the sustainability index of the four cases study projects.

- ✓ **Project A: WWTP-Gaza**

Table (4.4): Sustainability index for project A

Sub factors	Global priority	Importance Score	Score percentage	Sustainability index
SKE	0.026	4	0.8	0.0208
VDC	0.036	4	0.8	0.0288
PLS	0.023	4	0.8	0.0184
ASP	0.017	3	0.6	0.0102
AM	0.038	3	0.6	0.0228
HEG	0.037	3	0.6	0.0222
EMI	0.045	2	0.4	0.018
FCG	0.024	2	0.4	0.0096
AFM	0.047	3	0.6	0.0282
FPD	0.031	4	0.8	0.0248
ENA	0.042	2	0.4	0.0168
UAP	0.028	2	0.4	0.0112
UWP	0.030	2	0.4	0.012
OMC	0.066	3	0.6	0.0396
EPC	0.044	3	0.6	0.0264
PI	0.188	2	0.4	0.0752

WD	0.093	1	0.2	0.0186
GI	0.007	2	0.4	0.0028
AL	0.010	3	0.6	0.006
INP	0.012	3	0.6	0.0072
CIP	0.013	5	1	0.013
MLP	0.007	3	0.6	0.0042
ARD	0.005	4	0.8	0.004
ASI	0.023	2	0.4	0.0092
ANR	0.014	1	0.2	0.0028
AAC	0.015	2	0.4	0.006
PSA	0.013	2	0.4	0.0052
APP	0.017	2	0.4	0.0068
AAE	0.026	2	0.4	0.0104
EIR	0.025	2	0.4	0.01
Project Sustainability index				**0.4912**

The results above indicate that the project A achieves 49.12% from the sustainability standards (according to the definition of sustainability in chapter 2). From the unstructured interview with the operation manager of this plant, he expected that the operation degree of the plant is approximately 40 % only (the percentage is for treatment process not for designed quantity). The main reasons for this low percentage were unavailability of spare parts for the equipment and cannot be imported due to the closure and high operation and maintenance costs as the manager's statement.

- ✓ **Project B: NGEST**

Table (4.5): Sustainability index of project B

Sub factors	Global priority	Importance Score	Score percentage	Sustainability index
SKE	0.026	5	1	0.026
VDC	0.036	5	1	0.036
PLS	0.023	1	0.2	0.0046
ASP	0.017	3	0.6	0.0102
AM	0.038	4	0.8	0.0304
HEG	0.037	1	0.2	0.0074
EMI	0.045	5	1	0.045
FCG	0.024	5	1	0.024
AFM	0.047	3	0.6	0.0282
FPD	0.031	3	0.6	0.0186
ENA	0.042	5	1	0.042
UAP	0.028	3	0.6	0.0168
UWP	0.030	2	0.4	0.012
OMC	0.066	4	0.8	0.0528
EPC	0.044	5	1	0.044
PI	0.188	1	0.2	0.0376

Sub factors	Global priority	Importance Score	Score percentage	Sustainability index
WD	0.093	1	0.2	0.0186
GI	0.007	1	0.2	0.0014
AL	0.010	1	0.2	0.002
INP	0.012	4	0.8	0.0096
CIP	0.013	2	0.4	0.0052
MLP	0.007	4	0.8	0.0056
ARD	0.005	1	0.2	0.001
ASI	0.023	4	0.8	0.0184
ANR	0.014	5	1	0.014
AAC	0.015	1	0.2	0.003
PSA	0.013	2	0.4	0.0052
APP	0.017	1	0.2	0.0034
AAE	0.026	5	1	0.026
EIR	0.025	5	1	0.025
Project Sustainability index				**0.574**

The results above indicate that the project B achieves 57.4% from the sustainability standards. From the unstructured interview with the operative manager of this plant, he expected that the operation percentage of the plant is approximately 66 % only (the percentage is for designed quantity not for treatment process (100% for treated output)) and he added that this operation percentage is due to new start working in this plant (before 3 months from the interview).

- ✓ **Project C: PEF-Waste Separation and composting**

Table (4.6): Sustainability index of Project C

Sub factors	Global priority	Importance Score	Score percentage	Sustainability index
SKE	0.026	5	1	0.026
VDC	0.036	4	0.8	0.0288
PLS	0.023	4	0.8	0.0184
ASP	0.017	5	1	0.017
AM	0.038	4	0.8	0.0304
HEG	0.037	4	0.8	0.0296
EMI	0.045	2	0.4	0.018
FCG	0.024	1	0.2	0.0048
AFM	0.047	3	0.6	0.0282
FPD	0.031	2	0.4	0.0124
ENA	0.042	2	0.4	0.0168
UAP	0.028	2	0.4	0.0112
UWP	0.030	1	0.2	0.06
OMC	0.066	2	0.4	0.0264
EPC	0.044	1	0.2	0.0088
PI	0.188	1	0.2	0.0376

Sub factors	Global priority	Importance Score	Score percentage	Sustainability index
WD	0.093	2	0.4	0.0372
GI	0.007	2	0.4	0.0028
AL	0.010	1	0.2	0.002
INP	0.012	2	0.4	0.0048
CIP	0.013	2	0.4	0.0052
MLP	0.007	1	0.2	0.0014
ARD	0.005	3	0.6	0.003
ASI	0.023	1	0.2	0.0046
ANR	0.014	1	0.2	0.0028
AAC	0.015	4	0.8	0.012
PSA	0.013	3	0.6	0.0078
APP	0.017	2	0.4	0.0068
AAE	0.026	2	0.4	0.0104
EIR	0.025	2	0.4	0.01
Project Sustainability index				**0.4312**

The results above indicate that the project **C** achieved 43.12% from the sustainability standards (according to the definition of sustainability in chapter 2). This project failed and stopped its work due to a group of factors. One of these factors was unavailability of spare parts for the equipment and cannot be imported due to the closure.

- ✓ **Project D: Sea water desalination plant for The Middle Area**

Table (4.7): Sustainability index of project D

Sub factors	Global priority	Importance Score	Score percentage	Sustainability index
SKE	0.026	4	0.8	0.0208
VDC	0.036	5	1	0.036
PLS	0.023	1	0.2	0.0046
ASP	0.017	1	0.2	0.0034
AM	0.038	1	0.2	0.0076
HEG	0.037	4	0.8	0.0296
EMI	0.045	4	0.8	0.036
FCG	0.024	4	0.8	0.0192
AFM	0.047	3	0.6	0.0282
FPD	0.031	5	1	0.031
ENA	0.042	5	1	0.042
UAP	0.028	4	0.8	0.0224
UWP	0.030	2	0.4	0.12
OMC	0.066	4	0.8	0.0528
EPC	0.044	1	0.2	0.0088
PI	0.188	1	0.2	0.0376
WD	0.093	1	0.2	0.0186

Sub factors	Global priority	Importance Score	Score percentage	Sustainability index
GI	0.007	5	1	0.007
AL	0.010	4	0.8	0.008
INP	0.012	5	1	0.012
CIP	0.013	4	0.8	0.0104
MLP	0.007	4	0.8	0.0056
ARD	0.005	3	0.6	0.003
ASI	0.023	5	1	0.023
ANR	0.014	1	0.2	0.0028
AAC	0.015	4	0.8	0.012
PSA	0.013	4	0.8	0.0104
APP	0.017	3	0.6	0.0102
AAE	0.026	5	1	0.026
EIR	0.025	1	0.2	0.005
Project Sustainability index				**0.546**

The results above indicate that the project D achieves 54.6% from the sustainability standards. From the unstructured interview with the operative manager of this plant, he expected that the operation percentage of the plant is very low (only 300m^3/d is treated from 2600m^3/d designed quantity). The main reason for this low percentage is the highly shortage in power resources (electricity) as the manager stated.

4.3 Sensitivity analysis

When performing a sensitivity analysis, it is likely to vary the priorities of the criteria and observe how the results would change.

For political criterion, the weight of this criterion may change positively or negatively in the future. By decreasing the political priority (PP) to 0.20,all of the other criteria priorities will be changed as follows:

$$PC_f = PC_i + \frac{PCi}{1-PPi} \times (PP_i - PP_f)$$

Where:

PC_f= Final criteria priority

PC_i= Initial criteria priority

PP_f= Final political priority

PP_i= Initial political priority

The results for decreasing PP to 0.20 and increasing it to 0.5 are shown in figure (4.3)

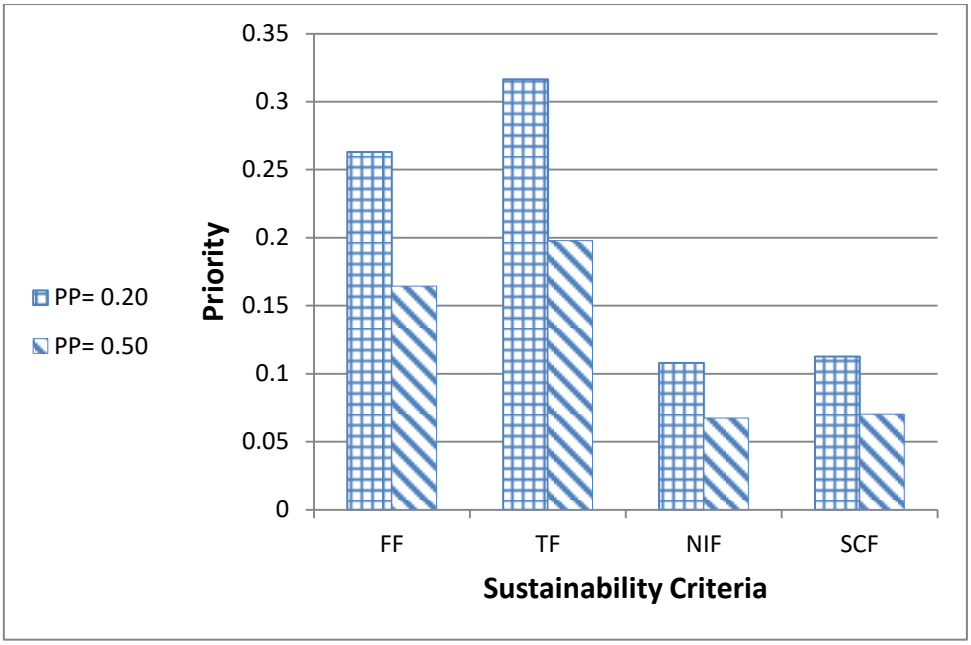

Figure (4.3): Criteria priority as a function of PP

By applying the previous results on the projects sustainability indexes calculation, the outcome indicated an inverse relationship between project sustainability indexes and political priority for all the projects except project B, The same indication appeared when increasing it by 0.50 as shown in figure (4.4).

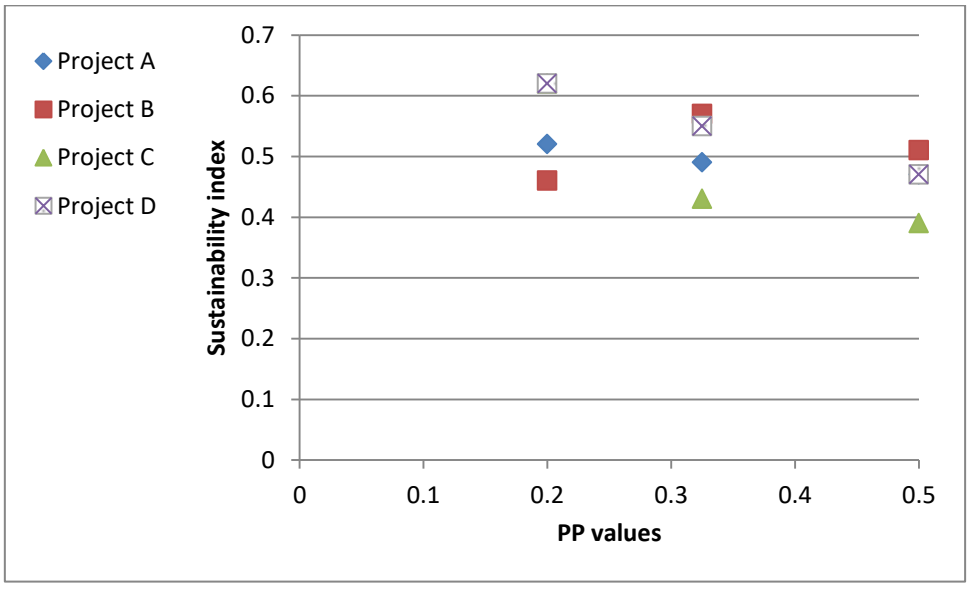

Figure (4.4): Project sustainability index as a function of PP

Figure (4.3) shows that the sustainability index of project B is directly proportional to the priority of political criteria. This result was expected because of the significant

support and great positive effect of this criteria on the operation of this project, whether from the Israeli or Palestinian side as the operating manager stated.

Chapter Five

Conclusions and recommendations

Chapter five: Conclusions and recommendations

This chapter introduces the whole work that was carried out through conclusion and recommendations for the water and waste treatment projects sustainability in Gaza Strip. This chapter clarifies where research objectives are met over the final findings of this study, study limitations in addition to some recommendations for future researches as results of findings are suggested.

5.1 Conclusions of the research aim and objectives

In achieving the aim of the research, four main objectives have been outlined and achieved through the findings. The outcomes were found as follows:

5.1.1 Outcomes related to objective one

1. ***The objective was:*** "To identify and prioritize the main factors affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects in developing countries".

- ***The first research question:*** What are the main and top factors affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects during the operation phase in Gaza Strip?

✓ This objective is achieved during the literature and previous study reviews as well as during inclusive piloting, in addition to semi-structured interviews that conducted through the study phases. Findings show that, five main factors are efficient enough to be the main criteria of the sustainability of the water and waste treatment internationally funded projects which are political, financial, technical, national/institutional and socio/economic and cultural.

✓ For main factors periodization, it is achieved through analysing pair wise comparison questionnaire by Expert choice package (2000) and the results shows that the political criteria has the highest priority to be considered in projects sustainability followed by the financial one.

5.1.2 Outcomes related to objective two

- ***The objective was:*** "To identify and prioritize the sub factors categorizing each of main factor affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects in developing countries".
- ***The second research question:*** What are the main and top sub factors affecting the sustainability of internationally funded water desalination, waste water and solid waste treatment projects during the operation phase in Gaza Strip?

✓ This objective is also achieved during the literature and previous studies reviews as well as during inclusive piloting, in addition to semi-structured interviews that conducted through the study phases. Findings show that, seven sub factors are categorized under technical factors, seven are categorized under financial factors, three are categorized under political factors, eight are categorized under national/institutional factors and five are categorized under socio/economic and cultural factors which are efficient enough to be the sub-criteria of the sustainability of the water and waste treatment internationally funded projects.

✓ According to sub criteria prioritization, the most important five are political stability (PI), working at hot (dangerous) (WD), levels of O& M costs (OMC), availability of good financial management and planning (AFM) and the plant's equipment/spare parts can be locally manufactured or imported (EMI) sub criteria.

5.1.3 Outcomes related to objective three

The objective was: "To develop a decision support model based on the Analytic Hierarchy Process (AHP) including the sustainability factors water desalination, waste water and solid waste treatment projects with their priorities".

- This objective is achieved through building a preliminary model including the criteria and sub criteria affecting the projects sustainability with their priorities

which are obtained from analysing pair wise comparison data by Expert Choice package software as mentioned in chapter 4.

5.1.4 Outcomes related to objective five

2. ***The objective was:*** "To obtain the sustainability index for four real projects based on the model".

- ***The fourth research question:*** What is the sustainability index for each project?

✓ This objective is achieved through applying the results of the pair wise comparison questionnaire with the collected sub criteria scoring collected data by the second one on a simple built equation. The results computed the sustainability index for the four given projects.

5.2 General conclusions

✓ Political situation, in general, is the most affecting factor on projects sustainability in Gaza strip as the closure and governmental instability affecting all other factors. As examples, EMI categorized under TF and EIR categorized under SCF, which are much related to the political situation in the country.

✓ It is not surprising that participants consider political factor to be more important than financial and technical because political barriers have a high impacts and more difficult to solve than other issues especially in Gaza strip situation with closure and governmental instability.

✓ It is likely that the technical factors are lower ranked than political and financial factors because if the political and financial issues are not effective, then technical issues (staff, equipment and others) would have no significant use.

✓ When the sustainability consideration is achieved during project management phases, a positive impact will appear in the operating situation of the project during its life period.

5.3 Limitations of the study

Although the research was carefully prepared and has achieved its aim, there were some inevitable limitations.

- Because of the geographical limit, this research was conducted only on Gaza strip in Palestine. It was difficult to think about a sample in West bank. Also, because of the time limit, it was difficult to think about using e-mail for sending and receiving questionnaires. It would help more to generalize the findings.
- Due to time limitation, this research is concerned with waste and water treatment projects only and that other categories of construction industry like heavy engineering construction (tunnels, bridges, dams, etc.) and industrial projects (factories and workshops) were not taking into account. Also, the results were applied only on four projects, another list of projects would help more to generalize the results
- Lack of studies related to treatment projects sustainability in Palestine and the surrounding region had limited somehow the discussion of the findings.

5.4 Recommendations for future studies

- When using AHP as an analytical method, it is recommended to choose a focus group or convenient statistic sample to be the respondent target group, as it needs high qualified experienced persons to fill the pair wise comparison questionnaire.

- Researchers are invited to do in depth investigation of key sustainability factors for other construction industry projects.

- The same study can be conducted using Fuzzy/AHP analysis method to provide more accurate results.

- It is strongly recommended that, researchers in the same field should take into consideration the different policy of each donor which may affect the final results.

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Appendix I

Experts' Qualifications

Table (A): Qualifications of pilot study experts

Name	Qualification	Occupation	Years of experience
Expert 1	Ph.D. in Water and Environmental Engineering	lecturing at the Faculty of Engineering and senior engineer at Consulting Firm	More than 20 years
Expert 2	Ph.D. in Environmental Engineering	Associate Professor in Environmental Engineering Department and Water-wastewater and environmental engineering Consultant	More than 20 years
Expert 3	Msc. In MBA	Head of international relations department	10 years
Expert 4	Msc. in civil engineering	Sanitation department's manager	10 years
Expert 5	Msc. in civil engineering	Office manager of a consulting firm	More than 10 years

Table (B): Qualifications of interviewees

Name	Qualification	Occupation	Years of experience
Expert 1	Ph.D. in Water and Environmental Engineering	Manager in water authority	More than 10 years
Expert 2	Ph.D. in Environmental Engineering	Manager of Waste water department in a ministry	More than 10 years
Expert 3	Msc. in civil Engineering	Treatment plant's manager	10 years

Appendix II

Questionnaire #1

Questionnaire name: pair wise comparison questionnaire

Research aim: the aim of this research is to identify and model the main affecting factors on the sustainability of water and waste treatment internationally funded projects during operation phase in developing countries especially in Gaza Strip.

This questionnaire consists of three parts;
Part 1: Personal information of respondent who is filling the questionnaire.
Part 2: Projects sustainability criteria comparison, this part concerns about pair wise comparison between the projects sustainability criteria.
Part 3: Projects sustainability sub criteria comparisons, this part concerns about pair wise comparisons between the projects sustainability sub criteria.

Part 1: General information

General information about the person who is filling this questionnaire. Please fill the right answer with (✓).

Gender			
Male		Female	

Qualification Level					
Bachelor degree		Master degree		Doctoral degree	

Specialization							
Civil		Environmental		Mechanical		Electrical	

Experience in contracting field					
Less than 10 years		10 to less than15 years		20 years and more	

Part 2 : Criteria comparison

Q_1. How important is technical factors (**TF**) when it is compared with financial factors (**FF**)?

Q_2. How important is technical factors (**TF**) when it is compared with political factors (**PF**)?

Q_3. How important is technical factors (**TF**) when it is compared with national & institutional factor (**NIF**)?

Q_4. How important is technical factors (**TF**) when it is compared with socioeconomic/cultural factor (**SCF**)?

Q_5. How important is financial factors (**FF**) when it is compared with political factors (**PF**)?

Q_6. How important is financial factors (**FF**) when it is compared with national & institutional factor (**NIF**)?

Q_7. How important is financial factors (**FF**) when it is compared with socioeconomic/cultural factor (**SCF**)?

Q_8. How important is political factors (**PF**) when it is compared with national & institutional factor (**NIF**)?

Q_9. How important is political factors (**PF**) when it is compared with socioeconomic/cultural factor (**SCF**)?

Q_{10}. How important is national & institutional factors (**NIF**) when it is compared with socioeconomic/cultural factor (**SCF**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_1	TF										FF
Q_2	TF										PF
Q_3	TF										NIF
Q_4	TF										SCF
Q_5	FF										PF
Q_6	FF										NIF
Q_7	FF										SCF
Q_8	PF										NIF
Q_9	PF										SCF

Q_{10}	NIF										SCF

Part 3: Sub criteria comparison

At the beginning, select what is the more important factor than the other, and then select the level of importance through its numbering by ticking the grade

1. Compare between each pair of the technical factors

Q_{11}. How important is local staff knowledge and experience in water and waste management (**SKE**) when it is compared with validity of treatment plants design and construction for treatment purposes (**VDC**)?

Q_{12}. How important is local staff knowledge and experience in water and waste management (**SKE**) when it is compared with plants location suitability (e.g. proximity to source of waste or water) (**PLS**)?

Q_{13}. How important is local staff knowledge and experience in water and waste management (**SKE**) when it is compared with availability of storage places for treated solid and water for reuse when needed (**ASP**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{11}	SKE										VDC
Q_{12}	SKE										PLS
Q_{13}	SKE										ASP
Q_{14}	SKE										AM
Q_{15}	SKE										HEG
Q_{16}	SKE										EMI

Q_{17}. How important is validity of treatment plants design and construction for treatment purposes (**VDC**) when it is compared with plants location suitability (e.g. proximity to source of waste or water) (**PLS**)?

Q_{18}. How important is validity of treatment plants design and construction for treatment purposes(**VDC**) when it is compared with availability of storage places for treated solid and water for reuse when needed(**ASP**)?

Q_{19}. How important is validity of treatment plants design and construction for treatment purposes(**VDC**) when it is compared with availability of monitoring plans and equipment at the project(**AM**)?

Q_{20}. How important is validity of treatment plants design and construction for treatment purposes(**VDC**) when it is compared with taking public health and environmental guidelines into consideration during design and construction phases(**HEG**)?

Q_{21}. How important is validity of treatment plants design and construction for treatment purposes(**VDC**) when it is compared with the plant's equipment/spare parts can be locally manufactured or imported (**EMI**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{17}	VDC										PLS
Q_{18}	VDC										ASP
Q_{19}	VDC										AM
Q_{20}	VDC										HEG
Q_{21}	VDC										EMI

Q_{22}. How important is plants location suitability(e.g. Proximity to source of waste or water)(**PLS**) when it is compared with availability of storage places for treated solid and water for reuse when needed(**ASP**)?

Q_{23}. How important is plants location suitability(e.g. Proximity to source of waste or water)(**PLS**) when it is compared with availability of monitoring plans and equipment at the project(**AM**)?

Q_{24}. How important is plants location suitability(e.g. Proximity to source of waste or water)(**PLS)** when it is compared with taking public health and environmental guidelines into consideration during design and construction phases(**HEG**)?

Q_{25}. How important is plants location suitability(e.g. proximity to source of waste or water) (**PLS**) when it is compared with the plant's equipment/spare parts can be locally manufactured or imported(**EMI**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{22}	PLS										ASP
Q_{23}	PLS										AM
Q_{24}	PLS										HEG
Q_{25}	PLS										EMI

Q_{26}. How important is availability of storage places for treated solid and water for reuse when needed (**ASP**) when it is compared with availability of monitoring plans and equipment at the project(**AM**)?

Q_{27}. How important is availability of storage places for treated solid and water for reuse when needed (**ASP**) when it is compared with taking public health and environmental guidelines into consideration during design and construction phases(**HEG**)?

Q_{28}. How important is availability of storage places for treated solid and water for reuse when needed (**ASP**) when it is compared with the plant's equipment/spare parts can be locally manufactured or imported (**EMI**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{26}	ASP										AM
Q_{27}	ASP										HEG
Q_{28}	ASP										EMI

Q_{29}. How important is availability of monitoring plans and equipment at the project (**AM**) when it is compared with taking public health and environmental guidelines into consideration during design and construction phases(**HEG**)?

Q_{30}. How important is availability of monitoring plans and equipment at the project(**AM**) when it is compared with the plant's equipment/spare parts can be locally manufactured or imported (**EMI**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{29}	AM										HEG
Q_{30}	AM										EMI

Q_{31}. How important is taking public health and environmental guidelines into consideration during design and construction phases(**HEG**) when it is compared with the plant's equipment/spare parts can be locally manufactured or imported (**EMI**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{31}	HEG										EMI

2. Compare between each pair of the financial factors(Q_{32}-Q_{52})

Q_{32}. How important is financial capacity of local governments(**FCG**) when it is compared with availability of good financial management and planning(**AFM**)?

Q_{33}. How important is financial capacity of local governments(**FCG**) when it is compared with financial policy of the Donor (willingness to continue the funding)(**FPD**)?

Q_{34}. How important is financial capacity of local governments(**FCG**) when it is compared with existence of national /inter agency to complete the operation costs after the end of donor's fund (**ENA**)?

Q_{35}. How important is financial capacity of local governments(**FCG**) when it is compared with user's ability to pay for the services related to water and waste management(**UAP**)?

Q_{36}. How important is financial capacity of local governments when(**FCG**) it is compared with user's willingness to pay for the services related to water and waste management(**UWP**)?

Q_{37}. How importance is financial capacity of local governments(**FCG**) when it is compared with levels of O & m costs, e.g. For electricity, equipment maintenance of treatment systems(**OMC**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{32}	FCG										AFM
Q_{33}	FCG										FPD
Q_{34}	FCG										ENA
Q_{35}	FCG										UAP
Q_{36}	FCG										UWP
Q_{37}	FCG										OMC

Q_{38}. How important is availability of good financial management and planning(**AFM**) when it is compared with financial policy of the donor (willingness to continue the funding)(**FPD**)?

Q_{39}. How important is availability of good financial management and planning (**AFM**) when it is compared with existence of national /inter agency to complete the operation costs after the end of donor's fund(**ENA**)?

Q_{40}. How important is availability of good financial management and planning (**AFM**) when it is compared with user's ability to pay for the services related to water and waste management(**UAP**)?

Q_{41}. How important is availability of good financial management and planning (**AFM**) when it is compared with user's willingness to pay for the services related to water and waste management(**UWP**)?

Q_{42}. How important is availability of good financial management and planning (**AFM**) when it is compared with levels of O & m costs, e.g. For electricity, equipment maintenance of treatment systems(**OMC**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{38}	AFM										FPD

Q_{39}	AFM										ENA
Q_{40}	AFM										UAP
Q_{41}	AFM										UWP
Q_{42}	AFM										OMC

Q_{43}. How important is financial policy of the donor (willingness to continue the funding)(**FPD**) when it is compared with existence of national /inter agency to complete the operation costs after the end of donor's fund?

Q_{44}. How important is financial policy of the donor (willingness to continue the funding)(**FPD**) when it is compared with user's ability to pay for the services related to water and waste management(**UAP**)?

Q_{45}. How important is financial policy of the donor (willingness to continue the funding)(**FPD)** when it is compared with user's willingness to pay for the services related to water and waste management(**UWP**)?

Q_{46}. How important is financial policy of the donor (willingness to continue the funding)(**FPD**) when it is compared with levels of O & m costs, e.g. For electricity, equipment maintenance of treatment systems(**OMC**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{43}	FPD										ENA
Q_{44}	FPD										UAP
Q_{45}	FPD										UWP
Q_{46}	FPD										OMC

Q_{47}. How important is existence of national /inter agency to complete the operation costs after the end of donor's fund(**ENA**)when it is compared with user's ability to pay for the services related to water and waste management(**UAP**)?

Q_{48}. How important is existence of national /inter agency to complete the operation costs after the end of donor's fund(**ENA**) when it is compared with levels of O & m costs, e.g. for electricity, equipment maintenance of treatment systems(**UWP**)?

Q_{49}. How important is existence of national /inter agency to complete the operation costs after the end of donor's fund(**ENA**) when it is compared with user's willingness to pay for the services related to water and waste management(**OMC**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{47}	ENA										UAP
Q_{48}	ENA										UWP
Q_{49}	ENA										OMC

Q_{50}. How important is user's ability to pay for the services related to water and waste management(**UAP**) when it is compared with user's willingness to pay for the services related to water and waste management(**UWP**)?

Q_{51}. How important is user's ability to pay for the services related to water and waste management(**UAP**) when it is compared with levels of O & m costs, e.g. for electricity, equipment maintenance of treatment systems(**OMC**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{50}	UAP										UWP
Q_{51}	UAP										OMC

Q_{52}. How important is user's willingness to pay for the services related to water and waste management(**UWP**) when it is compared with levels of O & m costs, e.g. for electricity, equipment maintenance of treatment systems(**OMC**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{52}	UWP										OMC

3. Compare between each pair of the political factors(Q_{53}-Q_{55})

Q_{53}. How important is existence of political commitment and supporting laws(**EPC**) when it is compared with political instability (closure ,wars, governmental stability and confliction) (**PI**)?

Q_{54}. How important is existence of political commitment and supporting laws when it is compared with working at hot (dangerous) points(**WD**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{53}	EPC										PI
Q_{54}	EPC										WD

Q_{55}. How important is political stability (closure ,wars, governmental stability and confliction) (**PI**) when it is compared with Working at hot (dangerous) points(**WD**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{55}	PI										WD

4. Compare between each pair of the national/institutional factors(Q_{56}-Q_{83})

Q_{56}. How important is coordination among the relevant agencies in the same country (gabs and interferences)(**GI**) when it is compared with availability of legislation for water and waste management(**AL**)?

Q_{57}. How important is coordination among the relevant agencies in the same country (gabs and interferences)(**GI**) when it is compared with the Institutional/national priority given to these projects(**INP**)?

Q_{58}. How important is coordination among the relevant agencies in the same country (gabs and interferences)(**GI**) when it is compared with national/institutional capacity to implement overall plans for water and waste management (**CIP**)?

Q_{59}. How important is coordination among the relevant agencies in the same country (gabs and interferences)(**GI**) when it is compared with availability of motivation laws to encourage the involvement of private sector in these projects(**MLP**)?

Q_{60}. How important is coordination among the relevant agencies in the same country (gabs and interferences)(**GI**) when it is compared with availability of research and development activities related to water and waste projects(**ARD**)?

Q_{61}. How important is coordination among the relevant agencies in the same country (gabs and interferences)(**GI**) when it is compared with availability of sufficient infrastructure for treating, conveying and distributing waste for reuse(**ASI**)?

Q_{62}. How important is coordination among the relevant agencies in the same country (gabs and interferences)(**GI**) when it is compared with availability of natural and power resources in the country(**ANR**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{56}	GI										AL
Q_{57}	GI										INP
Q_{58}	GI										CIP
Q_{59}	GI										MLP
Q_{60}	GI										ARD
Q_{61}	GI										ASI
Q_{62}	GI										ANR

Q_{63}. How important is availability of legislation for water and waste management(**AL**) when it is compared with the institutional/national priority given to these projects(**INP**)?

Q_{64}. How important is availability of legislation for water and waste management(**AL**) when it is compared with national/institutional capacity to implement overall plans for water and waste management(**CIP**)?

Q_{65}. How important is availability of legislation for water and waste management (**AL**) when it is compared with availability of motivation laws to encourage the involvement of private sector in these projects?

Q_{66}. How important is availability of legislation for water and waste management (**AL**) when it is compared with availability of research and development activities related to water and waste projects?

Q_{67}. How important is availability of legislation for water and waste management (**AL**) when it is compared with availability of sufficient infrastructure for treating, conveying and distributing waste for reuse

6_{58}. How important is availability of legislation for water and waste management (**AL**) when it is compared with availability of natural resources in the country

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{63}	AL										INP
Q_{64}	AL										CIP
Q_{65}	AL										MLP
Q_{66}	AL										ARD
Q_{67}	AL										ASI
Q_{68}	AL										ANR

Q_{69}. How important is the institutional/national priority given to these projects (**INP**) when it is compared with national/institutional capacity to implement overall plans for water and waste management(**CIP)**?
Q_{70}. How important is the institutional/national priority given to these projects (**INP**) when it is compared with availability of motivation laws to encourage the involvement of private sector in these projects(**MLP**)?
Q_{71}. How important is the institutional/national priority given to these projects (**INP**) when it is compared with availability of research and development activities related to water and waste projects(**ARD**)?
Q_{72}. How important is the Institutional/national priority given to these projects (**INP**) when it is compared with availability of research and development activities related to water and waste projects?
Q_{73}. How important is the institutional/national priority given to these projects (**INP**) when it is compared with availability of natural resources in the country?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{69}	INP										CIP
Q_{70}	INP										MLP
Q_{71}	INP										ARD
Q_{72}	INP										ASI
Q_{73}	INP										ANR

Q_{74}. How important is availability of motivation laws to encourage the involvement of private sector in these projects**(MLP)** when it is compared with national/institutional capacity to implement overall plans for water and waste management(**CIP)**?
Q_{75}. How important is availability of motivation laws to encourage the involvement of private sector in these projects**(MLP)** when it is compared with availability of research and development activities related to water and waste projects(**ARD**)?

Q_{76}. How important is availability of motivation laws to encourage the involvement of private sector in these projects**(MLP)** when it is compared with availability of sufficient infrastructure for treating, conveying and distributing waste for reuse (**ASI**)?
Q_{77}. How important is availability of motivation laws to encourage the involvement of private sector in these projects**(MLP)** when it is compared with availability of natural resources in the country(**ANR**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{74}	MLP										CIP
Q_{75}	MLP										ARD
Q_{76}	MLP										ASI
Q_{77}	MLP										ANR

Q_{78}. How important is national/institutional capacity to implement overall plans for water and waste management(**CIP)** when it is compared with availability of research and development activities related to water and waste projects(**ARD**)?
Q_{79}. How important is national/institutional capacity to implement overall plans for water and waste management(**CIP)** when it is compared with availability of sufficient infrastructure for treating, conveying and distributing waste for reuse **(ASI**)?
Q_{80}. How important is national/institutional capacity to implement overall plans for water and waste management(**CIP)** when it is compared with availability of natural resources in the country(**ANR**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{78}	CIP										ARD
Q_{79}	CIP										ASI
Q_{80}	CIP										ANR

Q_{81}. How important is availability of research and development activities related to water and waste projects(**ARD**) when it is compared with availability of sufficient infrastructure for treating, conveying and distributing waste for reuse**(ASI**)?
Q_{82}. How important is availability of research and development activities related to water and waste projects(**ARD**) when it is compared with availability of natural resources in the country(**ANR**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{81}	ARD										ASI
Q_{82}	ARD										ANR

Q_{83}. How important is availability of sufficient infrastructure for treating, conveying and distributing waste for reuse**(ASI**) when it is compared with availability of natural resources in the country(**ANR**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{83}	ASI										ANR

5. Compare between each pair of the Socioeconomic/cultural factors(Q_{84}-Q_{93})

Q_{84}. How important is awareness & acceptance of civil society on benefits of treatment and reuse(**AAC**) when it is compared with private sector Awareness on the interest of waste recycling (**PSA**)?

Q_{85}. How important is awareness & acceptance of civil society on benefits of treatment and reuse(**AAC**) when it is compared with Ability to persuade the private sector to invest in recycling sector(**APP**)?

Q_{86}. How important is awareness & acceptance of civil society on benefits of treatment and reuse(**AAC**) when it is compared with awareness & acceptance of the end users (e.g. industrial /agricultural users) to use treated water/solid(**AAE**)?

Q_{87}. How important is awareness & acceptance of civil society on benefits of treatment and reuse(**AAC**) when it is compared with export and import regulations(**EIR**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{84}	AAC										PSA
Q_{85}	AAC										APP
Q_{86}	AAC										AAE
Q_{87}	AAC										EIR

Q_{88}. How important is private sector awareness on the interest of waste recycling (**PSA**) when it is compared with ability to Persuade the private sector to invest in recycling sector(**APP**)?

Q_{89}. How important is private sector Awareness on the interest of waste recycling (**PSA**) when it is compared with awareness & acceptance of the end users (e.g. industrial /agricultural users) to use treated water/solid(**AAE**)?

Q_{90}. How important is private sector awareness on the interest of waste recycling (**PSA**) when it is compared with export and import regulations(**EIR**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{88}	PSA										APP
Q_{89}	PSA										AAE
Q_{90}	PSA										EIR

Q_{91}. How important is ability to persuade the private sector to invest in recycling sector(**APP**) when it is compared with awareness & acceptance of the end users (e.g. industrial /agricultural users) to use treated water/solid(**AAE**)?

Q_{92}. How important is ability to persuade the private sector to invest in recycling sector(**APP**) when it is compared with export and import regulations(**EIR**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{91}	APP										AAE
Q_{92}	APP										EIR

Q_{93}. How important is awareness & acceptance of the end users (e.g. industrial /agricultural users) to use treated water/solid(**AAE**) when it is compared with export and import regulations(**EIR**)?

Question	Alternative	Absolutely More Important	Very Strongly More Important	Strongly More Important	Weakly More Important	**Just Equal**	Weakly More Important	Strongly More Important	Very Strongly More Important	Absolutely More Important	Alternative
Q_{93}	AAE										EIR

Appendix III

Questionnaire #2

Questionnaire Name: Sub-criteria scoring

Part 1: General information	
Plant location:	
Plant Name:	
Operating percentage of the plant	

Part 2: Sub criteria scoring

Score each of the sub criteria by which it is achieved in your project:
5= Very strongly achieved /has a high positive effect, 3= Moderately achieved , 1= Very strongly not achieved /has a high negative effect, (2, 4) Intermediate values between adjacent scale values)

Technical sub criteria	**5**	**4**	**3**	**2**	**1**
Local staff knowledge and experience in water and waste management					
Validity of treatment plants design and construction for treatment purposes					
Plants location suitability(e.g. Proximity to source of waste or water)					
Availability of storage places for treated solid and water for reuse when needed					
Availability of monitoring plans and equipment at the project					
Taking public health and environmental guidelines into consideration during design and construction phases					
The plant's equipment/spare parts can be locally manufactured or imported					
National/institutional sub criteria					
Financial capacity of local governments					
Availability of good financial management and planning					
Financial policy of the Donor (willingness to continue the funding)					
Existence of national /inter agency to complete the operation costs after the end of donor's fund					
User's ability to pay for the services related to water and waste management					
User's willingness to pay for the services related to water and waste management					
Levels of O & m costs, e.g. For electricity, equipment maintenance of treatment systems					
Political sub criteria					
Existence of political commitment and supporting laws					
Political stability (closure ,wars, Governmental stability and confliction)					
Working at hot (dangerous) points					

National/institutional sub criteria					
Coordination among the relevant agencies in the same country (gabs and interferences)					
Availability of legislation for water and waste management					
Institutional/national priority given to these projects					
National/institutional capacity to implement overall plans for water and waste management					
Availability of motivation laws to encourage the involvement of private sector in these projects					
Availability of research and development activities related to water and waste projects					
Availability of sufficient infrastructure for treating, conveying and distributing waste for reuse					
Availability of natural and power resources in the country					
Socioeconomic/cultural sub criteria					
Acceptance of civil society on benefits of treatment and reuse					
Private sector Awareness on the interest of waste recycling					
Ability to Persuade the private sector to invest in recycling sector					
Acceptance of the end users (e.g. Industrial /agricultural users) to use treated water/solid					
Export and import regulations					