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RISK-INFORMED STRATEGIC PLANNING APPROACH FOR INFRASTRUCTURE: Water Sector Case Study in Gaza City

طريقة مطورة لاعتبار المخاطر في التخطيط الاستراتيجي للبنية التحتية: حالة دراسية لقطاع المياه في مدينه غزة

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بسم الله الرحمن الرحيم

" أفمن أسس بنيانه على تقوى من الله ورضوان خير أم من أسس بنيانه على شفا جرف هار فانهار به في نار جهنم والله لا يهدي القوم الظالمين"

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ABSTRACT

The under-taken research work includes the development of a risk-informed strategic planning approach for infrastructure sectors that is suitable for use in developing countries such as Palestine. The approach consists of five phases i.e., *Phase 1*: Preparation for Planning; *Phase 2*: Information Diagnosis; *Phase 3*: Strategic Choice; *Phase 4*: Implementation; *Phase 5*: Monitoring. This developed approach overcomes the limitations of other worldwide-recognized approaches to strategic planning when applied to developing countries. The approach numerically accounts for special conditions that exist in developing countries, especially in Palestine such as the high level of uncertainties and risks, political influence, external factors, etc. the approach also includes sensitivity, forecast and economic analyses, a decision making methodology and a monitoring process.

The practical use of the developed approach has been demonstrated through its implementation to the real life of Gaza City water sector case study. The first priority for investment within infrastructure sector in Palestine is water and wastewater including storm water. A number of plans for solving the problem of water in Palestine have been proposed and partially implemented in various areas including Gaza City. However, the problem of water still exists. In the developed approach an analytical hierarchy process has been used to prioritize three strategic planning alternatives against nine criteria envisaged suitable for Gaza water sector. The approach has successfully identified a strategic alternative that comprises of three components that address water, wastewater, and storm water development and management.

ملخص البحث

هذا البحث يقدم اقتراحا لطريقة مطورة للتخطيط الاستراتيجي لقطاع البنية التحتية تعتمد بالأساس على إدراج تأثير المخاطر في التخطيط وتشتمل على العديد من الخطوات التي تؤدي إلى حل المشاكل المتعلقة بقطاعات البنية التحتية المختلفة في البلدان النامية مثل فلسطين و التي تتميز بحضور كبير للوضع السياسي والاقتصادي الغير مستقر . وتشتمل الطريقة على خمس خطوات مهمة هي: التجهيز للتخطيط، جمع وتحليل المعلومات، اختيار الحلول الاستراتيجية، التطبيق و المتابعة مع تقييم التخطيط. ولقد تم الوصول إلى هذه الطريقة المطورة بعد مراجعة واسعة لتلك الطرق المستخدمة في العالم ومعرفة محاسنها وعيوبها والاستعانة بما ينفع منها للحالات الشبيهة بالوضع الفلسطيني وكذلك علاج العيوب التي يمكن أن تشكل عائقا يؤثر على نتائج التخطيط السليم.

أما بالنسبة للاستخدام العملي لهذه الطريقة فقد تم تطبيقه بنجاح على قطاع المياه في مدينة غزة. و يشكل هذا القطاع واحدا من أهم القطاعات في البنية التحتية في فلسطين وفي المدينة.ولقد تم في السابق اقتراح العديد من الخطط الاستراتيجية لحل المشكلات المتعلقة بهذا القطاع الهام وتم فعلا تطبيق بعض الأجزاء من هذه الخطط ولكن مع الأسف فان المشكلة لا زالت قائمة. لذا فان جزءا مهما من هذا البحث يشتمل على الخطوات التي تم تطبيقها والحلول التي تم تبنيها نتيجة استخدام الطريقة المطورة في مدينة غزة وكذلك يشتمل البحث على خطة استراتيجية لحل مشكلة المياه في مدينة غزة حتى عام ٢٠٢٥ والتي تشتمل على حلول منطقية لكل من مشكلة المياه، الصرف الصحي وتصريف الأمطار.

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TABLE OF CONTENTS

APPROVAL ……... ……ii
ABSTRACT …….…….iii
ACKNOWLEDGMENT ..……..……. v
TABLE OF CONTENTS…..……vi
LIST OF TABLES ……....x
LIST OF FIGURES …….... xii
LIST OF ABBREVIATIONS. …….....xiii
CHAPTER ONE:
INTRODUCTION 1

1.0 Introduction 1
1.1Research Problem 1
1.2 Research Objectives 2
1.3 Area of Implementation 2
1.4 Report Organization 3
CHAPTER TWO:
REVIEW OF STRATEGIC PLANNING APPROACHES 4

2.0 Introduction 4
2.1 Worldwide Recognized Approaches to Strategic Planning 4
2.1.1 Foundational Planning Approach 5
2.1.2 Goals-driven Planning Approach 6
2.1.3 Objective Oriented Planning Approach 6
2.1.4 Critical Issues Approach. 7
2.1.5 Scenario Analysis Approach 8
2.1.6 Result- based Accountability Approach. 8
2.1.7 Concluded Remarks 8
2.2 Other Approaches to Strategic Planning 9
2.3 Decision Making Process for Strategic Planning 14
2.4 Strategic Planning in Palestine 18
2.5 Components of Strategic Planning (Summary) 19

2.6 Conclusion..... 20

CHAPTER THREE:
DEVELOPED STRATEGIC PLANNING APPROACH FOR INFRASTRUCTURE IN PALESTINE 22

3.0 Introduction..... 22
3.1 Elements of the Developed Approach..... 22
3.2 Phase 1: Preparation for Planning..... 25
3.3 Phase 2: Information Diagnosis..... 26
3.3.1 Phase 2: Step 1: Analysis of Existing Conditions..... 27
3.3.1.1. Phase 2: Step 1: Activity 1: SWOT Analysis……..28
3.3.1.2. Phase 2:Step1: Activity 2: Interface with Other Systems..... 31
3.3.2 Phase 2: Step 2: Development of Operational System Model..... 31
3.3.3 Phase 2: Step 3: Establishment of functional objectives..... 31
3.3.4 Phase 2: Step 4: Analyze System Economics..... 32
3.3.4.1. Phase 2: Step 4: Activity 1: Sensitivity Analysis..... 33
3.3.4.2. Phase 2: Step 4: Activity 2: Risk Analysis..... 36
3.3.4.3. Phase 2: Step 4:Activity 3: Yearly Forecasts..... 37
3.3.5 Phase 2: Step 5: Development of Economical Model..... 38
3.4 Phase 3: Strategic Choice..... 41
3.4.1 Phase 3: Step1: Examination of future services and project scenarios 41
3.4.1.1. Phase 3: Step1: Activity 1: Development of alternative design response..... 43
3.4.1.2 .Phase 3: Step 1: Activity 2: Development of alternative operating response..... 44
3.4.2 Phase 3: Step 2: Screening and Evaluation..... 44
3.4.3 Phase 3: Step 3: Selection from strategic alternatives..... 47
3.5 Phase 4: Implementation..... 47
3.6 Phase 5: Monitoring..... 48
3.7 Conclusion..... 49

CHAPTER FOUR:

IMPLEMENTATION OF THE DEVELOPED APPROACH FOR WATER SECTOR IN GAZA CITY 50

4.0 Introduction 50
4.1 Case study: Phase 1: Preparation for Planning 50
4.2 Case Study: Phase 2: Information Diagnosis 51
4.2.1 Case Study: Phase 2: Step 1: Analysis of existing conditions 51
4.2.1.1. Case Study: Phase 2:Step1: Activity 1: SWOT Analysis 67
4.2.1.2 .Case Study: Phase 2: Step 1: Activity 2: Interface with other systems 68
4.2.2 Case Study: Phase 2: Step 2: Development of Operational System..... 69
4.2.3 Case Study: Phase 2: Step 3: Establishment of Functional Objectives. 73
4.2.4 Case Study: Phase 2: Step 4: Analysis of System Economics..... 73
4.2.4.1. Case Study: Phase 2: Step 4: Activity 1: Sensitivity Analysis 73
4.2.4.2. Case Study: Phase 2: Step 4: Activity 2: Risk Analysis 76
4.2.4.3. Case Study: Phase 2: Step 4: Activity 3: Yearly Forecasts 76
4.2.5 Case Study: Phase 2: Step 5: Development of Economic System Model 80
4.3 Case Study: Phase 3: Strategic Choice..... 81
4.3.1 Case Study: Phase 3: Step 1:Examination of alternative future services and projects scenarios 81
4.3.1.1 .Case Study: Phase 3: Step 1: Activity 1: Development of alternative design response 82
4.3.1.2 .Case Study: Phase 3: Step 1: Activity 2: Development of alternative operating response 83
4.3.2 Case Study: Phase 3: Step 2: Screening and Evaluation of scenarios.. 84
4.3.3 Case Study: Phase 3: Step 3: Selection from Strategic Alternative..... 84
4.4 Case Study: Phase 4: Implementation 85
4.4.1 Case Study: Phase 4: Step 1:Prioritization of projects and programs . 85
4.5 Case Study: Phase 5: Monitoring..... 90
CHAPTER FIVE:
GENERAL REMARKS AND CONCLUSIONS..... 92

5.0 Introduction 92
5.1 Developed Approach 92
5.1.1 Description of the developed approach 92
5.1.2 Applicability of the developed approach 93
5.1.3 Limitation and requirements of the developed approach 94
5.2 Implementation of the Developed Approach to Case Study 95
5.2.1 Influence of risks and uncertainties in case study 96
5.2.2 Results of case study 97
5.3 Conclusion 98
5.4 Recommendations 99
REFERNCES…… ….101
Appendix A: Mathematical forms of AHP…….……110
Appendix B :Water supply-demands figure for Gaza Strip …….……...111
Appendix C :Prioritizing Alternatives by AHP ……..…..……..... 113
Appendix D :Map of Gaza City …….…….117

LIST OF TABLES

Table 2.1: Comparison of different approaches to strategic planning 9
Table 2.2: Comparison between traditional approaches and SPM 11
Table 2.3: Comparison between the Ranking method and AHP 15
Table 3.1: SWOT analysis matrix for housing sector 30
Table 3.2: Brainstorming session for analyzing system economics 33
Table 3.3: Variables in Water Sector to be considered in Sensitivity Analysis 35
Table 3.4: Sensitivity Indicator and Switching Value 35
Table 3. 5: Actions to mitigate risk at different levels 36
Table 3. 6: Principles to apply for risk analysis 37
Table 3. 7: Major forecasts for some infrastructure sectors 38
Table 3.8: Matrix of Assessment 43
Table 3.9: Pairwise comparison reciprocal matrix 45
Table 3.10: Criteria priority vector 45
Table 3.11: Alternative pairwise comparison with respect to each criterion 46
Table 3.12: Alternative priority vector of pairwise comparison 46
Table 3.13: Composite global priorities 46
Table 3.14: Alternative prioritization 46
Table 4.1: Per capita water consumption by region (m^3/person/year)` 52
Table 4.2: Water resources and use: Regional comparison 53
Table 4.3: Ground water resources in Palestine 55
Table 4.4: Quality of ground water in Gaza Strip 56
Table 4.5: Gaza Municipality Wells Production through Year 2002 60
Table 4.6: Gaza Municipality water wells production from 1980 61
Table 4.7: Water Quality for Water Wells in Gaza City: 63

Table 4.8: Relationship between water department with other departments MOG 64
Table 4.9 Cost data for water sector in MOG 65
Table 4.10: Cost data for wastewater sector in MOG 66
Table 4.11: House connections for water supply system in Gaza 66
Table 4.12: SWOT analysis of Gaza City 68
Table 4.13: Projects related to water sector in Gaza City 69
Table 4.14: Variables in water sector (Gaza) to be considered in sensitivity analysis 74
Table 4.15: Sensitivity Analysis for Current Water Situation in Gaza City 75
Table 4.16: Risk analysis for Gaza City 76
Table 4.17: Forecasts of population growth for Gaza City 77
Table 4.18: Forecasts of sewage generation for Gaza City 78
Table 4.19: Runoff forecasts for Gaza City. 78
Table 4.20: Projected water demand-supply for Gaza Strip. 79
Table 4.21: Forecasted water demand for Gaza City. 80
Table 4.22: Important elements to be included in strategic choices 81
Table 4.23: Proposed alternatives 82
Table 4.24: Matrix of assessment (Engineering response) 83
Table 4.25: Matrix of assessment (Operation response) 83
Table 4.26: Investment costs in Gaza City (2004-2025). 85
Table 4.26A: Proposed Investment Plan (Gaza City- 2004-2025) 87
Table 4.27: Proposed tariff structure for water sector of Gaza City. 88
Table 4.28: Sensitivity Analysis for Alternative No.3 89
Table 4.29: Monitoring Sheet for Strategic Plan in Gaza City 91

LIST OF FIGURES

Figure 2.1: The Circle of Strategic Planning Process for Non-compliant Situation. 12
Figure 2.2: Strategic Planning Approach for Florida. 13
Figure 2.3: Analytic Hierarchy Process Flowchart. 17
Figure 3.1: Elements of Risk-Informed Strategic Planning Approach for Infrastructure. 24
Figure 3.2: Framework for analyzing actual situation. 29
Figure 3.3: Flow Chart for economic analysis models 40
Figure 3.4: Ways of finding ideas on problem solutions 42
Figure 4.1: Inter- ministerial Co-ordination in water sector in Palestine 71
Figure 4.2: Inter- ministerial Co-ordination in water sector for MOG 71
Figure 4.3: proposed Flowchart of Water Sector for Municipality of Gaza 72
Figure 4.4: Flow of Funds for Municipality of Gaza 86

LIST OF ABBREVIATIONS

AHP	Analytic Hierarchy Process
Cl^-	Chloride
ESCAP	United Nation Strategic Environmental Planning
GTZ	German Technical Group
IRR	Internal Rate of Return
JWU	Jerusalem Water Undertaken
M&E	Metcalf and Eddy
MOA	Ministry of Agriculture
MOF	Ministry of Finance
MOG	Municipality of Gaza
MOPIC	Ministry of Planning and International Cooperation
NO3	Nitrate
NPV	Net Present Value
O&M	Operation and Maintenance
PDP	Palestinian Development Plan
PNA	Palestinian National Authority
PWA	Palestinian Water Authority
SPM	Strategic Planning and Management
SWOT	Strength, Weakness, Opportunity, Threats
TAHAL	Israeli Consultancy firm
TFGWB	Trust Fund for Gaza and West Bank
WHO	World Health Organization

WRD	Water Resources Division
ZOPP	Objective Oriented Planning Process (Germany)

CHAPTER ONE

INTRODUCTION

1.0 Introduction

Infrastructure can be broadly defined as the physical facilities making up public utilities through which goods and services are provided to the public (Yuzo Akatsuka, 1999). The infrastructure supporting human activities includes complex and interrelated physical, social, ecological, economic, and technological systems such as transportation, energy production and distribution, water resources management, waste management, facilities supporting urban and rural communities, communications, sustainable resources development, and environmental protection (ASCE, 2003). In addition, infrastructure includes the provision of types of social facilities regarded as essential for the maintenance of public health and welfare. Improving the infrastructure in an area can widely facilitate the way of living for all residents in that area, which results in economic and social progress (Guy Felio', 1998).

Infrastructure development, however, is a long-term issue in which it is important to define when, where and what infrastructure elements should be constructed in terms of their possible long term influence on economical and social aspects at both local and national levels. Planning of infrastructure facilities is a multi-sector complex process that involves a number of decision-makers, uncertainties, conflicting criteria, policies, etc. Since the process of developing and planning begin, goals must be formulated, criteria determinated, critical needs counter-weighted, and policies and programs designed that will lead to long-term sustainable development and not just short-term gain. (Paul, 2001)

1.1Research Problem

The undertaken research work is concerned with the development of a strategic planning approach for infrastructure that includes SWOT analysis, expert-opinion elicitation process, and multi-criteria risk-based decision analysis and

implementation guidelines. The approach deals with different fields within infrastructure sector and can handle the inputs from a group of players involved in implementation and management of infrastructure. These include the decision-makers, the stakeholders who can influence the decision and/or affected by it and the analysts. In particular, the approach will be applied for the water sector. A real life application is used to demonstrate its effectiveness. For this purpose the water problem of Gaza City has been used as a case study for the implementation of the developed approach.

1.2 Research Objectives

The undertaken research work will focus on the development of a strategic planning approach for infrastructure that includes risk and uncertainty analysis. Central research objectives that guide this study are:

- Development of a Risk Informed Strategic Planning Approach for Infrastructure in Palestine as a developing country.
- Creation of a strategic plan for water sector in Gaza City by using the developed approach.

In an effort to achieve these research objectives, this study conducts wide evaluation analysis of approaches used in strategic planning in other countries, and make necessary study of current strategic planning in Palestine. The goal of the analysis is to fill a knowledge gap that deviates decision-makers from making optimal decisions during strategic planning in Infrastructure field and Water Sector as case study.

1.3 Area of Implementation

Palestine (defined here as West Bank, Gaza Strip, and East Jerusalem) is the study area for Infrastructure. Implementation of the developed approach has been used in Water Sector in Gaza City, thus, after studying the water situation at the regional and national level; the research will focus on water situation in Gaza City.

The developed approach can be also used in other developing countries with similar circumstances like Palestine with some modification in criteria used in the approach.

1.4 Report Organization

The undertaken research consists of five chapters that cover the proposed subject as follows:

Chapter One: Introduction

Chapter Two: Review of Strategic Planning Approaches: This chapter summarizes various literatures on strategic planning approaches used all over the world with emphasis on these ones concerning infrastructure. Subsequently, this chapter elaborates on approaches that can be applied in developing countries with detail analysis of their advantages and disadvantages. A review of existing strategic planning processes in Palestine is discussed within this chapter. In addition, needed discussion of these techniques and methods used in strategic planning processes for decision-making processes are highlighted.

Chapter Three: Developed Strategic Planning Approach for Infrastructure in Palestine: This chapter describes the developed approach for infrastructure planning in developing countries with needed steps that can be applied for the Palestinian case.

Chapter Four: Case Study: Implementing of the Developed Approach in Water Sector in Gaza City: This chapter provides full implementation of developed approach to strategic planning of water sector in Gaza City.

Chapter Five: General Remarks and Conclusions: This chapter includes the concluded remarks, main conclusion from the research and recommendations drawn from the research work.

CHAPTER TWO

REVIEW OF STRATEGIC PLANNING APPROACHES

2.0 Introduction

Strategic planning is a systematic planning process involving a number of steps that identify the status of an organization including its mission, vision for the future, operating values, needs, goals, prioritized actions and strategies, action plans and monitoring plans (CAI, 2001; Procter & White, 1996). It is a tool, a methodology, a long-term process that can regulate and help in managing infrastructure sectors and conditions, especially in developing countries, where infrastructure sectors are normally in poor, unsafe conditions, suffering from lost-time delays and more frequent and costly maintenance and operations (John Bryson, 1995). To improve infrastructure conditions it is advised to implement a long-term range strategy that strengthens the process for managing capital assets, including the acquisition, maintenance, modernization, and eventual disposal of infrastructure. (Kent, 1991). In addition, strategic planning may be characterized in two ways: intellectually, it is a process of problem solving. Socially, it is a process of advice giving. Most commonly definitions or descriptions of planning refer to it as a particular type of problem solving. (Howell, 1983).

A well-planned system of infrastructure facilities is one of the primary prerequisites for a country's sustainable- development (Alterman, 1983). There is, especially in developing countries, a pressing need for planning in this field where the work is done within the constraints of several limited budgets and against the lack of even the most basic infrastructure (Kevin, 2001).

2.1 Worldwide Recognized Approaches to Strategic Planning

In the world of business, management, and engineering, many approaches to strategic planning have been developed. The followings are the most recognized ones that can be applied for infrastructure systems and projects. (Social Entrepreneurs, 2003):

1. Foundational Planning Approach
2. Goals- driven Planning Approach
3. Objective Oriented Planning Approach (ZOPP)
4. Critical issues Approach
5. Scenario Analysis Approach
6. Result based Accountability Approach

Each approach has its advantages and disadvantages, thus, the organization can choose its one based on its unique situation, mix of people, time requirements, and other factors.

2.1.1 Foundational Planning Approach

This approach to strategic planning focuses on two major elements, i.e. the kind of business the organization deals with and the customers who receive this business or services (John Pearce & Richard JR, 1994). For using of this planning approach, the following questions must be answered: Which kind of business the organization deals with? Who are the currents and prospective customers and what is the level of satisfaction the organization needs to provide for these customers? What does the customer consider value? What is the organization plans to achieve these needs of customers?

Big companies prefer to use this kind of strategic planning because of its emphasis on customer's satisfaction which leads to big profit, especially in private sectors, where the profit is the most important objective of the organization. Using such kind of strategic planning in infrastructure can partially help in identifying social impact of the services; however, other elements that must be identified are not included in this approach. These include political and Socio-economic elements, requirements of donors, importance of services and others. In addition this approach ignores the analysis of external threats and opportunities that influence the infrastructure level of services and development.

2.1.2 Goals-driven Planning Approach

This approach to strategic planning emphasizes on defining where the organization wants to go, what it wants to accomplish, and then uses these goals as driving force to determine how it will go about achieving the goals (Denis, 2003). In order to implement this approach the following steps must be applied:

1. Clarify mission, vision and values.
2. Perform a situation analysis: which means analyzing the current and expected future situation of the organization in terms of its external and internal powers and weaknesses.
3. Develop goal, and define the strategy to achieve it.
4. Evaluate the impact on the organization.

This approach can be more attractive than the first one because of its focal element (goals) that can motivate people to work. These goals can be considered as additional supporting force in infrastructure operations; however, they may lead to confusion in performance of strategy if they are not well defined, or even if they are not realistically given. Certainly, infrastructure strategic planning needs a wide analysis of external and internal attributes of the organization and must deal with their changes. These are well defined in this approach, but the whole approach is not flexible and can not be changed according to the revolving evaluation of the whole process during its implementation, In addition, the decision making process is not clear in this approach.

2.1.3 Objective Oriented Planning Approach

Similar to goals-driven approach is Objective Oriented Planning Approach (ZOPP, from German expression Zielorientierte Projektplanung), an approach developed by German Technical Group GTZ, (World Bank Group, 2002). This approach has been widely used in the world and most donors prefer to use it in developing countries because of its emphasis on stakeholder output and their expectation from already established objectives (COMIT, 1998). The instruments of ZOPP pertain to four areas: analytical instruments, instruments for

conceptualizing interventions, planning synthesis and operational planning. The strengths and limits of ZOPP are similar to these for Goals-driven Planning (ZOOP, 2003).

2.1.4 Critical Issues Approach

The critical issue approach mirrors the goal approach in defining the mission and performing a situation SWOT analysis (Strengths, Weakness, Opportunities, and Threats). These analyses are used then to determine the most significant issues facing the organization.

> *"Critical issues may be internal weaknesses that must be corrected; external threats to be mitigated; emerging opportunities to be pursued; or other such things that are expected to have a major impact on the organization"* (Social Entrepreneurs, 2003).

In this approach the following steps are applied:

1. Clarify mission, vision, and values.
2. Perform a situation analysis.
3. Identify and prioritize critical issues.
4. Establish strategies to overcome critical issues.

Using this approach in infrastructure can be successful in certain sectors that do not require big forecasts for some important elements, e.g. road maintenance. However, in large sectors like water sector, this approach is not applicable. The reason is that this approach can be a somewhat reactive approach that focuses on the structure of the organization only and ignores other important elements that must be predicted during the process of planning. In water sector planning, as an example, the following forecasts needs to be done: water demand and supply for horizon year, population, quality of water, wastewater generation, rainfall, and others. These forecasts are not included in this approach, thus the final result of the planning will be affected.

2.1.5 Scenario Analysis Approach

This approach adds another important step into strategic planning. The scenario approach involves developing several alternative pictures of what the most the organization might look like in the future. The scenarios are reviewed and then the selected one is implemented to turn the vision into reality. The steps of this approach are:

1. Clarify mission, vision, and values.
2. Perform a situation analysis.
3. Identify major scenarios for the future.
4. Selection of one scenario.
5. Establish strategies to realize the selected scenario.

Implementing this approach in strategic planning of infrastructure can be very useful when the demand planning is applied for short time period. The reason is that this approach is not a continuous process and its limit is not a subject of monitoring. Strategic planning needs more evaluations of the implemented strategies before, during, and after their implementation, which are not available in scenario approach.

2.1.6 Result- based Accountability Approach

This approach emphasizes on positive outcomes of customers and many of needed analysis are not included in it. Thus, using it in infrastructure strategic planning can not give suitable solutions. It can be used as one phase or step included in strategic planning for infrastructure in order to monitor the process of planning.

2.1.7 Concluded Remarks

Each of the previous approaches has relative advantages and disadvantages. Each approach may need some development in order to be adequate for infrastructure strategic planning. Table 2.1 summarizes these attributes of each one.

Table 2.1: Comparison of different approaches to strategic planning

Approach	Advantages	Disadvantages
Foundational Planning Approach	- Emphasis on very important items like the mission and how to deliver value to the customers. - Proven tools are available to implement the approach.	- External forces are not included. - Detailed analysis of threats and opportunities do not exist.
Goals-driven Planning Approach/ ZOPP	- Can be proactive. - Goals can motivate people to work - Well-defined goals provide a good way to measure progress over the time period covered by the plan.	- Goals need to be well defined or they can create confusion.
Critical- issues Planning Approach	- Detailed analyses of internal and external factors. - Realistic approach with realistic objectives.	- Can be somehow reactive approach.
Scenario Analysis Approach	- Wide range of thinking. - Trends to hold people's interest better during the planning process.	- This approach often ignores existing or emerging challenges facing the organization, especially if a situation analysis is not included in the process.
Result-based Accountability Approach	- All planning revolves around positive outcomes for customers.	- Some people object to the emphasis on only pursuing results that are measurable through quantitative indicators.

Most of the approaches given in Table 2.1 do not adequately account for internal and external environments that may influence the sector in short, medium, and long terms. They also do not adequately account for uncertainties that normally influence strategic plans especially in politically unstable countries such as Palestine or other countries with similar or different situations (Pallottino, 2002).

2.2 Other Approaches to Strategic Planning

Other strategic planning approaches have been developed by many institutions for strategic planning. Most of these approaches are a combination of previous mentioned approaches with needed modification for each case that need specific

strategic planning. Figure 2.1 for example illustrates the circle of strategic planning process applicable to non- compliant situation. The process was adopted based on mix of Goals driven approach with Scenario approach. This process was developed by Nathan Garber organization **(**Nathan Garber & Associates, 2003). The approach shows how planning can be a revolving process with needed steps for identifying current and future situation, and establishing adequate policy for implementation. However, one important element is missing in this approach which can extremely affect infrastructure strategic planning. This element is identifying vision and values. Without these two important elements, any infrastructure strategic planning can not be comprehensive (SCSF, 2002).

Other example given in Figure 2.2 shows strategic planning process that was implemented in Florida Department of Transportation (Florida Strategic Plan, 1999). This example illustrates how to use a mix of strategic planning approaches in a revolving process independent of the field under planning. Revolving means continues monitoring and evaluations and modification within the three important phases of strategic planning: preparation, selecting alternative, and implementation.

Nevertheless, developing countries have specific circumstances that normally influence their strategic planning. Unstable political situations and large changes in population growth or Socio-economic life may raise a wide range of unexpected uncertainties that can affect any planning process and lead to a misuse of strategic actions. For this purpose The United Nations Strategic Environmental Planning ESCAP, has organized a series of meetings in the course of 1998-2000 in many developing countries. The result of these meetings was the adoption of a list of guidelines on strategic planning and management for water and energy. (ESCAP, 2002). According to these guidelines, strategic planning and management is best when it is a five-step process as follows:

Step1: Set objectives and targets on the basis of a vision.

Step 2: develop programs of action with relevant groups.

Step 3: Implement the program.

Step 4: Monitor, evaluate and report progress.

Step 5: Review and reset objectives and targets where necessary.

In addition, to achieve the best result of strategic planning for infrastructure in developing countries a set of modifications has been made for many issues of strategic planning. ESCAP guidelines on Strategic Planning and Management (SPM) summarizes these modifications as shown in Table 2.2

Table 2.2: Comparison between traditional approaches and SPM (ESCAP, 2002)

Issue	Traditional Approach	ESCAP guidelines on Strategic Planning and Management (SPM)
Goal	Tackling infrastructure issues when and where they occur based on their urgency.	Developing a comprehensive plan to provide infrastructure services to the society in a sustainable manner.
Driving force	Economic growth and crisis management, and the availability of investment funds.	Sustainable services for the long-term.
Criteria for Success	Development and expansion of capacity.	Social development and economic growth, ultimately sustainable development.
Responsibility	Governmental agencies.	Governmental agencies in partnership with civil society.
Types of instruments	Regulatory framework, investment policy.	A mix of regulatory framework, agreements, fiscal incentives, and user fees.
Technology	Technocratic approach.	Technology is one of the tools.
Role of the society	Comply with regulations.	Engagement- commitment-empowerment.
Monitoring	Law enforcement by the government.	Comparing short term results with long term goals on regular basis of actors.

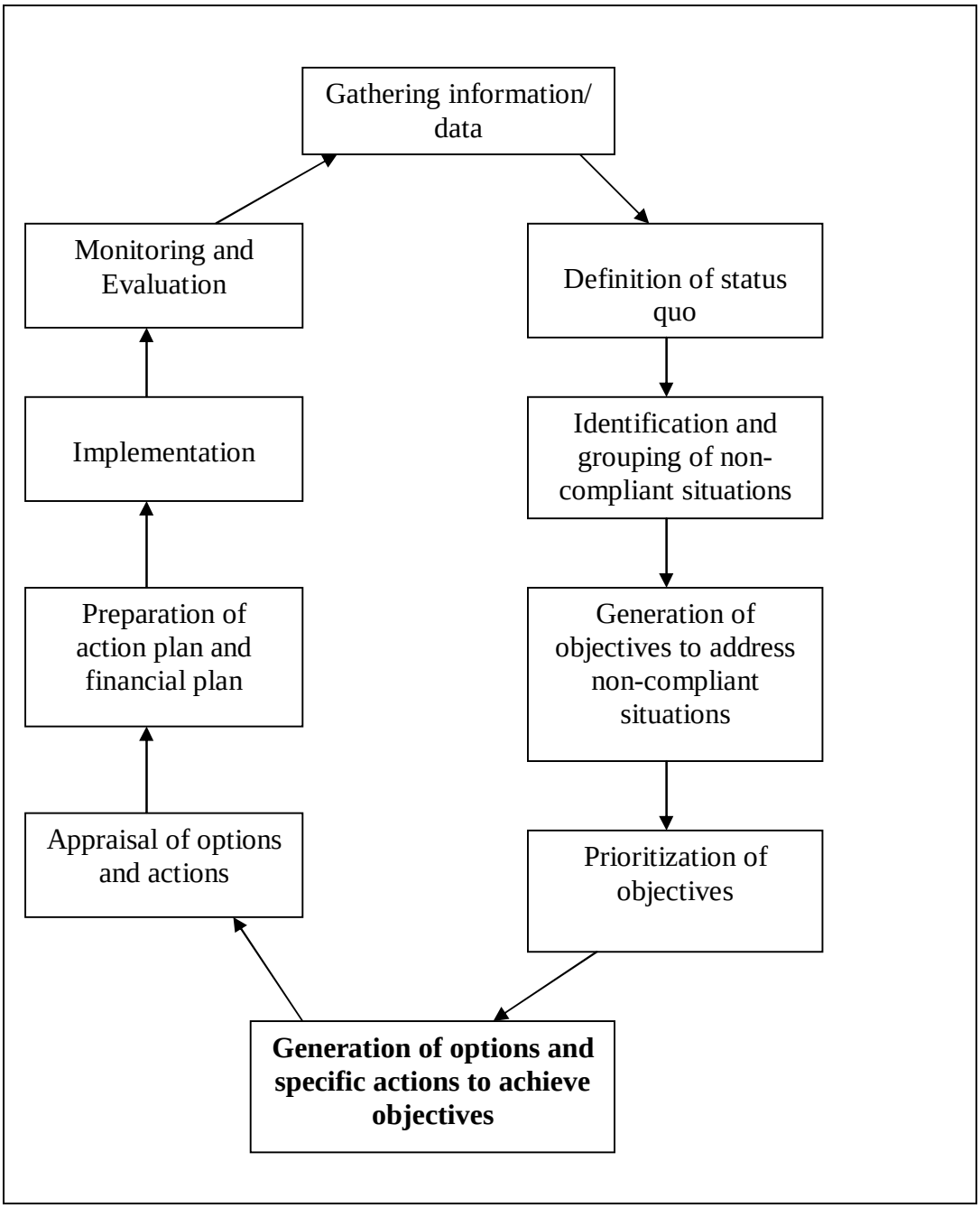
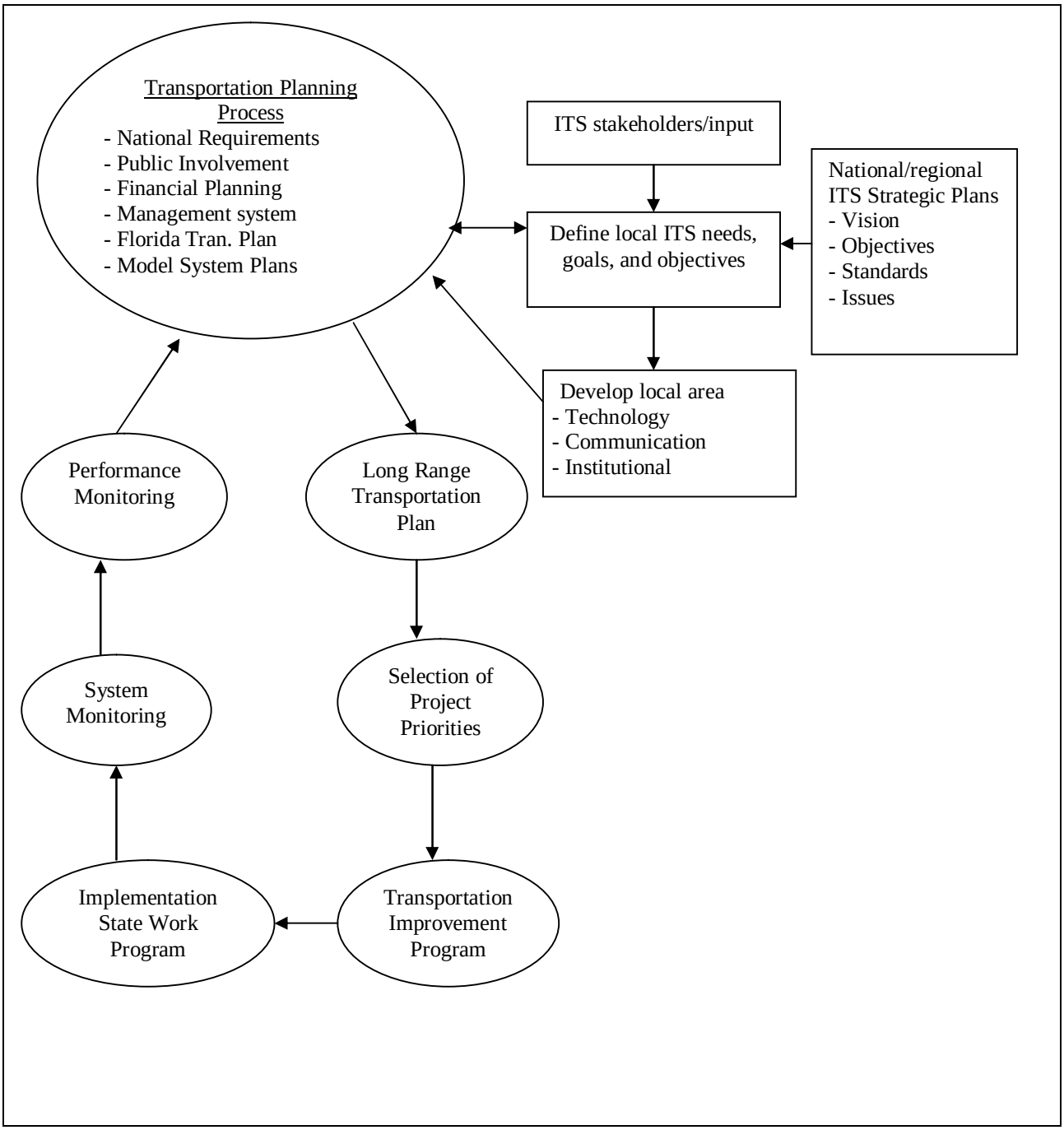


Figure 2.1: The Circle of Strategic Planning Process for Non-compliant Situation. (Nathan Garber & Associates, 2003)



ITS: Internal Transportation System

Figure 2.2: Strategic Planning Approach for Florida, 1999.

2.3 Decision Making Process for Strategic Planning

Each strategic planning process must produce specific decisions that conclude the problem analysis and suggest alternatives for best solutions. Thus, decision-making is a process of choosing among alternative courses of action in order to obtain goals and objectives. Infrastructure strategic planning is influenced by various variables (criteria). These also influence the decision making process (Buchanan & Henig, 1996). Choosing the right method that can help in multi-criteria decision analysis is one of the most important jobs of planning committee (Forman, 1998). The development of appropriate and effective tools for decision making requires an understanding of the environmental and social contexts within which these decisions are made. Socio- political influences and existing organizational structures and formalized frameworks, which define both the stakeholder and how they interact, impose specific process towards achieving a desired outcome (Francois, et al, 2001).

Normally, two methods are used for multi-criteria decision making process (Papke, 2002). The first one is ranking method, by weighting criteria with specific numbers that are given to show the importance of the criteria and sub-criteria. The second is Analytic Hierarchy Process (AHP) that allows the decision makers to model a complex problem in a hierarchical structure showing the relationships between the goal, objectives (criteria), sub objectives, and alternatives. Uncertainties and other influencing factors can also be included.

Table 2.3 shows the advantages and disadvantages of each one. These attributes were collected from many literatures and papers concerning decision-making process and methods (Ziara, et al, 2002); (The quality Portal, 2003); (G.R. Finnie, 1999); (Forman, 1999); and others

Table 2.3: Comparison between the Ranking method and the Analytic Hierarchy Process for multi-criteria decision making

	Weighting Method	**Analytic Hierarchy Process**
Advantages	- Easy determines the relationship between criteria and sub criteria. - Can be suitable for evaluating alternatives with low risks. - Does not require long time or lot of information.	- Helps capture both subjective and objective evaluation measures. - Provide a useful mechanism for checking the consistency of the evaluation measures. - Alternatives are suggested by teamwork thus reducing bias in decision making.
Disadvantages	- The meaning and use of number do not give a clear understanding of ranked alternatives. - Can be misused in these evaluations with uncertainties and risks.	- Many inconsistencies may happen during implementation of the method such as: lack of information, lack of concentration, or inadequate model structure.

It is clear from previous comparison that AHP is more proper for decision making process in the developed approach. Using this technique in its decision making process, Palestine will become one of over 60 countries in the world that use this method (Forman, 1999). The best use of this process can be summarized in four main steps (Ziara, et al, 2002; Jaber & Mohsen, 2000), these are:

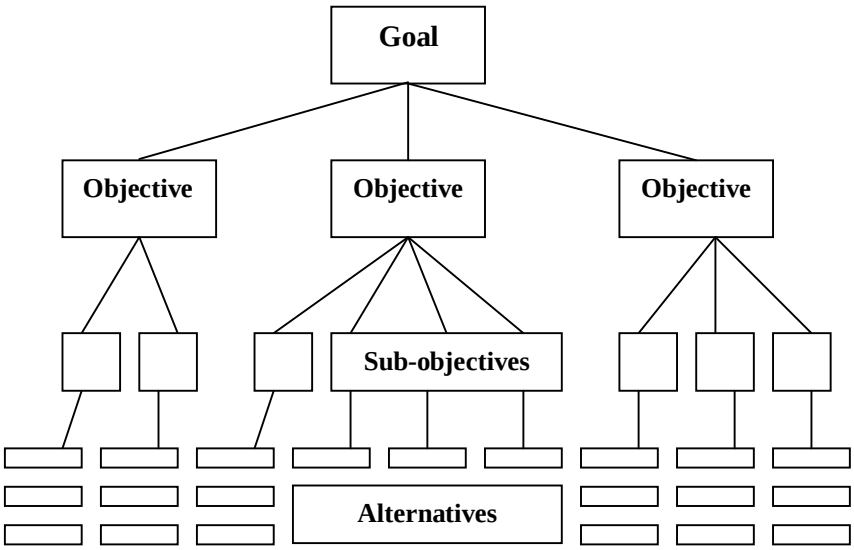
1. Step 1: Decomposition of the problem into a Hierarchy: where the problem is decomposed into levels depends on elements included in the study.
2. Step2: Pair- Wise Comparison of Criteria: this step in AHP generates a set of matrices as shown in (Appendix A).
3. Step 3: Pair-wise Comparison of Candidate Alternatives: In this step, the corresponding priority vector and inconsistency indices are obtained using the same analytical procedures as in step 2.
4. Step 4: Synthesis of Priority Alternatives: This step is to apply the principle of composition priorities to obtain a cardinal ranking of infrastructure alternatives.

The structure of the AHP allows decision-makers to model a complex problem in a hierarchical structure showing the relationship of the goal, objectives (criteria), sub-objectives, and alternatives (Ernest, et al). Figure 2.3 illustrates two cases of how can the problem under study be illustrated by AHP. The first case in Figure 2.3 shows the general shape of decision hierarchy that can be used differently according to the problem, and the second case is more specific and shows how AHP can be used for project prioritization which is more close to the infrastructure fields.

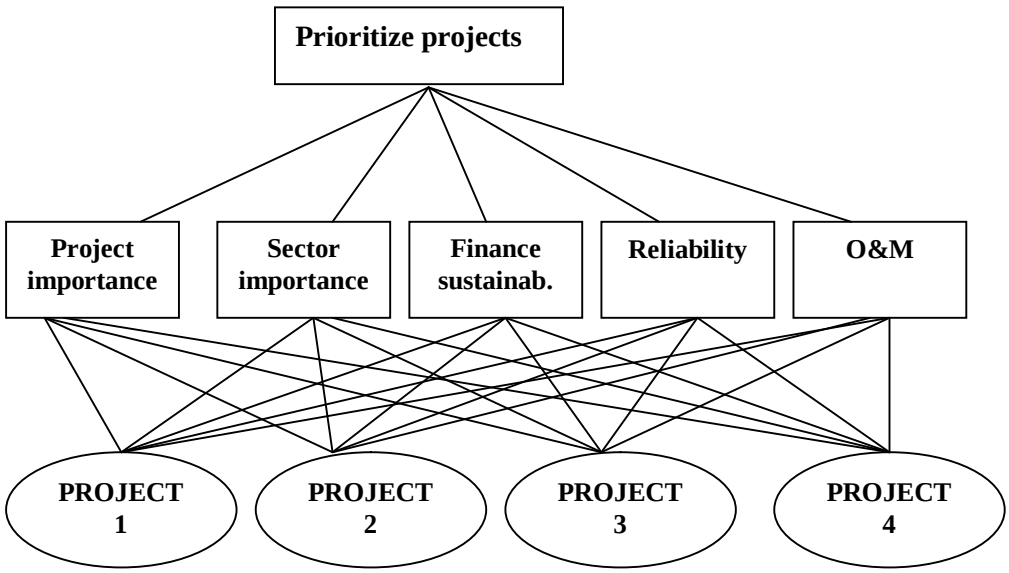
For practical and precise implementation of AHP it will be necessary to identify the needed criteria and sub-criteria for each sector under study. These criteria are divided into three important ones as follows:

1. Obligatory Criteria (Must Criteria) which are indispensable (laws, norms, limitations of any kind, human standards, given guidelines) and must be realistic.
2. Desirable Criteria (Should Criteria) which reflect political priorities, sector objectives, professional standards and considerations, etc; and
3. General Criteria that is useful for determining the general approach of a development project.

The best use of AHP requires a number of criteria between three and nine criteria. For this purpose the number of criteria must be identified within this range and all needed other criteria can be reduced inside the most important nine (Robins, 1999). This will enforce the planner to share the idea of identifying criteria with these people related directly to the sector under study. However, criteria should be well independent, and be able to cover off the dimension of the problems in a complete way (Saaty, 1994).



Case 1: General Decision Hierarchy (General Shape)



Case 2: Analytical hierarchy process for project prioritization

Figure 2.3: Analytic Hierarchy Process Flowchart.

2.4 Strategic Planning in Palestine

The situation prevailing in the Palestinian society differs from that of any other regional country. The lack of adequate authority, of a state, of laws, etc., has produced a number of contradictions and conflicts during the sustainable development process of the society. During the occupation period, there were not any actions towards strategic planning in Palestine that may achieve national interests. Even after establishing the Palestinian National Authority (PNA), strategic planning was a big challenge, since the pledge of $2.5 billion for five years was based on outside strategic planning which was inefficient (Samih Abed, 1999).

However, the importance of infrastructure development has been recognized at national and local level in Palestine since the establishment of Palestinian National Authority (PNA). The five year Palestinian Development Plan (PDP, 2003) indicates the desired level of infrastructure investment where 49% of total resources were allocated to infrastructure by the year 2003.

Unfortunately, the process of strategic planning is not usual manner for decision making process in the reality of Palestine. Not only in the whole field of infrastructure, but also in sub-sectors that make the infrastructure field integrated and comprehensive sector that needs more attention and analysis for each elements of its sub-sector (Amin Baidoun, 2000). Some of the strategic infrastructure projects in Palestine were constructed without full analysis that can make these projects useful for the society. The decision of constructing such projects has not been taken according to the right and real analysis needed for strategic planning, thus, many difficulties have been raised and these projects were not efficient as much as they cost.

In addition, the long time occupation of Palestinian territories by Israel since 1967, without any planning or even short term improvement of infrastructure, except one planning for water sector in Gaza by Israeli consultancy firm TAHAL, has put this field in very poor, damaged and useless conditions. Even TAHAL

planning for water sector in Gaza was taken from the viewpoint of occupation, which was against Palestinian demands (Tahal, 1972).

After the establishment of the PNA, some constraints are still facing strategic planning in Palestine and make it difficult process to be implemented. These include: different donors require different kind of projects, decision making process is not clear in many infrastructure sectors, big conflicts in prioritizing projects, many risks and uncertainties are usually ignored, and limited budgets make the economic and sensitivity analysis very difficult (Amran; et al, 2003).

Despite these difficulties, Palestinian Water Authority (PWA) has made the first right step toward true strategic planning for water sector in Palestine. Many important elements have been, for the first time, taken into account during the process of planning, the responsible bodies have been well formulated, and major elements of strategic planning have been analyzed and developed. However, the process of planning needs continuous modifications and developments to take into consideration the analyses of risk and sensitivity elements that were not well defined or highlighted within the process. In fact, these elements can become very important and may influence strategic planning in Palestine because of the big changes that occur in Socio- economic life as a result of many uncertainties.

2.5 Components of Strategic Planning (Summary)

Previous review of strategic planning shows that all strategic planning approaches are similar in three main components: Plan development, Plan execution, and Plan review. Many of the functional areas within these components are similar. (CAI, 2001).

Plan development is the first component of strategic planning. Within this component an assessment of the current status of structure of the organization with needed evaluation and SWOT analysis should be done, mission and vision statements have to be developed, operating values determined, needs assessments performed, and critical issues predicted. This component includes also the

development and prioritizing of long range and short-term goals and finally, the establishment of a monitoring process to assess the progress made at both long range and short-term period.

Plan execution is the second phase of strategic planning. In this step the proposed plan is directed into action through the allocation of resources. Identifying programs and procedures can do realization of plan to the realities, but with prepared budgets for them.

Plan review is required constantly to improve the plan and ensure its execution. This review can be easy worked when it is scheduled and continuously evaluated. This can be achieved through surveys, management review conferences, or discussions at meetings.

2.6 Conclusion

Strategic planning approach must reflect the specific situation where it has been implemented. This means that any approach should contain some phases that specified the sector, the country, the level of service, or any other requirements. Ignoring these elements in strategic planning approach will sure lead to conflicts or even misuse of all process.

Most of the reviewed approaches that have been using all over the world give initial guidelines of the general planning approach. This statement is clearly observed from previous review of strategic planning approaches. The review shows how these approaches can change according to the sector, objectives, circumstances, decision-makers of the institution, and others. So, no one of them can be directly copied from one country to an other because it is difficult to find two countries with totally same situation.

In Palestine, it is necessary to apply an approach for infrastructure strategic planning that is based on considerations of uncertainties that are related to internal and external political, economical, and social influences. These considerations should be directly and numerically accounted for in the planning approach.

The following Chapter describes the development of the risk-informed approach for strategic planning of infrastructure in developing countries, such as Palestine.

CHAPTER THREE

DEVELOPED STRATEGIC PLANNING APPROACH FOR INFRASTRUCTURE IN PALESTINE

3.0 Introduction

According to the review in Chapter Two for many approaches and analytical tools, this chapter will focus on developing a strategic planning approach for infrastructure in developing countries especially in Palestine. The developed approach benefit from the advantages of existing approaches to produce a comprehensive approach that can meet the needed steps for planning process in the field of infrastructure in Palestine. All aspects that may make Palestinian case as a special one that needs special adoption of these tools will be taken into consideration. The criteria used in the developed approach suit the conditions of Palestine.

3.1 Elements of the Developed Approach

Since strategic issues require top management decisions, they require top management involvement. Usually this involvement is not a problem in private sector, where the decision making process is clear and does not allow a conflict during implementation of the approved polices. In public or governmental sectors which is a usual reality in infrastructure, this involvement may make a big constraint because of interrelations between different sectors and a variety of responsible bodies of each sector with various demands (John, 1994). In most developing countries, e.g. Palestine, governments own a large portion of infrastructure sectors and suffer from wrong involvement of top management decision, thus, beside all constraints mentioned in previous review, the developed approach will also focus on decision making process and the best methodology to do it.

Therefore, the developed approach consists of the following five phases as shown in Figure 3.1:

Phase 1: Preparation for planning.

Phase 2: Information Diagnosis.

Phase 3: Strategic choice.

Phase 4: Implementation.

Phase 5: Monitoring.

The approach requires data, information and related in-depth analysis by various disciplines and specialists as inputs into the planning process. For this reason, each of phases 2, 3 and 4 is divided into steps and activities according to the needed classification of information and actions. Each step and activity has to be done by special group of involved people and specialists. As shown in Figure 3.1 each one of these phases ends with one step that summarizes all steps within the phase and introduces to the following phase. The reason of creating this hierarchy is to enable smooth flow of information that can ease the decision making process.

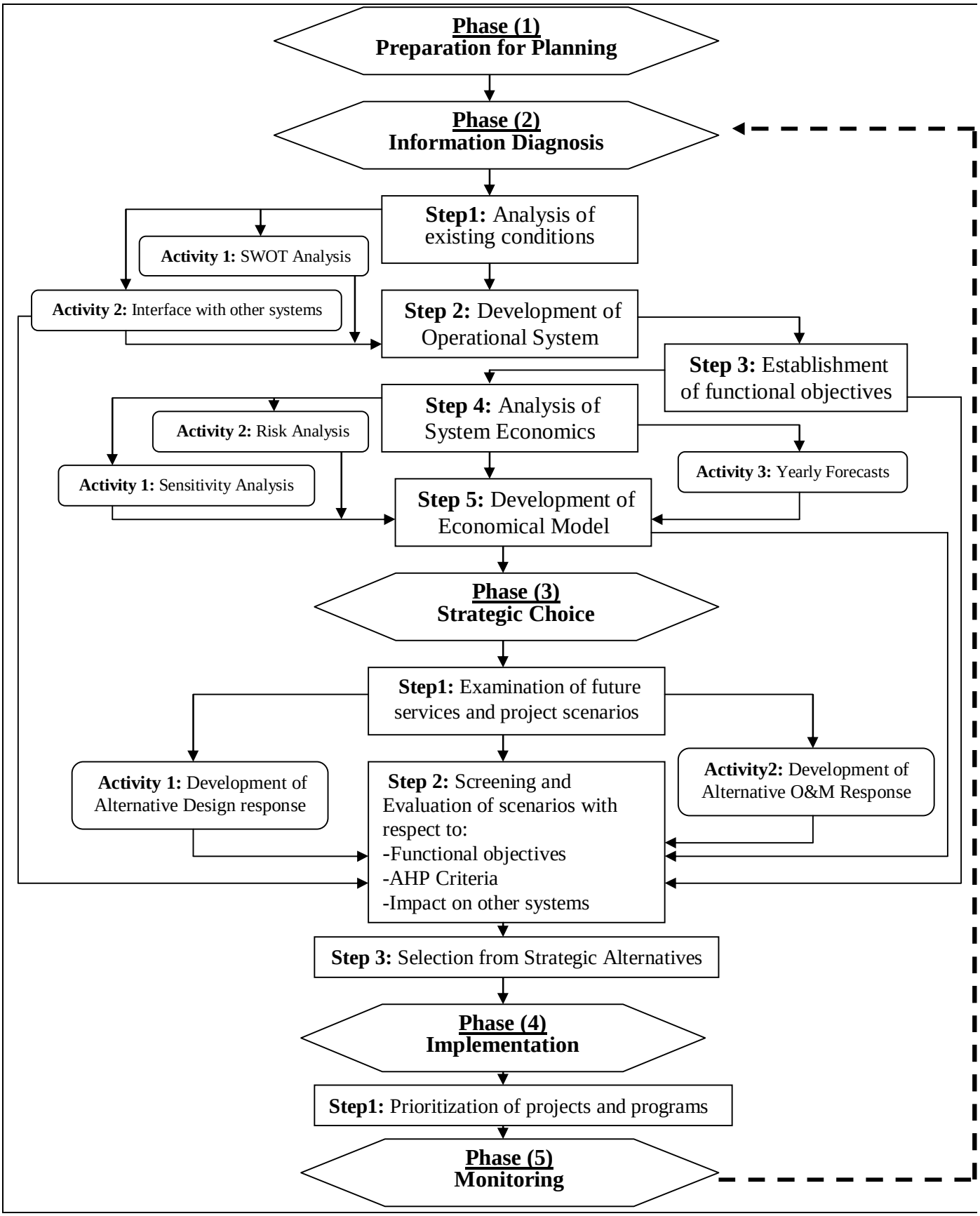


Figure 3.1: Elements of Risk-Informed Strategic Planning Approach for Infrastructure.

3.2 Phase 1: Preparation for Planning

The developed approach begins with a period of exploration and discussion between institutions regarding the validity and necessity of the process. The initiative often belongs to the leader who has a vision of what the organization he heads could or should be. This vision is a map for the organization, it has to be shared from the beginning with the members of the organization and they must all be prepared to accept a new organizational culture into their every day reality. Furthermore, working in infrastructure strategic planning needs more time than other fields because it contains many sections, deferent services, and various levels of managers and operators, which may lead to conflicts or contradictions This means that the preparatory work may take several months since the decision to adopt the process of strategic planning launches the organization on new direction towards a new organizational culture, as well as towards a sharing of different values and beliefs (Goodstein, Nolan, & Pfeiffer, 1992). The preliminary step must therefore explicate an analysis of the advantages and disadvantages of the process, must inform the members of the organization of the intention of management, and finally, must obtain the willing participation of staff members in the project.

In this phase, a planning committee is formed. Some institutions may hire a consultant or professional facilitators to do the job, others do the job by forming a planning committee from the high skilled employees of the institutions, and some may use mix of both. However, this committee has to contain several members from several institutions that can influence the performance of sectors of infrastructure. Consultants may be also added to facilitate its work at technical level.

In addition, this phase requires establishing two important units: planning unit and planning council or planning representative. Planning unit includes these responsible bodies within geographic area of the plan. Planning council members and who are responsible for planning process for major areas or those who influence strategic planning from other institutions.

3.3 Phase 2: Information Diagnosis

In this phase, the planning committee defines the values and beliefs that will be favored and upon which the mission statement will be based. These values and beliefs have to be developed from cultural, ecological, demographic, religious, educational and ethnic conditioning. A social attitudes change, so, too, does the reaction and demand toward infrastructure services. The planning committee has to arrive at a consensus regarding the values and beliefs to be recognized and accepted by all, as those to be included in the planning process.

The information needed for this phase is the determination of the vision and mission the organization shares with its staff, its community, and its stakeholders. The vision statement has to reflect the image or state to which the organization aspires and emphasizes the dream of where the organization will be at a specific time. For example the vision of Palestinian Water Authority in 2020 is to ensure the equitable and sustainable management and development of Palestinian's water resources (NWP, 2000). The developed approach defines the mission statement as the organization's purpose stated in a memorable phrase. Mission statement will reflect the vision of organization, so it is the base from which strategies and action plans are developed. For example: the U.S. Geological Survey Agency (USGS) defined the mission Water Resources Division (WRD) as follows (USGS, 1999):

> *"The mission of WRD is to provide reliable, impartial, timely information that is needed to understand the Nation's water resources. WRD actively promotes the use of this information by decision-makers to:*
>
> - *minimize the loss of life and poverty as a result of water- related natural hazards such as floods, droughts, and land movement.*
> - *Effectively manage ground water and surface water resources for domestic, agricultural, commercial, recreational and ecological uses.*
> - *Protect and enhance water resources for human health*
> - *Contribute to wise physical and economic development of Nation's resources for the benefits of present and future generations. "*

In the developed approach, there must be a deeper understanding of certain threats, opportunities, external and internal environments that will help in decision making process during planning. Beside these elements, it is important to identify strengths and weakness of the institution and other needed information for each sector of infrastructure elements.

At the end of this phase of the developed approach, the organization will have a brief and clear diagnosis of its external and internal environments. This phase of planning is often demanding for institution since it is necessary to decide the strategic stakes in order to act.

In reference to Figure 3.1 of the developed approach, the phase of Gathering of Information and Analysis consists of the following steps:

3.3.1 Phase 2: Step 1: Analysis of Existing Conditions

During this step, it is necessary to draw all of the background analysis that has been undertaken to prepare the new planning. Strength, weakness, opportunities and threats (SWOT) analysis and interface with other projects are necessary to highlight the most important strategic issues that are expected to influence the intended planning. The partnering of the different elements and the extensive data collected as a result of the analysis can serve as a spark for roundtable discussions and refinement of current strategies or generation of new strategies. For best review of actual situation of the sector under study, the developed approach requires the implementation of the framework shown in Figure 3.2. The figure includes necessary guides needed for future analysis of the developed approach. The planning committee during implementation the framework must mention all available information and illustrate all figures, tables, statistics, and other data that give clear picture about actual situation.

In addition, two activities must be done in this step in the developed approach as follows:

3.3.1.1. Phase 2: Step 1**: Activity 1:** SWOT Analysis

The developed approach requires a wide number of experts and senior managers to do this analysis in order to cover the four elements of the SWOT analysis. As the developed approach is based on collected and analyzed data, then the information and analysis during this step must draw a clear picture of the area or institution under study. The responsible group for this step must reflect the complexity of the problems facing the body under study and indicate the key points of its strengths and power to stand against these problems using all available materials and experiences such as: published data, reports, opinions, statistics and others. In addition, SWOT analysis must include influencing external and internal factors. The external influencing factors include political, economical, technological, social aspects, etc. The internal factors include institutional capabilities, resources and systems. These factors must be included in SWOT Analysis Matrix shown in Table 3.1. This matrix is formed as an example for SWOT analysis of Housing Sector and can be used for other infrastructure sectors.

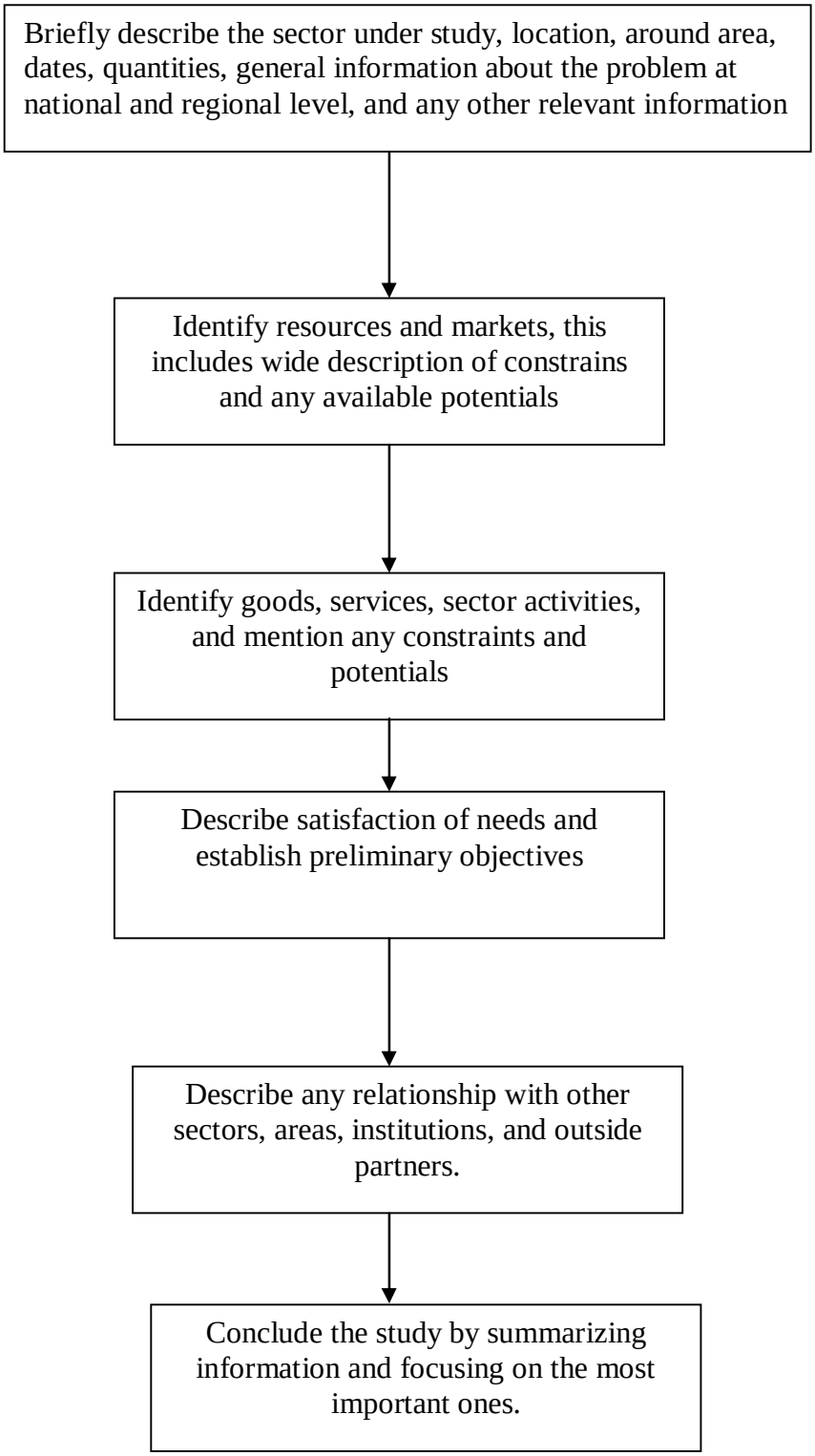


Figure (3.2): Framework for analyzing actual situation.

Table 3.1: SWOT analysis matrix for housing sector (A.B. Zahlan, 1997)

	Internal		External	
	Institutions	**Resources**	**Residents**	**Economics**
Strength	-qualified engineering and design units -high level of cooperation -flexibility in sector structure	-possibility of attracting donors -possibility of developing housing local material	-cooperative and educated	-High possibility of long term investment. -accepted cost benefit income
Weakness	-shortage of regulations - inadequate test material workshops -responsibility conflicts -lack of planning and managerial skill	- low investment -low price of housing units -high cost of exported material -low subsidies -high housing demands	-high population growth - high number of destroyed buildings	- bad economic situation - lack of financial sources -high cost of land
Opportunity	-providing some subsidies and, grants , and soft loans -encouraging co-operative housing to assume leading roles in planning and managing -improvement of infrastructure services	-establishment of necessary credit institutions -Improvement of structural plans and boundaries of cities, towns and villages. - establishment of legal framework to organize property rights and ownership, and rental contracts	-Population structure as market opportunity. - Sufficient and efficient use of governmental lands.	- enhancing privet investment - release of public lands -enhancing economic contribution of financial institutions
Threats	-uncertainties -inadequate power to implement proposed projects	-land confiscation by occupation	-social acceptance of new plans -big migration	-migration of corpus -inadequate privet policy -lack of local industry

3.3.1.2 Phase 2:Step1: **Activity 2:** Interface with Other Systems

This step requires precise inventory of the projects and plans that can influence the concerned field under study. Data about such projects must include exact description of them, their attributes, durability, dates of constructions, costs, previous plans and how can they influence the future planning. For example, when working in strategic planning of road sector within a city, a wide inventory must be done to determine recent developed streets, parking, traffic signs, and all suggested future traffic plans of the city. Beside this information, it is obvious to explain how to get maximum benefits from the existing projects and include them in new planning process as possible.

3.3.2 Phase 2: Step 2: Development of Operational System Model

This step is created in the developed approach in order to allow an open meeting for all planning groups, committees, and analysts. A detailed SWOT analysis review, status quo situation and shared visions must be discussed. Work plan and time schedule for the planning process will be formulated during this step. Terms of reference for each group must be identified. This step ends when each individual participant has specific information about his job and the level of data and analysis he has to prepare.

3.3.3 Phase 2: Step 3: Establishment of functional objectives

Step 2 produces a comprehensive idea about these objectives that can be realistic and meet the institution needs with its power to realize them. The developed approach structure allows separate analysis of objectives and their systematically identifying, categorizing, specifying and balancing. Four important actions must be done for correct objective analysis during this step. These are:

1. Empirical inventory of interests, motives and objectives of all parties concerned (e.g. development goals, sector guidelines, objective of relevant institutions, objectives of different groups of people involved or concerned).

2. Logical analysis of objectives with respect to positive overlapping and/or contradictions or conflicting objectives.
3. Clarification of priority objective to be applied.
4. Specification of the broad objectives identified in the process.

This step ends with generation of a set of objectives for the issue under study, which represents the position of all-relevant parties, and which is accepted by responsible decision-makers.

3.3.4 Phase 2: Step 4: Analyze System Economics

This step is an important one in the analysis needed for strategic planning for Palestine (ADB, 2000). It is also the base step of the developed approach, because it contains the three major elements concerning risks and uncertainties. For this reason, the developed approach divides this step into three activities; each one can be done with separate group of people. These activities are risk and sensitivity analysis, and yearly forecasts. In addition, the step of analyzing system economics must start with discussion and brainstorming of all three groups of people who will do the job (Deborah, 2001). Table 3.2 is an example that highlights some points that can be discussed during brainstorming process within this step and target group of each one.

Table 3.2: Brainstorming session for analysis system economics

Participants	Needs/ problems	Ideas	Constraints	Duties/ previous experiences
Institution high level staff with planning committee	Discuss the future demands of services and institution's weakness to provide them	Generate ideas and ways of solving problems	Discuss economic and financial constraints according to the increasing demands of services	Distribute duties for collecting current data and expected future forecasts according to the previous experiences
Sector managers with planning committee	Identify current and expected future demands	Discuss possibility of improving sector services	Discuss shortage of supports that delay services	Collect previous experience of risks, uncertainties and other constrains
O&M staff with planning committee	Identify any difficulties during operation and maintenance process within the sector	Collect suggestions of best O&M	Identify how can risks and uncertainties affect process of O&M	Collect previous experience(if any) about risks and uncertainties
Economists and statistical experts with planning committee	Discus and analyze future expected demand	Find ways of how will the future forecasts will be done	Discuss possibility of implementing best ways for execution the job	Form groups for collecting and forecasting needed data.

As seen from Table 3.2, three groups must be formed to continue the following work of sensitivity and risk analysis and yearly forecasts

3.3.4.1 Phase 2: Step 4: **Activity 1:** Sensitivity Analysis

In carrying out the sensitivity analysis, this step demands the following tasks (Alfonso, 1997):

a) Identifying the key variables: a set of key variables will be chosen on the following basis:

a-1) Variables that are numerically large, such as investment cost and projected Water demand

a-2) Essential variables, which may be small, but the value of which is very important for the design. For example assumed population growth and water tariffs.

a-3) Variables occurring early in the project life. For example investment costs and initial fixed operating costs, which will be relatively unaffected by discounting.

a-4) Variables affected by economic, such as changes in real income.

In general, these variables that can be considered in water system during sensitivity analyses are summarized in Table 3. 3

b) Calculation of Effect of Changing Variables: the values of basic indication of project viability should be recalculated for different values of key variables. Calculating "sensitivity indicators" (SI) and "switching values" (SV) as shown in Table 3. 4 preferably do this.

c) Analysis of effects of changes in key variables: after calculating SI and SV according to the changes of different variables, the analysis of the results can be done. The higher the SI, the more sensitive the alternative is to the change in the concerned variable. The lower the SV, the more sensitive the Net Present Value (NPV) is to the change in the variable concerned and the higher the risk with the alternative.

Table 3.3: Variables in Water Sector to be considered in Sensitivity Analysis

Possible key variable	Quantifiable variables	Underlying variables
Water demand	- Population growth - Domestic and non domestic consumption - Unaccounted for water	- Price elasticity - Income elasticity
Investment cost (economic & financial)	- Water demand - Construction period - Real price - Conversion factors	
Operation & Maintenance costs	- Personal costs(staff) - Cost of energy - Cost of maintenance - Efficiency of utility	
Financial revenue	- Quantity of water consumed - Service level - Income from connection fees	- Water tariff
Economic benefits	- Water demand - Resources costs saving	- Willingness to pay
-Cost recovery -Revenue -Production Cost	- Water tariff - Subsidies	

Table 3.4: Sensitivity Indicator and Switching Value

	Sensitivity Indicator (SI)	Switching Value (SV)
Definition	Compares percentage change in Net Present Value PNV with percentage change in a variable or combination of variables.	The percentage change in a variable or combination of variables to reduce the NPV to zero.
Expression	$\mathbf{SI}=\frac{(NPV_b - NPV_1)/NPV_b}{(X_b-X_1)/X_b}$ where: X_b: value of variable in the base case X_1: value of the variable in the sensitivity test NPV_b: value of NPV in the base case NPV_1: value of the variable in the sensitivity test	$\mathbf{SV}=\frac{(100*NPV_b)}{(NPV_b-NPV_1)} * \frac{(X_b-X_1)}{X_b}$ $= 100 * 1/SI$

3.3.4.2 Phase 2: Step 4: **Activity 2:** Risk Analysis

The sufficient technique for risk analysis in this step depends on suggested alternatives that will be created to solve the problem (APM, 2000). In cases where these alternatives are expected to be particularly sensitive to certain variables, it has to be assessed how likely it is that such changes would occur (Kosmowski, 2000). This must be done by studying earlier experiences, comparable alternatives, and by investigating the situation in the sector as a whole. Mitigation measures should be taken to reduce the extend of uncertainty surrounding those variables where possible. Table 3.5 shows how can this activity be done at three important levels: project, sector, and national level.

Table 3. 5: Actions to mitigate risk at different levels (Kosmowski, 2000)

At the project level	At the sector level	At the national level
- Ensure contractor performance. - Formulate capacity building activities to ensure technical and financial management of water system - Incorporate the cost of sanitation or wastewater collection and treatment into project economic costs to ensure that environmental effects can be mitigated	- Make price and tariff adjustment to ensure sufficient revenue - Conduct technical assistance programs to develop operational management skills	- Implement legislative reforms and regulation to provide an enabling environment for productive activities.

Many techniques can be used to identify the main risk sources or factors such as check lists, interviews, brainstorming sessions or questioners. The benefits gained from using this analysis can increase the understanding of how can these risks can influence the alternatives and if there is any need to change them (Larry, 1993). Table 3.6 summarizes the principles that must be applied for risk analysis for water sector:

Table 3. 6: Principles to apply for risk analysis

No.	Principles to Apply
1	Identify those variables for which future values are unknown and are likely to affect alternative sustainability. (Key Variables).
2	Fully explain the general nature of the data set that is used for modeling those variables' value (its origin, forecasted projection or any missing data points).
3	If the data derives from subjective sources, explain the method by which it was elicited (e.g., from visual technique, from subjective questioning, from an expert- based process, etc.).
4	Explain the statistical nature of those variables' assigned probability distribution.
5	Make clear the goodness of fit of the distribution to the data set, and quote appropriate statistical measures.
6	Explain and justify the extent of any variable desegregation.

3.3.4.3 Phase 2: Step 4: **Activity 3:** Yearly Forecasts

Infrastructure strategic planning is directly affected by many factors that influence the level and quality of services. Depending on the sector under study, projection for these factors must be done during the process of planning. This step of the developed approach includes a description of the overall future situation, which would be desirable and realistically predicted. Table 3. 7 includes major factors that must be predicted for some infrastructure sectors during future strategic planning.

Table 3. 7: Major forecasts for some infrastructure sectors

Sector	Major forecasts
Water Sector	Population growth/ Water demand/ Water production/ Wastewater generation/ Rainfall/ Balance between water supply and demand.
Road Sector	Population growth/ Traffic load/ Utilities/ Traffic Classifications/ Land Use/ Urban planning/ Drivers/ Size and type of industry.
Solid waste	Solid waste production/ Damping Sites/ Classification of Solid waste/ process of collection.
Energy and Telecommunications	Number of users/ Networks/ Streets/ Resources.

The flexibility of the developed approach allows other forms not included in Table 3. 7 according to the planning committee's evaluation of the situation of the sector under study. The factors can also be classified in other ways to be more specific for each sector. For example, the prediction of each factor can be classified into domestic, commercial, industrial, agricultural, or public services demands. However, in this step, all predicted factors should, in a large extent, define the need of information. The analyst will have to determine the key factors which need to be considered into the analysis and design.

3.3.5 Phase 2: Step 5: Development of Economical Model

Summarizing data that was collected and analyzed from risk and sensitivity analysis, and projecting them into future expected figures will give a brief introduction about the needed solutions by which the problem will be solved (Boulter, 1997). In this step the development of economical model will direct planner into right direction of proposing this alternative that meat expected forecasts with full consideration of benefits-costs constrain. In order to achieve best results from the previous steps of phase 2, this step must be implemented by all members of planning committee. Those will, together, fulfill and analyze the data collected during separate steps and come to consensus what are the best

benefits that can be used from the studied situation. Figure 3.3 is suggested as an example of a flow chart for economic model applied for water and sewage sectors. Each time when this step implemented, the planning committee according to the sector under study must create a similar flow chart as shown in Figure 3.3. By exercising the tasks in Figure 3.3, the planning committee will come to the initial idea about the future alternatives that will be suggested to solve the problem under study. This will be discussed in detail, in the following phases of the developed approach.

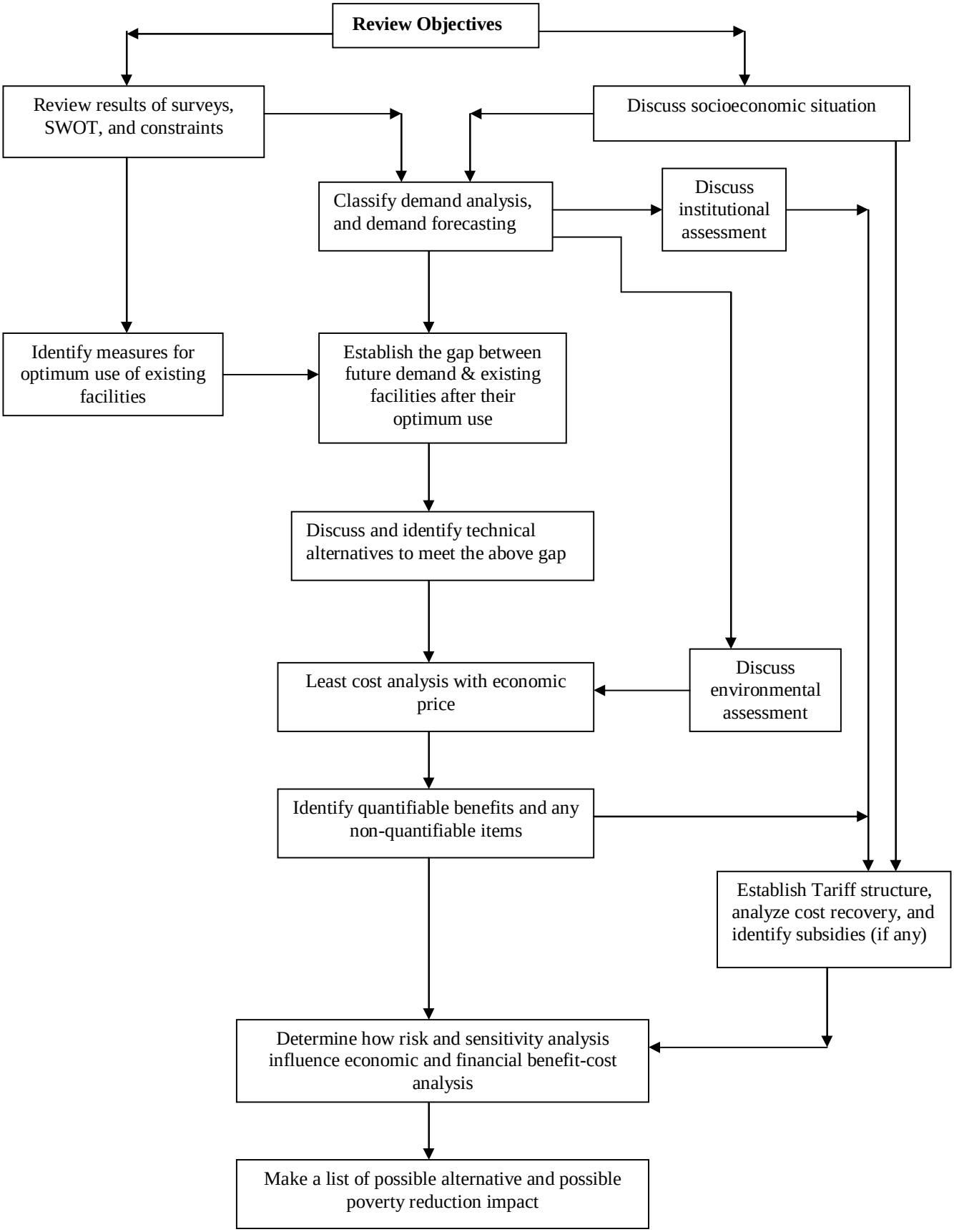


Figure 3.3: Flow Chart for economic analysis model

3.4 Phase 3: Strategic Choice

This is the phase where the planning committee considers alternative strategies and chooses those that the organization will pursue. In this phase the institution mission and objectives will be realized based on the results of the SWOT analyses. Accordingly, a number of strategic alternatives are formulated where each of these alternatives is evaluated in accordance with selected criteria suitable for Palestine. Then, most appropriate alternative is selected as a main direction of the strategy.

This phase is divided into three linked steps as follows:

3.4.1 Phase 3: Step1: Examination of future services and project scenarios

This step of the developed approach requires answers of two important questions. The first one is which choice do we have? and the second is: Which choice do we make? By answering these questions the planning committee can reach to first ideas of comprehensive future alternatives. The planning committee also should identify the needed criteria that will be included later in the process of decision making.

The developed approach proposes the flowchart shown in Figure 3.4 for easy way of finding ideas for future alternatives. As shown in the figure, this step must end with applying relevant and specific criteria for all suggested alternatives. The source of ideas on alternative solutions, that is included in Figure 3.4, may be publications, books, correspondence or own experiences, experiences gained elsewhere or /and by others and general goals, guidelines.

In order to complete the examination of possible implementation the suggested alternatives, this step consists of two activities in the developed approach these are as follows:

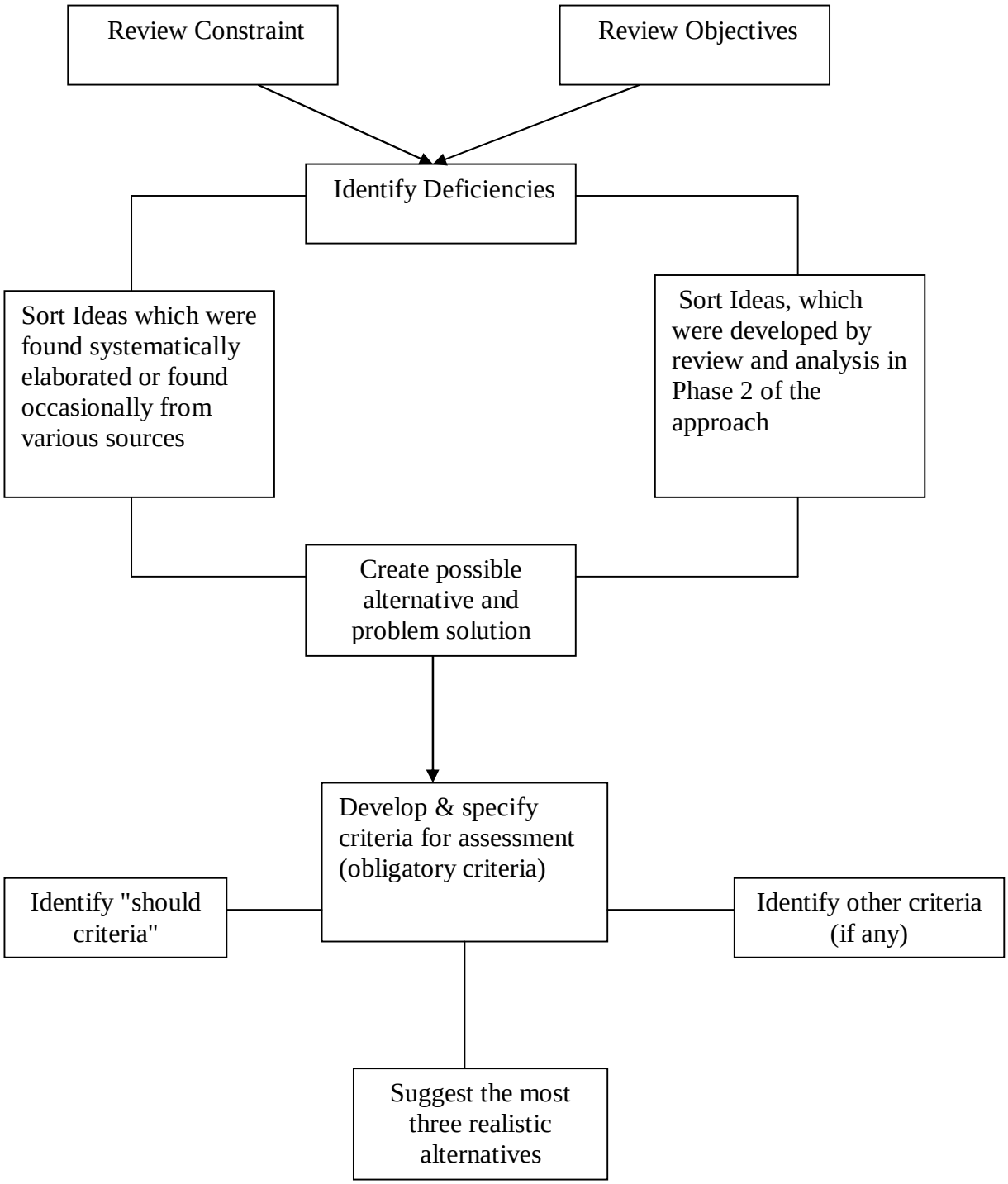


Figure 3.4: Ways of finding ideas on problem solutions

3.4.1.1 Phase 3: Step1: **Activity 1:** Development of alternative design response

In this step, engineering unit must review all suggested alternatives and precede the following job:

a) Make a necessary preliminary design for each alternative

b) Reevaluate the proposed criteria

c) Identify time horizon for alternative implementation and available resources for construction needed facilities.

d) Suggest other criteria (if any) for later evaluation of alternatives.

At the end of this activity, the technical experts will prioritize the alternatives from its point of view according to its study of each alternative. The developed approach suggests an assessment matrix as shown in Table 3.8 that matches different alternatives to be assessed with deferent aspects.

Table 3.8: Matrix of Assessment

Alternative	**A**	**B**	**C**
Criteria 1. 2. 3. 4. .			
Horizon Time			
Construction time			
Construction cost			
Materials			
Priority/ Response			

Assessment matrices should be filled with specific information concerning each alternative according to the preliminary design. The last raw of the matrix must be filled with opinion of engineering unit about each alternative, e.g. the favorite alternative takes number 1, and so on.

3.4.1.2 Phase 3: Step 1: **Activity 2:** Development of alternative operating response

This step is created in the developed approach for consultation with these people who are working in the process of operation and maintenance of the concerned field. In this step all suggested alternatives must be evaluated again, but this time according to the long-term operation and maintenance process. For this reason the following procedure must be implemented:

a) Identify probability of achieving objectives.
b) Review cost-benefit considerations.
c) Evaluate alternatives according to the risks and uncertainties for long term operations and maintenance.
d) Review and modify (if needed) the proposed criteria for later evaluation of all suggested alternatives.

A similar matrix as in Table 3.8 will be formulated at the end of this activity.

3.4.2 Phase 3: Step 2: Screening and Evaluation

This important step in the developed approach requires maximum transparency and attention. All participants (from planning committee) in the planning process through previous phases must participate in this step in order to come to consensus about all comparisons of alternatives. As explained in Chapter 2, AHP will be used in the process of evaluation all alternatives. The job of alternative prioritization in this step requires the following actions:

1. List all proposed criteria that will influence the decision making process: this includes all three kinds of criteria Must, should and other criteria.
2. Formulate Pairwise comparison reciprocal matrix: this is the first step of implementing AHP; the Pairwise comparison reciprocal matrix contains all suggested criteria and compare each criteria against all others. Table 3.9 illustrate how could this matrix be formulated.

Table 3.9: Criteria Pairwise comparison reciprocal matrix

Criteria	Cost	Social impact	Sustainability	Uncertainty	…….
Cost	1	0.333	2	2	
Social impact	3	1	0.333	3	
Sustainability	0.5	3	1	1	
Uncertainty	0.5	0.333	1	1	
…….					1
Total	5	4.67	4.333	7	…..

As seen from the table, the cost is weighted to be three times more important than social impact, which means that the social impact will have 1/3 importance against cost, and so on for all criteria.

3. Determine priority vector: the easy way to determine priority vector is to formulate an other matrix that contains each weight in pairwise comparison reciprocal matrix divided over the total of its column as shown in Table 3.10 below:

Table 3.10: Criteria priority vector

					Priority vector
1/5=0.2	0.33/4.67	2/4.33	2/7	Total of raw =A	**A/T**
3/5	1/4.67	0.33/4.33	3/7	Total of raw = B	**B/T**
0.5/5	3/4.67	1/4.33	1/7	Total of raw = C	**C/T**
0.5/5	0.33/4.67	1/4.33	1/7	Total of raw = D	**D/T**
Total=1	Total=1	Total=1	Total=1	**Total of raw = total of column = T**	**1**

4. Formulate Alternative Pairwise Comparison matrix: in this step all alternative must be evaluated against each criterion separately, which means it is necessary to have a number of matrix equal to the number of criteria. Each matrix must give a clear picture of prioritization of alternatives according to each criterion. For example, three alternative can be compared according to the Cost criterion as shown in Table 3.11:

Table 3.11: Alternative pairwise comparison with respect to each criterion

	Alt.1	Alt.2	Alt.3				**Total**	**Priority vector**
Alt.1	1	2	2	1/2	2/3.5	2/5	a1	a1/t1
Alt.2	0.5	1	2	0.5/2	1/3.5	2/5	b1	b1/t1
Alt.3	0.5	0.5	1	0.5/2	0.5/3.5	1/5	c1	c1/t1
Total	2	3.5	5	1	1	1	t1	**1**

5. Formulate a matrix that includes all alternative priority vectors of pairwise comparison with respect to each criterion. This matrix has the following shape:

Table 3.12: Alternative priority vector of pairwise comparison

	Crit.1	**Crit.2**	**Crit.3**	**Crit.4**	**…..**
Alternative 1	a1/t1				
Alternative 2	b1/t1				
Alternative 3	c1/t1				

6. Composite global priorities: the next matrix is a combination of priority vectors of reciprocal matrix and priority vector of alternative comparison and has the following shape:

Table 3.13: Composite global priorities

	Crit.1	**Crit.2**	**Crit.3**	**Crit.4**	**……**
	A/T	B/T	C/T	D/T	
Alt.1	a1/t1	a2/t2	a3/t3	a4/t4	
Alt.2	b1/t1	b2/t2	b3/t3	b4/t4	
Alt.3	c1/t1	c2/t2	c3/t3	c4/t4	

7. Calculate the priority vector of all alternatives: finally the prioritization of alternatives will be identified by calculation of priority vector as follows:

Table 3.14: Alternative prioritization

	Priority Vector
Alternative 1	a1/t1* A/T+ a2/t2* B/T+ a3/t3* C/T+…….+……..
Alternative 2	b1/t1* A/T+ b2/t2* B/T+ b3/t3* C/T+…….+…….
Alternative 3	c1/t1* A/T+ c2/t2* B/T+ c3/t3* C/T+…….+…….

Alternative with higher priority vector will be selected as first candidate for implementation.

3.4.3 Phase 3: Step 3: Selection from strategic alternatives

Once the alternatives are compared and prioritized, the selected one is highlighted and rearranged. In this step, the planning committee has to prepare a report that includes all documents related to the selected alternative and summarize all previous analysis that were prepared to reach to the selected alternative. As this step has been created to introduce the next work of forming action plan, then the report must include the following:

1. Preliminary design of selected alternative.
2. Expected time schedule for implementing the suggested solutions.
3. Financial and economic analysis.
4. Advantages and disadvantages of the alternative.
5. Any other needed information.

By finishing this step, phase three of the developed approach will result in a clear solution of the problem under study, the following two phases will emphasis the work on the selected alternative and its implementation.

3.5 Phase 4: Implementation

The formulation of strategic plan is done in this phase of the developed approach. The strategy consists of all goals, policies, programs, actions, decisions and allocation of resources that define the institution.

In addition, during this phase, it is necessary to allocate the necessary financial and human resources to realize the strategies, objectives, and plans that emerge from the strategic planning process. An organization structure must also be formed according to the new demands of the plan as well as the allocation of staff and tasks to be completed. This means that the selected strategy must be translated to the level of individual activities or stakes. Every action to be taken by initiating responsible body in order to implement the strategy, to promote the achievement of results, to manage the process, and to monitor the progress. In other words this phase of strategic planning is concerning the formulation of action plan. The action plan may also include the actions of other agencies, private companies, and

other stakeholders. The action plan should specify the following information for every action:

1. Clear description of the action.
2. Time frame for the execution of the action.
3. Organization responsible for the execution of the action.
4. Means of implementation of the action (budget, tools).

At the end of this phase, an action plan with clear description of each task and each project must be formulated with indicated starting dates for each task.

3.6 Phase 5: Monitoring

The main purpose of this phase as an integral element of strategic planning is to ensure that the activities of all participants in the process relevant to the success of the sustainable Infrastructure future plan are being executed and result in the desired outcome. This feedback mechanism makes progress or lack of it visible (ESCAP, 2002). The developed approach suggests the following ways to monitor progress:

1. Statistical information collection and dissemination on infrastructure services, use, demand and supply, etc.
2. Qualitative study.
3. Inspection or supervision by separate government agency.
4. Use of indicators.

In addition, this phase requires preparations of set of indicators at the start of the project and report on them in an annual basis from the second year of the implementation of the project. The following are some indicators suggested for a sustainable water future:

- Quantity or Demand-Supply balance.
- Quality or ratio of pollutants in water such as NO3, Cl^-, etc.
- Affordability of water services.
- Accessibility of water resources.

The results of the monitoring exercise will provide the institution with important data and information to evaluate the progress in the course of the planning cycle. In the evaluation of this material it may become obvious that certain policies,

instruments, and process arrangements need to be changed. This insight moves the process forward in a new cycle, towards an adjustment of the strategy or the plan.

3.7 Conclusion

Figure 3.1 illustrates the developed of a hybrid risk-informed approach for strategic planning of infrastructure in Palestine. This approach has been developed after recognizing the limitation of many applying approaches mentioned in Chapter 2 and other similar approaches used in the world. Phases, steps and activities included in the developed approach allow flexible use of all information and previous experiences needed to better diagnosis of the problem under study. The decision making process within the approach requires also maximum participation of responsible bodies for identifying most needed criteria for best results. In addition, monitoring process at the end of the planning process insures better evaluation of achieved goals and continues evaluation of the whole process.

In this approach, risks and uncertainties are main factors in the strategic planning of infrastructure. Chapter four of this research is included to show a case study for the implementation of this approach in water sector for Gaza City. For this purpose the following chapter four also will focus on a review of water situation in Palestine and the City of Gaza.

CHAPTER FOUR

IMPLEMENTATION of THE DEVELOPED APPROACH for WATER SECTOR in GAZA CITY

4.0 Introduction

The practicality of the developed approach for use in real life application is demonstrated in this chapter. Selecting Gaza City as a pilot area for implementing this approach has been decided because of the importance of this city in Palestine. Gaza is the biggest city in Palestine with the highest population, the gap between water demand and supply in this city is very big, and water quality is very poor. Thus, comprehensive strategic planning of water sector in Gaza can influence that one in Palestine. Solving the problem of water in Gaza City well help in Strategic Planning of water in the whole country and make the methodology of using strategic planning easy work to be implemented.

The implementation of the proposed approach has been based on real data collected from many sources related to this field in the city. Consultation with responsible people from Municipality of Gaza and Palestinian Water Authority has helped the planning committee (the author) in making needed discussion of the problem and proposed solutions. Moreover all needed forecasts and analysis have been made according to the proposed methods stated within the developed approach and as discussed in previous chapters.

The five phases of the developed approach have been implemented in the case study as discussed in the following sections.

4.1 Case study: Phase 1: Preparation for Planning

This phase of strategic planning requires forming Planning Committee that will be responsible for the planning process. For this purpose, the researcher has acted as a planning committee with consultation with influencing people from different relevant institutions.

4.2 Case Study: Phase 2: Information Diagnosis

4.2.1 Case Study: Phase 2: Step 1: Analysis of existing conditions

4.2.1. a General information about Gaza City

Gaza City is located along the coast of the eastern Mediterranean Sea stretches over a distance of 10 km from Jabalia in the north to Wade Gaza in the south; the total area of the city is about 38 square kilometer. The current population of the city is about 400,000 and more than 100,000 from other cities are visiting, working, or studying in Gaza every day (PCHR, 2002).

Most public and private commercial and other institutions have their headquarters in Gaza. Furthermore, it can be considered as one of the most important centers for tourism and recreation in PNA territories. The city has no major industries and only small light industries and workshops. Population average growth rate is about 3.5% per year (PCBS, 1996).

After the peace accord signed in 1993, Gaza, for the first time, has been managed by Palestinian Administration. However, the long time period of occupation has destroyed the city infrastructure and has led to a very critical environmental scarcity and later, complex constraints to rebuild the city or even to improve its damaged infrastructure.

While various efforts have been exerted to improve the city, the second Intifada began in October 2000. The political, social, and economic situation of Palestinians in the city has dramatically declined. Since the beginning of Intifada, an estimated 75,000 Palestinian jobs (in Israel) have been lost, of which 22% is from Gaza City only, affecting some 150,000 of Gaza City residents (USAID, 2002). Unemployment has jumped from 10% to 43% and the estimated number of people living below the poverty line of $2 per person per day has increased to nearly half of the population of the city (PCHR, 2002).

4.2.1. b Water Supply

In general, current water situation in the world is critical. World Bank reports that one thousand million people remain without access to safe drinking water and more than 1.7 thousand million people do not have adequate sanitation in 1993 (World Bank, 1994).

The future of water in the world is highly uncertain. Some of this uncertainty is due to relatively uncontrollable factors such as weather. But other critical factors can be influenced by the choices made by human beings. These factors include income and population growth, investment in water infrastructure, allocation of water to various uses, reform in water management and policy decisions (CEC, 2002).

In 1995 the world withdrew of 3906 cubic kilometer of water was observed while the total global withdrawals is projected to increase by 22% in 2025, to 4772 cubic kilometer (Rosegrant, et al, 2002). Table 4.1 shows the water consumption by region, for 1995 and 2025.

Table 4.1: Per capita water consumption by region (m^3/C/year) (FAO, 1996)

	Asia	Latin America	Sahara &Africa	W. Asia N. Africa	Developed countries	Developing countries
1995	25	24	23	22	48	26
2025	37	37	18	25	54	35

There is no doubt that the period from 1970 to 1990 was the struggle for petrol in the Middle East countries. However, the present and the coming period are expected to be a struggle for water (Refaat, 1993). One of the most important reasons of these conflicts is that most of the Middle East countries are located in an area where water resources are extremely scarce (FAO, 1996). Competition among agriculture, industry and cities for limited water supplies is already constraining development efforts in these countries (Weissbach, 2000). As populations expand and economies grow the competition for limited supplies intensify and so will conflicts among water users. Moreover, the annual renewable

water resources in most of these countries as shown in Table 4.1 are less than 1000 m^3 per capita/year. Also, most major river systems in these countries cross international borders, making water shortage subject to political conflicts. Water issues are also still one of the most complex subjects in peace talks between Israel and all countries around it, including Syria, Jordan, Palestine, and Lebanon (Aris, 2000).

Future pictures of water situation still not clear in these countries in the region that are suffering from water scarcity and political unstable situation (Jad Issac & Leonardo Hosh, 1992). The current Intifada in Palestine and the occupation of Iraq are expected to raise the conflicts to a very critical level, especially if the water improvement projects suffer from delays as a result of these unstable political situations. The World Bank reports that the countries around Palestine are already suffering from big gaps between water demand and water supply and the problem will increase dramatically in the future. Table 4.2 has been prepared by World Bank and illustrates a comparison between these countries regarded to water resources and use.

Table 4.2: Water resources and use: Regional comparison (World Bank, 1999)

	Israel	**Jordan**	**Syria**	**Lebanon**	**WBGS**
Resources (billion m3/year)	2.1	0.8	5.5	4.8	0.2
Consumption (billion m3/year)	1.9	1.0	3.2	0.8	0.28
Per capita consumption (m3/yr)	375	213	385	1200	115
Renewable resources (m3/c/yr)	290	229	1861	1199	134
Groundwater (% of renew resources)	60	28	16	63	94
Ground water use (% of recharge)	N.A	155	143	N.A	288
Dependency ratio (%from outside)	46	20.7	80	0.8	5.7
Water use (% of water resources)	122	91	48	27	88
Agriculture use (% of total)	65	69	98	68	82

WBGS: West Bank and Gaza Strip

In brief the current bad water situation in the region is directly affected by political situation. Since the 1967 occupation of the West Bank, Gaza, and the Golan Heights, Israel expanded its control over water resources in the area. This control was extended after Lebanon Invasion in 1982 to include some parts of Litany River. According to the Table 4.2, Israel consumes 1900 Mcm of both surface and ground water. Of this amount, about 50% originate in neighboring Arab states, Golan Heights and the West Bank (Arie, 2000)

At the national level, in Palestine and (Israel), the problem of water scarce is more complex than other countries in the region. Nearly 60% of the consumed water is used for agriculture purposes; only 40% of total consumption figures are for domestic and industrial use (PASSIA, 2002). Growth of population and changes in the Socio-economic context, however, will cause domestic and industrial consumption to increase.

Water scarcity has played a very large part in the conflict between Palestine and Israel. This conflict has started when Israel declared all water resources to be state owned and controlled by the military. A military order 158 (in 19 November 1967) prohibited Arab population from drilling new water wells and transferred the majority of its water into Israeli settlers. In Palestine the current total water consumption for all purposes is about 75 liters per capital per day, compare that with the consumption in Israel proper which averages about 350 liters per capital per day (PASSIA, 2000).

4.2.1. c National Water Resources

The main water resources in Palestine are limited, even before Israeli occupation for Palestinian territories. The most important ones of these resources are:

i) Ground Water

Major water resources in Palestine are coming from rainfall stored in aquifers, return flow from irrigation, sewage effluent, and water leakage from pipes. The West Bank aquifer system that is estimated at 630 Mcm has three major basins: the western basin located between Israel and West Bank mountains, the Northeast

basin located near Jenin and Nablus, and the Eastern basin located within West Bank (Abu Zahra, 2000). Gaza aquifer is a part of Coastal Aquifer, which is estimated at 42 Mcm. It used to be partially recharged from Wadi Gaza coming from Hebron, but after stooping the Wadi by Israel the aquifer has been over pumped.

ii) Surface Water

Only Jordan River is a surface water resource in Palestine. Even thought, more than 75% of its water is diverted by Israel before it reaches West Bank.

iii) Springs

There are 297 sprigs in West Bank from which only 114 are considered the main ones from which the annual discharge is amount of 65.9 Mcm as Jerusalem Water Undertaking (JWU) estimates.

Table 4.3 summarizes the ground water resources in Palestine and shows how limited they are. The figures in the table are as mentioned in peace talks (Oslo B, Article 40), (Appendix B).

Table 4.3: Ground water resources in Palestine (Mm^3) (Abu Zahra, 2000)

Basin	Israeli consumption	Palestinian consumption from wells	Palestinian consumption from Springs	Quantities available for development	Total estimated yield of aquifers
Western	340	20	2	-	362
Northeastern	103	25	17	-	145
Eastern	40	24	30	78	172
Gaza Aquifer					55
Total	483	69	49	78	734

By comparison, the water problems of Gaza Governorates are greater. More than one million people are living there with very limited water resources. Surface water does not exist; rainfall is low, varying from 400 mm per annum; and the coastal aquifer is over pumped. Only 60,000 in the Gaza strip drink water that is within contamination limits recommended by the WHO. (Abu Maylah & Aish, 1997).

4.2.1. d National Water Consumption

Currently, Palestinians are using 279 Mcm annually to supply their domestic, industrial and agriculture needs (NWP, 2000). While Israel's population consumes more than 1900 Mcm. From these figures if agriculture uses are excluded, El Najah University Report in 1999 indicates that the total water use by municipal and industrial sectors in Palestine during the same year was 101 Mcm from which 52 Mcm in the West Bank and 49 Mcm in Gaza Strip. The expected increase in demand due to the population growth and the realization of more acceptable consumption rates in 2025 is estimated at 300% of which 57% is for agriculture uses (Isam Shawwa, 2000).

4.2.1. e Water Quality

Gaza aquifer and some potential sources from the eastern aquifer in the West Bank suffer from a high salinity rate. In addition, coastal aquifer that includes Gaza is suffering from other pollutants that are present as a result of seawater intrusion or sewage leakage into ground (Kimberley & Dixon, 1995). Table 4.4 shows the portability of ground water in Gaza Strip.

Table 4.4: Quality of ground water in Gaza Strip

Dissolved Substances	Allowable concentration (ppm)	Gaza Concentration (ppm)
Total Dissolved Solids	500	1200-3200
Sodium(Na^{+})	20	300-1100
Chloride (Cl^{-})	250	400-1500
Calcium (Ca^{+2})	36	40-120
Sulfate ($SO4^{-2}$)	250	50-400
Magnesium(Mg^{+2})	30	40-120
Bicarbonates (HCO_3^{-})	225	300-700
Potassium (K^{+})	40	6-10
Nitrate (NO_3^{-})	45	40-140
Fluoride (F)	1.5	0.4-2.90

4.2.1. f Planning of Water Sector in Palestine

In Palestine, future-oriented strategic planning has only recently begun and it revolves mainly around political matters, relations, agreements and related issues.

In contrast to other countries, Palestine is trying to build itself from within a vacuum, borders are not known, resources are not defined and exchange with other countries are not allowed.

However, recognizing the deteriorating water situation had led the Palestinian National Authority (PNA), i.e. the Ministry of Planning (MOPIC), the Palestinian Water Authority (PWA), and the Ministry of Agriculture (MOA), to set overall policy and make several initial planning decisions (Metcalf & Eddy, 2000). These were:

i) The preparation of water sector strategic planning study for the West Bank and Gaza Strip, setting overall planning guidelines for water supply and usage in the Gaza Strip and West Bank.

ii) Implementation of legislation to form a coastal municipalities Water Utility to manage water supply and distribution throughout the Gaza Strip in a self-sustaining manner under the regulatory authority of PWA.

iii) Planning for a Gaza Strip wide water distribution system to provide adequate quantities of good quality water to all residents.

iv) Planning for three regional wastewater treatment plants along the eastern boarder, to treat wastewater produced in Gaza Strip to quality satisfactory for use in the irrigation of agriculture when required and recharge into the aquifer when not.

In parallel, efforts were directed towards upgrading of human capabilities and institutional development and reforms. Beside these efforts, many initiatives were tried to develop an effective approach that can be adopted to regulate the interrelation between the relevant institutions that work in the water sector and the consumers. PWA, Municipalities, Local Governments and donor agencies have tried to find suitable solutions for many problems and to put a list of priorities for

many projects. During these efforts, PNA has many agreements and contracts with international companies to help in making strategic plan and to hold a training program for local staff in order to improve their skills in management of water sector (USAID, 2002).

Despite of the great efforts that have been done by all actors working in the water sector, the problem of water has not been solved yet. It has become more complex after the start of the Intifada in September 2000. During the Intifada, Israel has destroyed many projects that have been started since 1993, and has destroyed a lot of agricultural lands and water wells in order to reduce water consumption from Palestinian side (PCHR, 2002; USAID, 2002). These new realities require reviewing of current planning and the adoption of a more effective planning approach that account more effectively to existing uncertainties.

Moreover, PWA in cooperation with many donors has created Palestinian National Water Plan (NWP). This plan has been constructed in order to provide a concise document, which provides a clear presentation of the vision, objectives, and related actions to accomplish these objectives to the various target groups. The planning approach has been based on estimate of demand for planning horizons up to 2020, and has been compiled on assumption regarding the outcome the current bi-lateral and multi-lateral negotiations in the region (NWP, 2000). The major assumptions that have been made in this regard were:

i) The availability of at least 388 Mcm/yr for the Palestinian use from the West Bank Mountains aquifer.
ii) The availability of at least 120 Mcm/yr for Palestinian use from Jordan River.
iii) The availability of at least thousand dunnams of suitable irrigation land in the Jordan valley.

If these further naturally occurring fresh water resources were not made available to Palestine, an overall deficit between demand and available supply of almost 107 Mcm/yr would result by 2020 (NWP, 2000).

4.2.1. g Current Water Conditions in Gaza City

The high population density in combination with poor water resources and years of heavy extraction has produced a crisis of absolute water availability in the city. This has led to unsustainable use of Ground Water that resulted in aquifer deterioration and seawater intrusion, and thus, high pollution of water resources.

Municipality of Gaza produces about 27 Mcm of fresh water annually. This amount of water is pumped from 29 water wells allocated in Gaza and some of them in Jabalia (See attached map in Appendix D). Table 4.5 shows the production of these wells during 2002 by months. The amount of produced water increases annually according to the water demand and Socio- economic development of the residents of the city. Table 4.6 illustrates the water production in Gaza City during the last twenty years.

Table 4.5: Gaza Municipality Wells Production through Year 2002/ (in Cubic Meter)

Table 4.6: Gaza Municipality water wells production from 1980

Year	Production (m^3)	Increase (m^3)	Increase %	Remarks
1980	18151100			
1982	18187800	36700	0.2	
1984	18271900	84100	0.4	
1986	17837300	-434600		First Intifada
1988	17291400	-545900		First Intifada
1990	20345600	3054200	17.6	Gulf War
1992	20573500	227900	1.10	
1994	21712800	1139300	5.53	
1996	22003700	290900	1.34	
1998	24804503	2800803	12.73	Return of PNA
2000	26250120	1445617	5.8	
2002	27714056	1463936	5.57	

Source of Amount of Produced Water: Municipality of Gaza/ Water Department. Other information is calculated accordingly.

The main water source in Gaza City is the coastal aquifer from which all quantity of water for the city needs is pumped. Recharge to the ground water in the city is primarily through infiltration of rainfall, return irrigation, and wastewater recharge. Rainfall infiltration has three major basins within the city. First basin is Sheikh Redwan reservoir that can contain more than 500,000 cubic meter of rainwater with infiltration rate of 15 cm/day. American Palestinian friendship Park is the second basin, of capacity of 25,000 cubic meters with infiltration rate of about 25-30 cm/ day, and Asqula Waqf reservoir with capacity of 20,000 cubic meters and infiltration rate less than 8 cm/day (MOG, 2000).

Gaza has one treatment plant that can treat about 40,000 cubic meter of wastewater daily. This amount of treated water is partially recharge into the ground (17,000 cubic meters) by four recharges bonds allocated south of the city, and the second part is pumped to the sea. As the MOG future plans, this amount of water will be used for irrigation in the future when the quality of treatment improved (PADCO, 2000).

World Health Organization (WHO) water quality criteria are being used to monitor the quality of water pumped to the city of Gaza. According to these criteria and test results for 25 water wells in the city, only 8 wells out of 25 wells have acceptable water quality. Table 4.7 shows the test results for water wells in

Gaza City in deferent periods, these tests have been done by Preventive Health Section of the Municipality's Health Department that is responsible for monitoring water quality.

The water and wastewater department in MOG includes four sections: Water, Wastewater Network, Pumps and Well's maintenance, and Wastewater Treatment Plant. The water and wastewater department's 240 employees comprise about 14% of the municipality staff. Many other departments within the municipality are connected with the water and wastewater department and give it needed support. Table 4.8 illustrates the relationship between water and wastewater department with other departments within MOG.

Table 4.7: Water Quality for Water Wells in Gaza City:

Table 4.8: Relationship between water department with other departments in MOG

Section/ Department	Duties
Prevention Health Section/ Health Department	Inspection new water lines, monitoring water quality, monitoring water tanks in high-rise building
Environmental Awareness Section	Educating and informing the publishing
Road Maintenance Section	Road maintenance after maintenance of water or wastewater networks maintenance
Project Preparation and Design Department	Design of water and wastewater utilities
Financial Department	Subscriber' account
Inspection and follow up Department	Ensuring water meter are not tampered with
Public Application Section	Receiving public application
General Inspection Department	

Summaries of cost data for water supply and wastewater generation are given in Table 4.9 and Table 4.10. Having in mind the current dramatic economic condition of residents of the city, the process of billing collection is going too slow with maximum bill collection of less than 20% of actual bill value (information from financial department in MOG). The data given in Table 4.9 and Table 4.10 are made for these conditions before the beginning of Intifada.

Table 4.9 Cost data for water sector in MOG

	ACTUAL 2000	ACTUAL 2002
Operating Expenses	**NIS**	**NIS**
Salaries	1,120,300.00	1.095,210.00
Temporary employment	210,000.00	198,000.00
Overtime	507,123.00	314,117.00
Social security	203,117.00	200,000.00
Inflation allowance	118,405.00	120,000.00
Contracted labor	72.120.00	80,000.00
Travel	100,000.00	5000
Gasoline & Oil	71,810.00	75,554.00
Motor repairs and spares	103,130.00	120,000.00
Water meter	72,045.00	61,000.00
Energy	4,800,416.00	5,655,000.00
Others	4,000.00	7,000.00
Subtotal	**7,382,463**	**7,930,881**
Support Department Costs		
Financial Department	60,000.00	60,000.00
Personnel department	30,000.00	30,000.00
Garage	100,000.00	100,000.00
Health and environment	20,000.00	20,000.00
Inspection and follow up department	40,000.00	40,000.00
Other departments	130,000.00	130,000.00
Other expenses	150,000.00	150,000.00
Subtotal	**530,000.000**	**530,000.000**
Depreciation	**4,812,214.00**	**4,812,214.00**
Grand Total	**12,724,677.00**	**13,273,095.00**
Billing/collection		
Billing	19,531,000.00	21,312,000
Collection	11,737.610.00	4,000,000.00
Collection %	61%	18.7 %
Quantities		
Quantities of water produced per year	26,250,120 m^3	27,714,056 m^3
Quantities of water sold	18,310,000	19,207,000
Water losses %	30%	30 %
Unit cost NIS/m^3 (before depreciation)	0.43	
Unit cost NIS/m^3 (after depreciation)	0.695	
Current Tariff		
1-10 m^3	0.30	
11-20 m^3	0.50	
>21 m^3	0.90	
Plus fixed charge of 3 NIS/month	3.00	

Source:

1. Actual costs on a cash basis for 2000 from annual account
2. Billing and quantity figures from the water department of MOG
3. Support department costs were estimated by the relevant departments

Table 4.10: Cost data for wastewater sector in MOG

	ACTUAL 2000
Operating Expenses	**NIS**
Salaries	810,124.00
Temporary employment	413,000.00
Overtime	810,000.00
Social security	170,000.00
Inflation allowance	106,800.00
Contracted labor	95,000.00
Travel	130,000.00
Gasoline & Oil	160,120.00
Motor repairs and spares	50,000.00
Energy	1,720,230.00
Others	
Subtotal	**4,465,274.00**
Depreciation	**1,800,000.00**
Grand Total	**6,265,274.00**
Billing/collection	
Billing	3,970,000.00
Collection	2,842,650.00
Collection %	71 %
Quantities	
Quantities of wastewater collected per year	15,000,000 m^3
Unit cost NIS/m^3 (before depreciation)	0.30
Unit cost NIS/m^3 (after depreciation)	0.42

Source:
1. Actual costs on a cash basis for 2000 from annual account
2. Billing and quantity figures from the water department of MOG
3. Depreciation estimated

In addition, the number of house connection according to the water consumption is presented in Table 4.11 for the whole city.

Table 4.11: House connections for water supply system in Gaza

Water consumption	Number of House Connections
0-0 (closed)	4286
From 1 to 10 m3/month	2347
From 11 to 20 m3/month	2789
From 21 to 30 m3/month	3212
More than 31 m3/month	21022
Service connections	8756
Total	**33656**

Source: Finance Department- Municipality of Gaza. Updated in June 22, 2003

4.2.1. h Analysis of Information

As a result of reviewing water situation in Gaza City, the City water situation is going to be a huge constraint for the development of the city. Three major problems are facing the city and will make the water sector as first priority to be improved within Municipality and also at national level. The first problem is demand-supply balance that indicates big gaps in near future as will as current present. The quantity of pumped water shown in Table 4.4 are already exceeded the allowed amount that the aquifer can produce. This big gap with limited water resources has raised many risks concerning water quality because of deteriorating the ground water aquifer. The second major constrain is the institutional framework with limited number of skilled managers and approximately equal amount of wages and overtime, which means that the same people are working all time all operation and maintenance requirements. The third problem is benefit-cost income and bill collection that indicates the very poor efforts exerted in analyzing economic benefits of projects related to water sector in MOG and unsuitable water tariff. Even the running costs are covered as shown from Table 4.9, but the profits can not cover any new improvements of the system.

As shown in Figure 3.1 this step consists of two activities as follows:

4.2.1.1 Case Study: Phase 2:Step1: **Activity 1:** SWOT Analysis

In Gaza city, the responsibility of water sector management still in hands of Municipality of Gaza (MOG) with high supervision of PWA. Municipal staff is doing all maintenance and operation activities. PWA finances some projects within the city, but all running costs are in direct responsibility of MOG, and so on are the revenue. Because of the tied relationship between MOG and PWA, Table 4.12 summarizes the key points through SWOT analysis for both institutions within Gaza City related to the water sector.

Table 4.12: SWOT analysis of Gaza City

	PWA & MOG	Resources	Residents	Economics
Strength	-High qualified & trained staff -Availability of new structure changes within the institution -Long established, strong and stable relationships between each others	-High possibility for attracting donors	-Strong local community -Well educated -Cooperative	-Big market for sold water
Weakness	-Limited regulation and conflicts in responsibilities -Hard condition for work and communication -Narrow range of sectors	-Low investment in water projects -Low wages and incomes -Low revenue from water projects -Low tariff -Big gap between water demand and supply -Low governmental subsidies	-Low commitment toward public projects -High population growth.	-Bad economic situation -Low incomes -Lack of outsider investors
Opportunity	-Availability of getting grants and soft loans -Political agreements will encourage donors -Improvements of services -Availability to build increased cooperation and linkage between communities	-Reduce water leakage -Encourage privet sector -Establish adequate tariff structure	-Population structure as market opportunity	-Enhance the economic contribution of financial institutions.
Threats	-Uncertainties as a result of unstable political conditions -Power for implementation proposed projects	- Draughts seasons that can reduce recharged amount of rainwater	-Social acceptance of proposed new strategic projects	-Continues out migration of corpus -Failure of private sector policy.

4.2.1.2 Case Study: Phase 2: Step 1: **Activity 2:** Interface with other systems

Some projects in Gaza City has been constructed since the establishment of PNA, some others are still under construction. To get the best benefits from these projects within the planning process for the city, Table 4.13 shows those projects

that will influence strategic planning of water sector and can be used within the future decision making process.

Table 4.13: Projects related to water sector in Gaza City

Project	Status	Effect on Water Sector
Gaza Wastewater Treatment Plant(expanding and rehabilitation)	Project implemented in 1998.	Aquifer recharge, and reuse in agriculture. Amount of treated wastewater is about 40,000 cubic meters daily.
Sheikh Redwan reservoir (expanding and development)	Third phase has been finished in 1999.	Stores and recharges rainwater into ground (capacity of 600,000 cubic meters).
Palestinian American Friendship Park	Constructed in 1998.	Collects and recharges rainwater into ground (capacity of 30,000 cubic meters).

4.2.2 Case Study: Phase 2: Step 2: Development of Operational System

According to the previous analysis, it is possible now to set up suitable institutional framework that can help in later phases of strategic process and its implementation. Two frameworks are suggested for this purpose, one has been already implemented in PWA, as shown in Figure 4.1, and the other is suggested for Gaza City as shown in Figure 4.2. The main tasks of responsible bodies shown in Figure 4.2 are: development of clear policy and strategic principles for water sector, establishment of functional objectives to solve current and future problems of water sector, and participating in strategic planning process with needed information and actions.

It should be noted that the author of this research has done this task with consultation with all bodies defined in the figure. First action that this committee can take is identifying vision, mission, and goals. These statements have been defined similar to these ones assumed in PWA strategic plan in order to avoid contradictions, and they are defined as following:

Vision: the equitable and sustainable management and development of Gaza water resources.

Mission: to secure an environmentally sound and sustainable development of water resources through efficient and equitable water management.

Goals: to find the optimum way to manage, protect, and conserve the limited water resources.

The suggested new chart of water services within the city is shown in Figure 4.3.

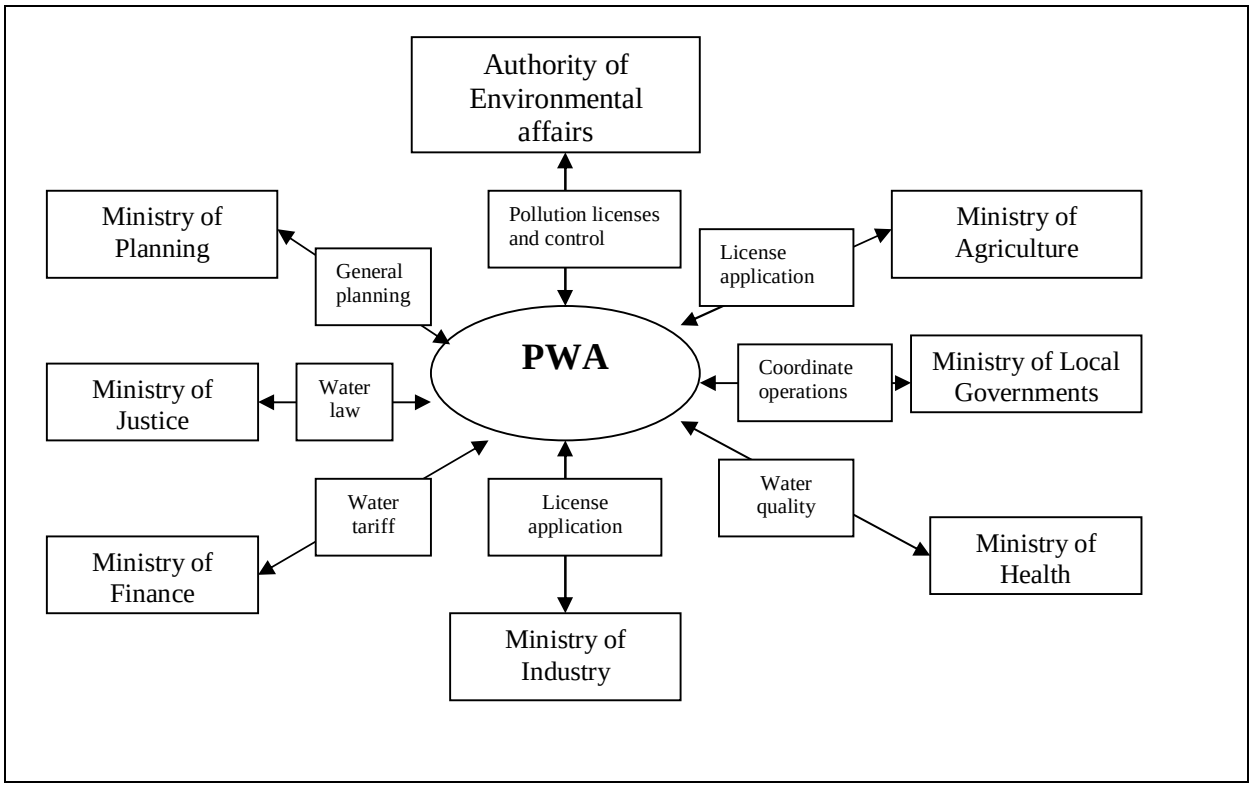


Fig 4.1: Inter- ministerial Co-ordination in water sector in Palestine (NWP, 2000)

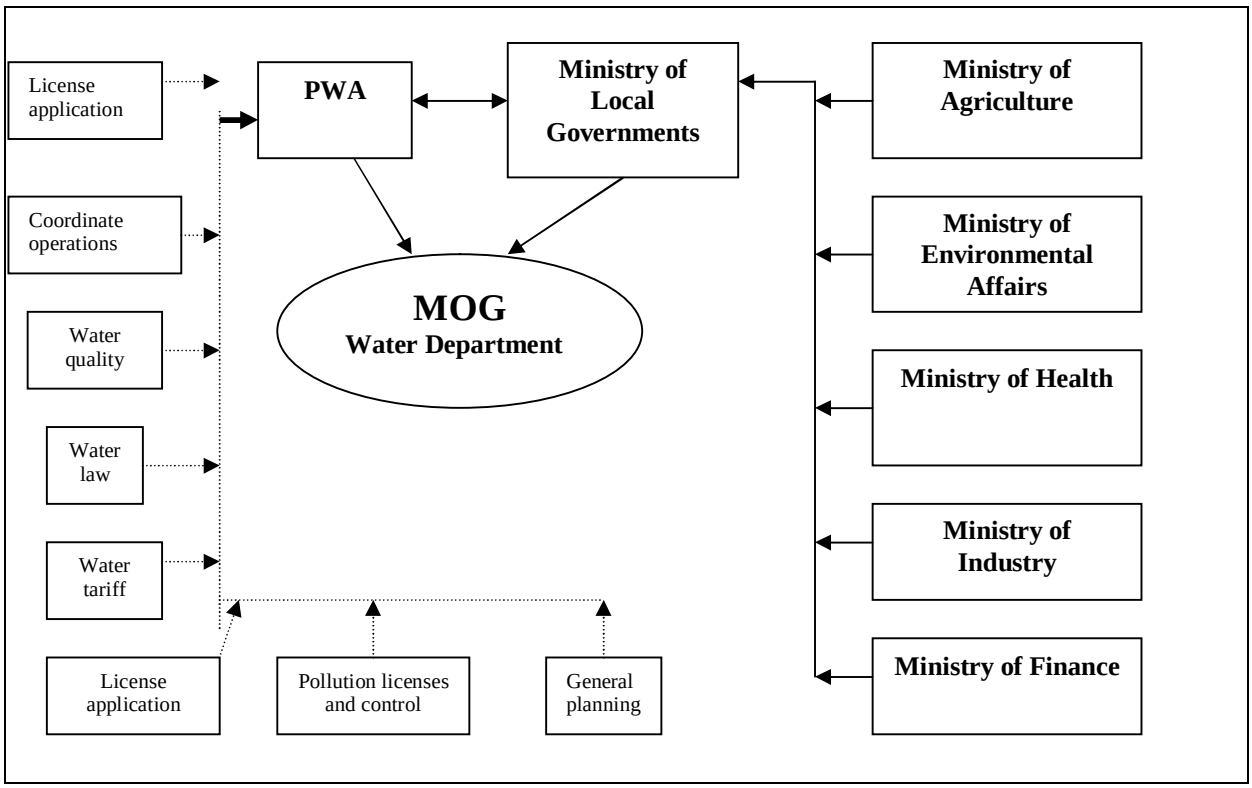


Fig 4.2: Inter- ministerial Co-ordination in water sector for Gaza Municipality

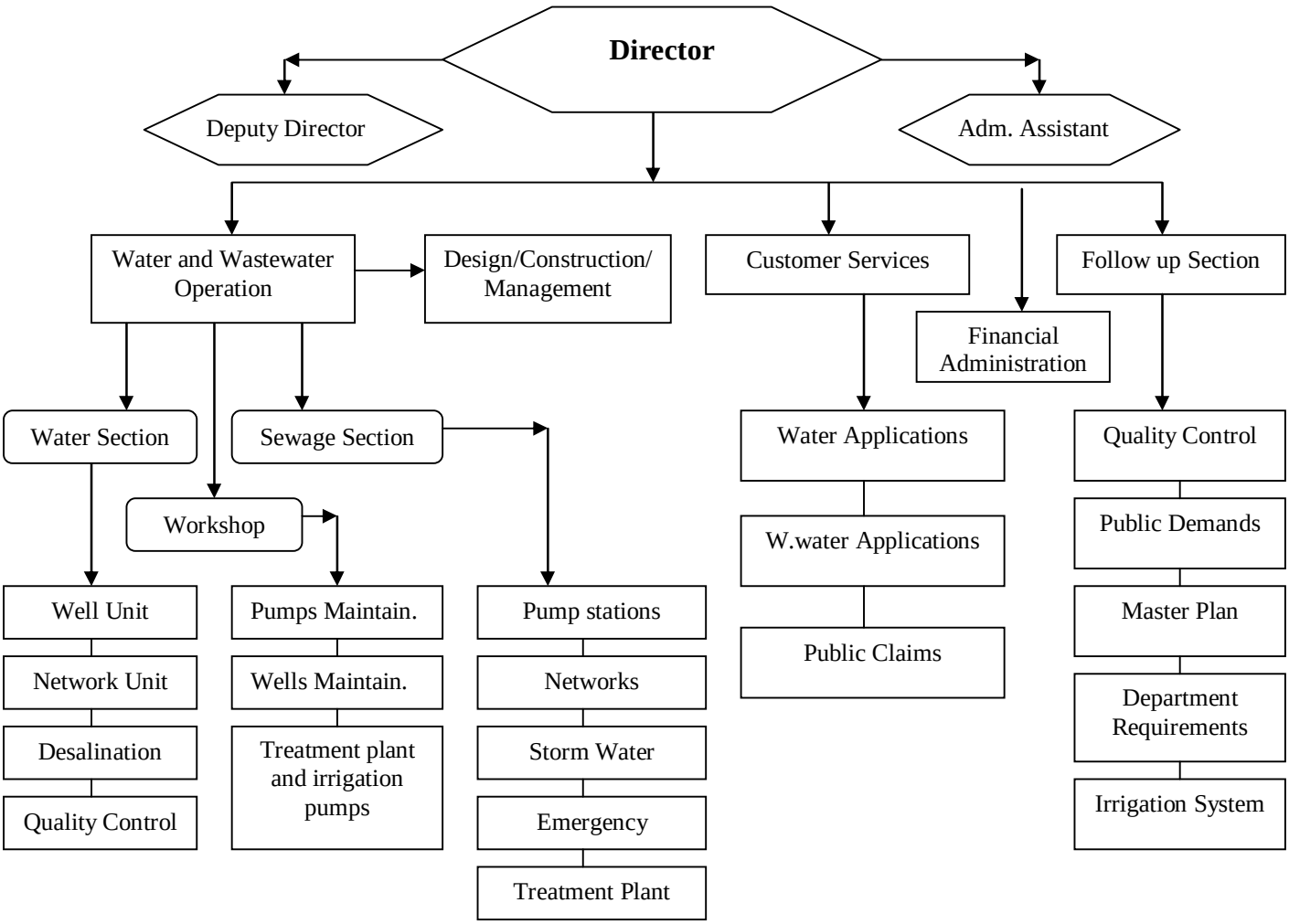


Figure 4.3: Proposed Flowchart of Water Services for Municipality of Gaza

4.2.3 Case Study: Phase 2: Step 3: Establishment of Functional Objectives

As a result of water situation analysis in Gaza City and according to the assumed vision, mission and goals for the water sector in MOG, reachable and functional objectives have been established. The main objective found after consultation with responsible bodies and institutions is to find the optimum way to manage, protect, and conserve the limited water resources with minimum water supply of 120 L/C/day, and water quality that meat WHO standard. All regulations and new law of water system will be taken as PWA new regulation (for this purpose see NWP of PWA).

4.2.4 Case Study: Phase 2: Step 4: Analysis of System Economics

The brainstorming session discussed in Chapter 3 for this step is implemented by consultation of all related bodies to the water sector in Gaza City. All elements mentioned in Table 3.2 were fully discussed in detail by the author who has done complete the task instead of a planning committee.

This step consists of three activities as follows:

4.2.4.1 Case Study: Phase 2: Step 4: **Activity 1:** Sensitivity Analysis

First step towards sensitivity analysis is identifying the key variables for water sector of Gaza City. These shown in Table 4.14 were identified after reviewing all factors included in many master plans for various cities like Khan Yunis, and Gaza, and after consultation with responsible bodies in MOG. In addition, all previously mentioned supporting tables concerning forecasts of major elements were taken into account during this analysis, and according to them some variables were added. Calculated NPV for Water Sector in Gaza under current condition of bad quality and inadequate quantity of water shows as in Table 4.15 that the benefits can cover the costs of maintenance and operation of whole sector but with possibility of low investment of about 21 million US dollars. Any other investment in the sector will make it sensitive to NPV and IRR and will require specific steps in calculation of benefits to reduce the gap between costs and benefits (revenue).

Table 4.14: Variables in water sector (Gaza) to be considered in sensitivity analysis

Possible key variable	Quantifiable variables	Underlying variables
Water demand	- Population growth (high rate of 3.5% annually) - Domestic and non domestic consumption (more than 50% of produced water is consumed in agriculture) - Uncounted water (more than 30% of produced water are considered as loses)	- Price and income elasticity
Investment cost (Economic & financial)	- Water demand (big gap between demand and supply requires big investment to be reduced) - Construction period - Real price	
Operation & Maintenance costs	- Personal costs (staff costs) - Cost of energy - Cost of maintenance - Efficiency of institution	
Financial revenue	- Quantity of water consumed - Service level - Income from connection fees	- Water tariff
Economic benefits	- Water demand - Resources costs saving	- Willingness to pay
Cost recovery / Revenues / Production cost	- Water tariff - Subsides	

Table 4.15: Sensitivity Analysis for Current Water Situation in Gaza City

4.2.4.2 Case Study: Phase 2: Step 4: **Activity 2:** Risk Analysis

Experience of working in water field in Gaza shows that many risks at three levels: project, sector and national level can be occurred. Table 4.16 summarizes these risks that must be taken into consideration during the process of suggesting solutions. These risks will be accounted for in the AHP.

Table 4.16: Risk analysis for Gaza City

Risks	Description/ mitigation
At the Project Level	
- Contractor performance	As all local contractors have low experience in constructing strategic water projects that need big investment and high skills, thus, a risk of failure of construction exists.
- Capacity building	Technical and Financial Management of water systems needs a big community support, working without formulating capacity building activities will lead to shortage of needed resources of implementation the proposed projects.
At the Sector Level	
- Price and Tariff	Unsuitable price and tariff can not ensure sufficient revenue that is important for M&O process.
- Operational and Management skills	Conducting technical assistance programs can help in developing operational and management skills that are essential for sustainability of projects.
At the National Level	
- Legislative reforms and regulation	Lack of regulations always leads to conflicts and contradictions that delay implementation of projects.
- Unstable political situations	As Gaza City always suffers from closures and Israeli invasions, thus it is advised to suggest these projects with minimum risks that can be occurred

4.2.4.3 Case Study: Phase 2: Step 4: **Activity 3:** Yearly Forecasts

Four major factors influence strategic planning of water sector in Gaza City. These are population growth, sewage generation, rainfall runoff, and water consumption per capita. The following supporting Tables 4.17 to Table 4.21. show these forecasts for Gaza as collected from water and wastewater department of MOG, PWA, and Palestinian Central Bureau of Statistics, or calculated accordingly.

Table 4.17: Forecasts of population growth for Gaza City (PCBS, 1996)

No.	Year	High Growth %	Medium Growth %	Low Growth %	Total High *1000	Total Medium *1000	Total Low *1000
1	1996	10	8	5	326.200	326.200	326.200
2	1997	10	7	5	354.136	348.292	346.141
3	1998	9	6	5	381.321	371.261	364.927
4	1999	9	6	5	410.699	394.976	383.728
5	2000	9	6	5	442.620	420.436	403.710
6	2001	9	6	5	477.206	447.672	424.854
7	2002	8	6	5	512.162	477.117	444.272
8	2003	8	5	5	548.298	504.406	464.977
9	2004	8	5	5	588.070	533.761	483.152
10	2005	8	5	5	631.856	565.515	502.965
11	2006	7	5	4	670.237	596.435	524.575
12	2007	7	5	4	714.988	630.576	548.438
13	2008	7	5	4	768.898	668.714	573.362
14	2009	7	5	4	807.042	703.057	598.394
15	2010	6	4	4	841.419	733.968	625.245
16	2011	6	4	4	877.591	764.737	650.736
17	2012	6	4	4	915.655	796.979	677.519
18	2013	6	4	4	955.713	829.587	702.371
19	2014	6	4	4	997.876	863.737	728.275
20	2015	6	4	4	1,042.25	896.993	755.276
21	2016	6	4	4	1,088.98	931.674	781.451
22	2017	5	4	4	1,132.66	967.842	804.422
23	2018	5	4	3	1,177.80	1,005.56	828.156
24	2019	5	4	3	1,224.99	1,044.90	852.678
25	2020	5	4	3	1,274.33	1,085.40	877.574
26	2021	5	4	3	1,325.93	1,127.63	900.891
27	2022	5	4	3	1,379.87	1,171.66	924.889
28	2023	5	4	3	1,436.29	1,217.58	949.588
29	2024	5	4	3	1,495.28	1,265.47	975.008
30	2025	5	4	3	1,556.97	1,315.42	1,001.17

Low population growth reflects these conditions where the political and Socio-economic situation are stable, high and medium population growth were indicated in Gaza City when these conditions were not stable. For example, high population growth was indicated in 1948, after Israel-Arabic war. Medium growth was indicated in 1996 after return of PNA. Reverse growth was indicated only one time, after 1967 war as a result of immigration out of Gaza. Current population in Gaza is approximately 450,000, which are near to that one estimated in Table 4.17

for low population growth for 2003. All three levels of population growth (high, medium, and low) will be taken into consideration during implementation of strategic planning because they directly influence water demand-supply balance and so the proposed target of 120 L/C/day will changes accordingly.

The second supporting forecast estimate is given in Table 4.18. This table shows how the sewage generation incases with increasing population and with increasing water supply and connected houses to the sewage networks in the city for all three levels of population growth.

Table 4.18: Forecasts of sewage generation for Gaza City

	Popul. 1996	Popul. 2005	Popul. 2015	Popul. 2025	Flow at 80 l/c/d (2005)	Flow at 90 l/c/d (2015)	Flow at 100 l/c/d (2025)
High	326200	631855	1042258	1556978	40438.7	84422.9	155697
Med.	326200	565315	896994	1315428	36180.1	72656.5	131542
Low	326200	502966	755277	1001171	32189.8	61177.4	100117

Source: Sewage Department- MOG/ Amount of sewage in (m^3/day)

As rain water is one of the most important water resources that supply the coastal aquifer above which Gaza is located, then the runoff forecasts will influence the strategic planning process. For this purpose Table 4.19 illustrates the runoff forecasts for Gaza City as calculated in Master Plan for Sewage in Gaza that has been prepared by M&E in 1996.

Table 4.19: Runoff forecasts for Gaza City

	Year 2005 (cm/day)	Year 2015 (cm/ day)	Year 2025 (cm/hr)
Intensity at 18 mm/hr (2 years storm)	368.091	454.248	509.420
Intensity at 26 mm/hr (5 years storm)	531.687	656.136	735.829
Intensity at 37 mm/hr (20years storm)	756.632	933.732	1,047.14
	(cm/day)	**(cm/day)**	**(cm/day)**
Intensity at 111 mm/hr (50 years storm)	2,269.89	2,801.19	3,141.42
Intensity at 207 mm/3 days(20 years)	4,233.04	5,223.85	5,858.32
Intensity at 280 mm/3 days(50 years)	5,725.86	7,066.08	7,924.31

The first case of intensity at 18 mm/hr was indicated in Gaza City in 1999. Storm water facilities efficiency was satisfactory and could stand against the storm,

furthermore, the storage and recharge process was efficient. However in winter 2003, the second case from Table 4.19 of 26 mm/hr was indicated, a big flood in storm water facilities has been occurred which led to huge losses of storm water that has been directed into sewage pump stations and to the sea. This means that Gaza City does not get adequate quantity of rainwater because of lack of its storm water facilities that can collect maximum available rainwater.

Water demand and supply will be calculated according to the previous tables of population forecasts, sewage reuse and runoff forecasts. As the coastal aquifer is one unit for all cities along Gaza Strip then the water demand-supply balance will be calculated for Gaza Strip as a Whole, but taking into consideration that Gaza City in all forecasts is assumed to be half of the calculated figures. The reason for this assumption can be justified because all forecasts for Gaza Strip show that Gaza City is currently has, and will have in the future approximately half of the projected population in Gaza Strip. (PSBC, 1996). Table 4.20 shows the projected water balance in Gaza Strip and Gaza City accordingly.

Table 4.20: Projected water demand-supply for Gaza Strip (NWP, 2000).

	Municipal and industrial water in (Mm^3/yr)				**Agriculture water in (Mm^3/yr)**			
	2003	**2005**	**2010**	**2020**	**2003**	**2005**	**2010**	**2020**
Demand	65	84	111	182	91	92	88	80
Resources	48	59	71	77	91	92	88	78
Gap	-17	-25	-40	-105	0	0	0	-2

Source: Water National Plan/ PWA.

The figures assumed in Table 4.20 have taken into consideration all available water resources in Gaza Strip included Ground Water, Storm Water, Return Irrigation, and reuse of Treated Waste Water. Even though a gap of 107 Mm^3/yr is accepted to occur in 2020 with respect to water consumption of 150 L/C/d.

The gap of demand-supply water can be calculated for Gaza City for 2025, as shown in the Table 4.21

Table 4.21: Forecasted water demand for Gaza City.

Year	Pop. Growth	Population	Losses (%)	Min. supply (L/C/d)	Projected amount (m^3/yr)
2003	Low	450,000	30 %	90	27,000,000
2025	Low	1,001,000	10 %	140	56,266,210
2025	Medium	1,315,000	20 %	120	69,116,400
2025	Low	1,001,000	57 %	120	69,116,400
2025	Low	1,001,000	35 %	120	59,189,130
2025	**Low**	**1,001,000**	**26 %**	**150**	**69,116,400**

As shown in the table the best case for forecasting water demand in 2025 is the case with low growth rate and 150 L/C/d, and water losses of 26%. The amount of about 69 Mcm/y can easy serve the expected medium growth rate of 120 L/C/d with 20 % water losses. Assuming that about 50 000 m^3/day of treated waste water will be used in agriculture uses, the water shortage in 2025 for Gaza City with low growth rate and 26% losses will be about 22 Mcm/yr.

4.2.5 Case Study: Phase 2: Step 5: Development of Economic System Model

The last step of phase two is available to be defined after all analyses that have been done. The following arguments have been assumed after using the flow chart in Figure 3.3 and consultation with responsible bodies and according to the analyzed situations. These arguments will be used later in strategic choice phase to determine the kind of projects that can be suggested.

Any suggested strategic choice for Water Sector in Gaza City must have the following attributes:

1. Must be able to decrease the expected gap between water demand and supply and meat WHO standard of water quality.
2. Must use available and technically reachable technique, such as wastewater reuse, seawater desalination, aquifer management, rainwater recharge, or others.
3. Must contain training program for technical team and contractors.
4. Must take into account economic situation and risks that constrain sustainability of the projects.
5. Must have adequate benefit-cost results and tariff structure modification.

4.3 Case Study: Phase 3: Strategic Choice

4.3.1 Case Study: Phase 3: Step 1: Examination of alternative future services and projects scenarios

Using the methodology as in the flowchart shown in Figure (3.4) of the developed approach the following notes and ideas have been used in suggesting solutions of the problem:

1. Previous analysis and yearly forecasts indicates big gap between water demand and water supply, high population growth, and expected bad economic situation.
2. Sensitivity and risks analysis show that large and geographically linked projects may face big constrains and so on will be subject to big delays or even elimination. Thus the strategic choice of proposed projects will take into account that one or combination of more than one of popular technique that can decrease the demand-supply gap.
3. As water quality of coastal aquifer is less than WHO standard resulted as over pumped aquifer and wastewater leakage, then the proposed alternatives shall includes the aquifer management and wastewater sector improvement.
4. Finally, the improvement of existing facilities will decease construction costs of proposed projects.

Table 4.22 summarizes the most important elements that will be included in strategic choice for water sector in Gaza City.

Table 4.22: Important elements to be included in strategic choices

Problem	Proposed Solutions	Suggested Facilities
Water Demand-Supply Gap	Seawater Desalination- Wastewater Reuse- Rain Water Recharge	Recharge Basins- Treatment Plants- Desalination Stations.
Water Quality	Aquifer Management	Water Wells and Other Water Facilities
Investment and O&M Costs	Rehabilitation and Improvement of Existing Facilities	Recharge Basins- Water Wells- Treatment Plants- Irrigation Systems
Risks and Uncertainties		Projects Within the City Only.

According to Table 4.22 and the previous planning steps the following table, Table 4.23, includes three realistic strategic alternatives that will be the subject of the next analysis of the proposed approach. All three alternatives are expected to solve the problem of water shortage and quality within Gaza City.

Table 4.23: Proposed alternatives.

Alternative	Water	Wastewater	Storm Water
Alternative (1) **Total of 343 $ million**	*Institutional setup *Aquifer management program *Seawater desalination plant *Main crier line * Reservoirs	* Expanding of treatment plant in Sheikh Ejleen * Improving Reuse System * Expanding of Recharge basins south of the city	* Upgrading Sheik Redwan basin * constructing storm water system in the west part of the city * Improving Asqula basin for storm water recharge.
	Cost up to 2025= 258 $ million	Cost up to 2025= 12$ million	Cost up to 2025= 73 $ million
Alternative (2) **Total of 312 $ million**	* Institutional setup * Aquifer management program * Upgrading of 29 water wells (within Gaza City). * Exporting water from near countries	* Upgrading of Sheikh Ejleen treatment plant (use of activated sludge method) * Spreading of irrigation network to cover 50% of green areas in the city	* Constructing new storm water basin south of the city * Improving Asqula basin for storm water
	Cost up to 2025= 225 $ million	Cost up to 2025= 50 $ million	Cost up to 2025= 37 $ million
Alternative (3) **Total of 282 $ million**	* Institutional setup * Aquifer management program * Upgrading of 29 water wells (within Gaza City). * Constructing small seawater desalination plant.	* Upgrading and expansion of existing treatment plant * Improving of Irrigation system to reduce water demand * Improving recharge system of treated wastewater.	* Rehabilitation of storm water existing system.
	Cost up to 2025= 212.3 $ million	Cost up to 2025= 49.5 $ million	Cost up to 2025= 19.4 $ million

The activities linked to this step are as follows

4.3.1.1 Case Study: Phase 3: Step 1: **Activity 1:** Development of alternative design response:

Table 4.24 summarizes the engineering evaluation of all three alternatives as shown in Matrix of Assessment in Chapter 3.

Table 4.24: Matrix of assessment (Engineering response)

Alternative	Alternative (1)	Alternative (2)	Alternative (3)
Criteria: Flexibility Costs Water conservation and reuse Sustainability	-Tied with existing projects and land use. -High cost of construction materials. -Good quality of produced water with high potential of wastewater reuse. -High sensitive to the political situation.	-Flexible implementation. -High cost of construction materials. -Good quality of produced water with high potential of wastewater reuse. -Low sensitive to the political situation.	-Flexible implementation. -Acceptable cost of construction materials. -Good quality of produced water but low potential of wastewater reuse. -Low sensitive to the political situation.
Horizon Time	20 years	20 years	20 years
Construction Time	4 years	2 years	4 years
Construction cost	350 $ million	320 $ million	300 $ million
Materials	Imported	Available	Imported
Priority/response	**3**	**1**	**2**

4.3.1.2 Case Study: Phase 3: Step 1: **Activity 2:** Development of alternative operating response

Table 4.25: Matrix of assessment (Operation response)

Alternative	Alternative (1)	Alternative (2)	Alternative (3)
Criteria: - Costs -Sustainability -O&M flexibility	-High costs of O&M -Sustainable -Low availability of local O&M	-High costs of O&M -Sustainable -High availability of local O&M	-Acceptable costs of O&M -Sustainable -High availability of local O&M
Horizon Time	20 years	20 years	20 years
O&M cost	7.5 $ million/year	7 $ million/year	6 $ million/year
Spare parts	Available	Available	Available
Priority/response	**3**	**2**	**1**

4.3.2 Case Study: Phase 3: Step 2: Screening and Evaluation of scenarios

Before using AHP in prioritizing one of the three suggested alternatives, these alternatives will be screened with respect of four important elements that are mentioned in the proposed approach as follows:

1- All three alternatives meat the established objective of 120 L/C/day and all include water, wastewater, and storm water development in order to improve water quality.
2- Depending on size of each alternative, the costs vary from 282 $ million for alternative 3, to 343 $ million for alternative 1. These costs can be big constrain during the implementation of the plan, thus, in accordance to cost consideration only alternative 3 can be the best because it has the lowest costs.
3- Approximately all needed existing facilities are included in all alternatives, but alternative 2 includes most of them, that makes it the best from all three from this point of view.
4- All alternatives are suggested according to the risk analysis, so, the uncertainty and risks in all three are minimized.

The use of AHP technique for prioritizing the alternatives is given in Appendix C.

As seen, alternative number 3 have the highest scores and will be selected as candidate one for strategic choice and implementation.

4.3.3 Case Study: Phase 3: Step 3: Selection from Strategic Alternative

The selected alternative (Alternative No.3) includes these elements of water sector that can solve the problem of shortage and quality of water in Gaza City. These are Water, Wastewater, and storm water elements. Implementing this alternative in the city can also help in solving the problem in all Gaza Governorates, which will be suitable alternative for strategic planning for Gaza Strip and Palestine consequently.

As described in Table 4.23, the alternative includes institutional setup, aquifer management, and maximum use of existing facilities. That means an adequate tariff structure and full economic analysis must be continuously performed.

The selected alternative can be implemented immediately after approval of responsible bodies of the city. This means that the beginning of solving the problem can be started one year from the start of implementation.

All sensitivity analysis and action plans must be discussed by planning committee and documented for implementation and monitoring for the long time performance. These will be highlighted in the following steps.

4.4 Case Study: Phase 4: Implementation

The accepted alternative is suggested for implementation in Gaza City along time period from 2004 to 2025. This interval will be divided into four intervals in five yearly intervals, except the first one that will be six years interval. The following table, Table 4.26 shows the suggested investment costs for implementation the plan.

Table 4.26: Investment costs in Gaza City (2004-2025).

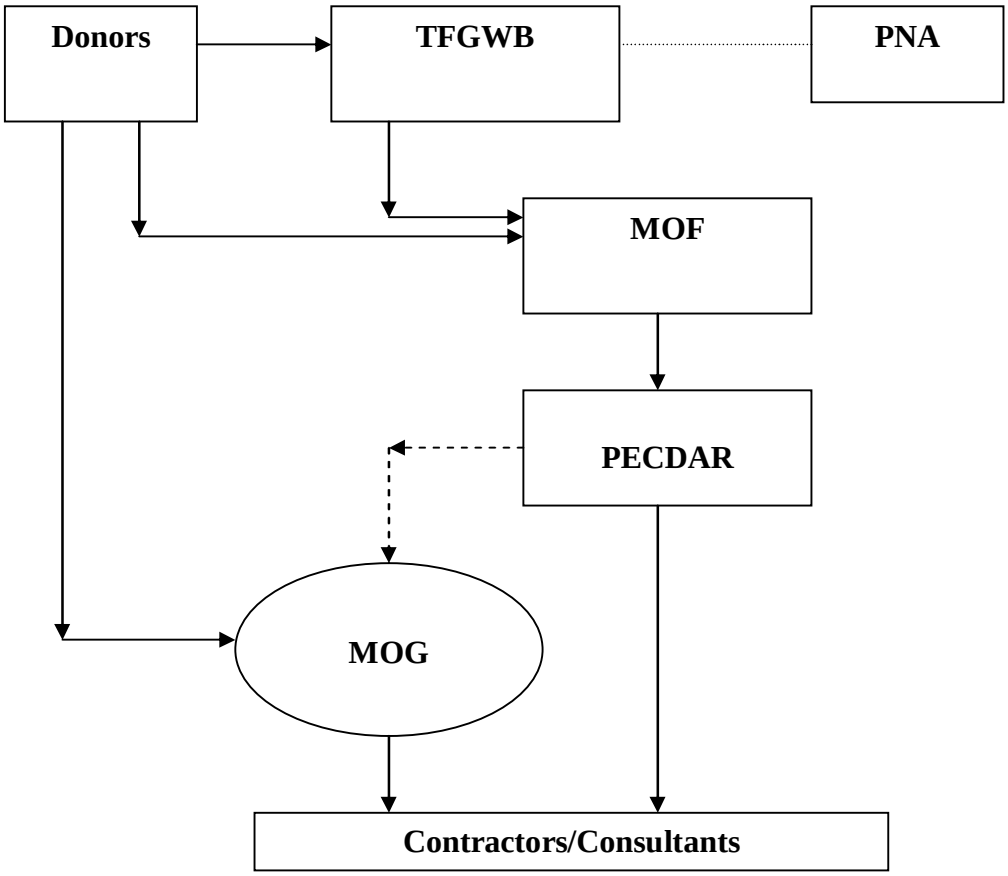
Sector	2004-2010	2011-2015	2016-2020	2021-2025	Total
Water	92,800,000	41,000,000	47,000,000	31,500,000	212,300,000
Wastewater	18,000,000	12,500,000	12,000,000	7,000,000	49,500,000
St. water	8,400,000	6,000,000	3,000,000	2,000,000	19,400,000
Total	119,200,000	59,500,000	62,000,000	40,500,000	**281,200,000**

4.4.1 Case Study: Phase 4: Step 1: Prioritization of projects and programs

An action plans and projects for implementation the selected alternative is illustrated in Table 4.26 A. the following elements have been also determined as part of action plan.

1. Flow of Funds

The proposed flow of funds will be assumed similar to that one currently implemented in MOG and PNA and illustrated in Figure 4.4



TFGWB- Trust Fund for Gaza and West Bank
MOF-Ministry of Finance

Figure 4.4: Flow of Funds for Municipality of Gaza

Table 4.26A: Proposed Investment Plan (Gaza City- 2004-2025)

2. Sensitivity Analysis

According to the analysis made in phase 2, the tariff structure of water has to be adopted to meet the minimum requirements of running costs of the water system in the city. Thus, before determination of sensitivity analysis, the current tariff structure will be changed according to the suggested one as shown in Table 4.27.

Table 4.27: Proposed tariff structure for water sector of Gaza City.

Use	Water Charge by the quantity used					Sewage by 1m^3 of water used
	No Limit	0-10 m^3	11-20 m^3	20-30 m^3	>30 m^3	
Household		0.4	0.6	0.9	1.2	0.3
Private gardens		0.4	0.6	1.2	1.5	0.3
Commerce		0.4	0.8	0.9	1.5	0.3
Industry		0.35	0.55	1.2	1.5	0.3
Small industry	1.00					0.3
Hospitals	0.8					0.3
Hotels	1.5					0.3
Public Institutions	0.5					0.3
Municipal gardens	1.00					0.3
Educational institutions	0.8					0.3
Agriculture (reuse)		0.2	0.3	0.4	0.5	0.3
Others	1.00					0.3

- **All figures are in US $**
- **0.2 $ can be added each five years for each item. (gradual increase)**

The proposed tariff structure in Table 4.27 has an advantage that it can limit the consumption of water for these people who consume more than 20 cubic meters per month by high tariff and do not affect these who consumed less than ten cubic meters. This means that beside covering the running cost of water sector this tariff can adjust the demand of water and make water affordable for all levels of population and industry. During the design of this tariff structure; social, economic, and political aspects have been taken into consideration. In addition, this tariff can be used gradually starting from that year when the first desalination plant starts to produce water.

Full sensitivity analysis for the selected alternative No.3 is included in Table 4.28.

Table 4.28: Sensitivity Analysis for Alternative #3

4.5 Case Study: Phase 5: Monitoring

If the implementation of programs and projects start in 2004 the monitoring process should start one year after, in 2005. Table 4.29 is designed to make the process of monitoring flexible and easy work.

As seen from Table 4.29, the selected indicators have two columns. One for actual value of the indicator that must be identified during the implementation of the action plan, and the other for the forecasted value that has been identified during the planning process. The best results of the successful implementation of the plan are when these two values are equals or approximately equals. Any big differences between values indicate that the process needs revising and modifications.

Table 4.29 includes also the amount of produced water by desalination plants for all three phases of construction. As seen from the table, it is expected to overcome the gap between water supply and demand in all years till horizon year of 2025 except in 2010 and 2015 where there is a small gap that can be covered by aquifer. All other years indicate saving in water quantity that advised to be from aquifer, e.g. in year 2016, the saving of (-7181603 m^3) will reduce the water supply from the aquifer for the same amount (28 000000- 7181603 $m^{3)}$. This action can add an other step towards aquifer protection.

The forecasted values of the pollutants are not included in Table 4.29 because they must meet WHO standard from the first day of the monitory process and stay within that range all over the whole period of implantation.

Finally, Table 4.29 is created according to the data included in Table 4.21 for Low population growth, minimum water supply of 150 L/C/day, and losses of 26%. It can be used also for medium population growth with water supply of 120 L/C/day and losses of 20% with some modification in forecasted values of population, water demand, and yearly gap.

Table 4.29: Monitoring Sheet for Strategic Plan in Gaza City

CHAPTER FIVE

GENERAL REMARKS AND CONCLUSIONS

5.0 Introduction

As Palestine try to draw its trajectory into twenty first centuries, the country is facing sever problems. One important constrain for Palestinian development is limited use of strategic planning tools in decision making process, especially in infrastructure fields that contains the most growing demands for the development of country. Palestinian decision-makers still face many constraints to take right decisions because of lack of strategic planning philosophy and confusing different outside methodology that often violate with national needs. However, national infrastructure planning should be based on full analysis and forecasting of many elements and factors that have to reflect a clear picture of current and future circumstances of the problem under study. The developed approach has been adopted to meet the best use of many tools used in strategic planning process such as SWOT analysis, sensitivity analysis, establishment of realistic objectives, economic analysis, identifying of needed criteria for decision making process, action and monitory plans and others. An example of water sector in Gaza City illustrated how this approach can be useful in directing water resources into right way to decrease the water shortage in the city.

5.1 Developed Approach

5.1.1 Description of the developed approach

This effective hybrid risk-informed approach for strategic planning of infrastructure has been developed to help decision-makers in Palestine and other developing countries with similar circumstances to take right decisions. The decision making process according to this approach is based on analyzing data, recognizing the power and limitation of the institutions, and influencing various elements needed to the sector under study. These elements are included in five phases in the developed approach as follows:

1. Phase one: Preparation for Planning: This phase is created in the developed approach as preparation phase of the whole strategic planning process and concerns about establishment of planning committee from relevant institutions and responsible bodies.
2. Phase two: Information Diagnosis: This phase provides full analysis of existing situation of the sector and institution under study and full forecasts of needed figures for the horizon year of the planning process. The phase is divided into five steps e.g. analysis of existing conditions, development of operational system, establishment of functional objectives, analysis of system economics and development of economical model. Five activities are included within these steps also. These are SWOT analysis, interface with other systems, risk analysis, sensitivity analysis and yearly forecasts. The phase is supposed to put the planning committee into right direction of the problem and proposed solutions.
3. Phase three: Strategic Choice: This phase will help the planning committee to use the best known methodology of decision making process such as analytic hierarchy process (AHP), then to implement them in prioritizing alternatives according to most important criteria.
4. Phase four: Implementation: The phase of implementation is concerning of creating action plans according to the result reached from phase three, and
5. Phase five: Monitory: During this phase the whole planning process will be evaluated according to previously established indicators.

5.1.2 Applicability of the developed approach

Many advantages make this approach an effective one to be used in developing countries, the most important of them are:

1. The approach is divided into five linked phases; each phase is an introduction to the following one. This flow of data and analysis links all information and make a comprehensive picture of the sector under study.
2. Each step of each phase can be done separately by responsible bodies for each task. However, in the end of each phase, there is a step that summarizes the results of all tasks within one phase.

3. All-important elements of infrastructure that are essential for developing countries are included such as economical, social, political constraints and others.
4. The developed approach defines common and definite development objectives.
5. The developed approach effectively accounts for the influence of risks and uncertainties in decision making process and requires full analysis of them in order to avoid conflicts or delays.
6. The developed approach clarifies the scope of responsibilities for all actors concerned thereby encouraging accountability, ownership, and sustainability.
7. The developed approach improves communication and co-ordination between co-operating organizations, and beneficiaries.
8. The developed approach includes analytic hierarchy process (AHP) for decision making process. This process is a multi-criteria process and has been successfully used in the world.
9. The developed approach includes evaluation and monitoring process. Therefore, it allows regular modifying and updating the plans or making needed changes during implementation in revolving manners.
10. The developed approach overcomes the limitation of many other approaches by including risks and uncertainties in its phases such as including the uncertainties as important criteria in AHP and making full analysis of them in different phases of the approach.

5.1.3 Limitation and requirements of the developed approach

Beside all its advantages, the developed approach requires teamwork to be well organized. This may make big constraints in developing countries like Palestine. Thus training on the concept of teamwork and implementation process for the developed approach is vital. Using this approach individually can lead to wrong and so on, misuse of the whole strategic planning process.

In addition, the best use of the developed approach is possible when repeated it more than one time. First time of using the approach can be somehow confusing

because some steps will not be clear to be fully analyzed. For example, making full sensitivity analysis can not be done without identifying the projects and policies; these usually come after sensitivity analysis in the developed approach. Once they have been determined, the flow of the approach goes smoothly.

5.2 Implementation of the Developed Approach to Case Study

The strategic planning of water sector in Gaza City has been taken as case study to show the practicality of the developed approach. Gaza City was selected because of the importance of the city and the huge problems of water scarcity and quality that is the city suffering from. In addition, solving the problem of water sector in Gaza will help in solving the problem of water in the whole country. It can serve the strategic planning process of water sector as pilot project where approximately half of water shortage and consumption in Gaza Governorates is concentrated in Gaza City.

All phases and steps of the developed approach have been implemented for water sector in Gaza. The analysis done in Phase two indicated a shortage of water of about 22 million cubic meter of water in 2025, water quality under WHO standard, inadequate tariff structure, confusing organization chart, bad inter-organizational relation-ship, and concentrated influence of risks and uncertainties that make big delays of projects. These elements and constraints have been taken into consideration during implementing Phase three. This was done by proposing those alternatives that maximum eliminate all of them, e.g. including risks and uncertainties as one important criteria in AHP and making full sensitivity analysis for all expected risks of the selected alternative.

Action plan and proposed time schedule has been identified in Phase four for the selected alternative is divided into intervals of five years up to 2025. Finally, in Phase five, the whole process is evaluated according to these indicators that makes planning committee in continues contact any changes.

5.2.1 Influence of risks and uncertainties in case study

The developed approach emphasis on influence of uncertainties and risks in the planning process, thus, they were effectively accounted for in three areas in the case study as follows:

1. In phase two, three important activities were preceded. The first one was collecting all available experiences of unexpected situation that influence the performance of water sector in Gaza. These experiences were taken into consideration during proposing the candidate alternatives and possibility to avoid them.
2. The second place was during establishment of the most important nine criteria for AHP method. Seven of the nine criteria were used in most strategic planning processes in Palestine. These are cost, implementation and flexibility, maintenance and operation, social impact, sustainability, water conservation and reuse, and project importance. Two other important criteria were added for the first time to these seven. These are uncertainty and consequence of failure. During pairwise comparison between criteria, these two criteria were given high scores to reflect their importance in comparison with other criteria and to favorite that alternative with best consideration of these criteria.
3. In phase four of the developed approach, the action plan was divided into short periods to allow continuous monitoring of the whole process. Thus, any unexpected situation or uncertainties will be mitigated and modified according to the new circumstances.

In addition, the sensitivity analysis of water sector for Gaza was done in the case study for Net Present Value (NPV) and Internal Return Ratio (IRR). These two values were calculated according to the normal and unexpected situation such as construction delays, increase of investment costs or O&M costs, or decrease of benefits that may happen as a result of political or economic unstable situation.

5.2.2 Results of case study

The analysis done during case study for current situation of water sector in Gaza City shows that the net cash flow of the sector is about 20 million US$. This amount can be satisfactory when the sector does not need any investment or rehabilitation. However, The case study analysis indicated also that the investment costs and maintenance and operation costs are much higher than this amount to cover the future water shortage and quality (about 280 million US$). The selected alternative according to the developed approach has successfully solved the problem by proposing suitable and available technical solutions, new tariff structure, new organizational and sector chart, and good way of water reuse and allocating of available resources. These solutions were created in three important parts of water sector, water, wastewater, and storm water. In water part the selected alternative suggests institutional setup, aquifer management, wells upgrading, and seawater desalination. Wastewater part was created to rehabilitate treatment plants and to improve irrigation system in order to increase wastewater reuse and to decrease aquifer pollution. Finally, improving storm water system was suggested to increase aquifer recharge and best use of rainwater as important source of water.

All these solutions are suggested with minimum investment costs and minimum implementation risks, but also with high possibility of cost recovery and water availability up to 2025. The flexibility of the developed approach allows also any needed modification for any unexpected situation. For this purpose, these solutions are suggested to be implemented by stages and are subject to the monitoring process according to established indicators such as population growth, water demand and supply, desalination process, wastewater reuse, pollutants and others.

In addition, the case study analysis shows that the current method of water supply by withdraw water from aquifer is highly influencing the aquifer deterioration that affect residents welfare that need immediate actions towards right way of using aquifer and protecting water resources. These analysis and proposed solutions have successfully illustrated the water situation in the future and best ways of overcoming the problem.

5.3 Conclusions

1. Infrastructure sectors in Palestine have been suffering from various constraints for a long time period. These include shortage of resources, limit of budgets, risks and uncertainties, conflicts and contradictions in decision making process, and others. A strategic planning approach has been developed for effective development of the infrastructure sectors. The special case of Palestine that includes high level of risks and uncertainties has been properly accounted for in the developed approach.
2. The developed approach is suggested to find best way of solving problems in infrastructure fields, to link all influencing factors in one process in order to create best view of the problem, and to help decision-makers in taking best actions. The applicability of the developed approach has been demonstrated by developing a strategic plan for water sector in Gaza City.
3. The municipality of Gaza, or any other local government, should undertake some of long-term infrastructure strategic planning in order to match its aspiration with its resources, and so meet at least the basic needs of all residents within the achievable time frame.
4. The developed approach has certain features in common: it is intended to be interactive and iterative. The infrastructure strategic planning process must be the result of interactive between planner, engineers, treasures, and the community. Outcomes must be practical, affordable and politically and socially acceptable.
5. The implementation of the proposed approach to water sector in Municipality of Gaza (MOG) has successfully resulted in defining of strategic plan for development of the sector. This plan has been discussed with relevant decision -makers involved in the sector where they showed their satisfaction. The developed approach is well accepted in West Bank too, and its implementation there is being considered.
6. The consequence of the developed approach has forced the author to continuously consult with all relevant persons working in this field in the city and the whole country also. This has led to creating a strategic plan for Gaza City that can solve the problem within the city, but also helps in realization of

future plans for the whole country and does not make any conflicts with any national strategic planning in the future.

5.4 Recommendations

1. The developed approach has been created for using in normal, but also in unstable conditions that any developing country may face. Using it in strategic allocation of infrastructure resources, especially water resources, or in strategic planning of infrastructure sectors, will benefits the country in decreasing the costs and time of many strategic projects. It is recommended to use the developed strategic planning process regularly.
2. The developed approach includes charts, matrix, and tables that can be used for all sectors included in infrastructure fields. These can ease the implementation of the approach to any infrastructure sector, and can be also modified according to the sector and planning committee judgment. Thus, before using the approach it is recommended to make necessary review of these elements according to the sector or problem under study.
3. The structure of the developed approach is created to be implemented in developing counties such as Palestine and other countries with similar conditions. Therefore, the criteria used in AHP can be changed, expanded, or modified. The flexibility of the developed approach allows also any changes in these indicators of sensitivity analysis for defining NPV and IRR. Hence, it is recommended to identify these criteria and indicators according to the country's need and priorities.
4. The developed approach consists of elements concerning infrastructure fields, but also can be used for other field, with specific changes that can replace some steps in the approach. For example it can be used for strategic planning of education, finance, politics, commerce, and others.

5. Future researches are recommended to expand the developed approach or to make it emphasis on benefits. These researches can focus on expanding sensitivity and economic analysis, creating new techniques for benefit-cost policy, establishment of new methods for major forecasts, or expanding the

beneficiaries' participation. However, it is advised to make these researches after successful use of the developed approach. In this case the developed approach will be the base case for any future developments.

6. The included strategic plan for water sector in Gaza City has been created according to real data and serious consultation with responsible bodies of water sector and related sectors in MOG, PWA, and others. Hence, the Municipality of Gaza can review the plan and implement it for its future water resources allocation.

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Appendix A: Mathematical Forms of AHP

Ă=(a_{ij})
Ă= Reciprocal matrix (**a_{ij}** =1/ **a_{ij}**)
Ă w= λ_{max} **w**
λ_{max} = eigenvalue

ICI= (λ_{max}- n)/ (n-1)(R.I.)
R.I.= random index that depends on matrix size.

n	1	2	3	4	5	6	7	8	9	10	….
R.I.	0.0	0.0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	

APPENDIX B:

B-1: Water Supply- Demand Figures in Gaza Strip

Resources	Amount in Mcm/y	Withdraw	Amount in Mcm/y
Rainwater	46	Municipal water	42
Wades	02	Agriculture	81
Ground water recharge	10	Industrial	02
Return potable water	27	Evaporation	01
Return irrigated water	30	Loss in pumping	08
Sea water intrusion	16	Decrease in water level	-3
Total	131		131

Source: Palestinian National Center for Information

B-2: Water Demand Forecasts in Gaza Strip:

Year	Water Demand		Total Mcm/y
	Agriculture	Domestic and industrial	
2000	91	54.51	145.51
2001	91.24	63.53	154.77
2002	91.48	72.54	164.02
2003	91.72	81.65	173.28
2004	91.96	90.58	182.54
2005	92.20	99.60	191.80
2006	91.42	104.51	195.93
2007	90.64	109.42	200.06
2008	89.86	114.33	204.19
2009	89.08	119.24	208.32
2010	88.30	124.15	212.45
2011	87.37	129.57	216.94
2012	86.44	134.99	221.43
2013	85.51	140.41	225.92
2014	84.58	145.82	230.40
2015	83.65	151.24	234.89
2016	82.72	157.28	240.00
2017	81.79	163.31	245.10
2018	80.68	169.34	250.12
2019	79.70	175.38	255.31
2020	79.70	182.00	261.70

Source: Palestinian Water Authority

B-3: Return Water into Coastal Aquifer under Gaza Strip:

		Return Water					
Year	Nature Flow	Return pot. Water	M&I	Surface water	Aquifer water	Irrigation.	**Total Mcm**
2000	55	11.92	15.81	3.3	22.75	0.00	108.87
2001	54.81	13.88	18.26	3.49	22.81	0.00	113.25
2002	54.62	15.58	20.66	3.68	22.87	0.00	117.68
2003	54.43	17.73	23.02	3.87	20.22	2.71	121.97
2004	54.24	19.77	25.33	4.06	19.87	3.12	126.38
2005	54.05	22.01	27.59	4.25	17.25	5.80	130.95
2006	53.86	23.32	28.22	4.44	16.75	6.11	132.70
2007	53.67	22.50	28.79	4.63	15.69	6.96	132.25
2008	53.48	23.74	29.29	4.82	15.14	7.33	133.79
2009	53.29	24.91	29.72	5.01	14.21	8.06	135.20
2010	53.10	26.18	30.08	5.20	13.62	8.45	136.63
2011	52.91	27.16	30.84	5.39	11.58	10.26	138.14
2012	52.72	28.46	31.56	5.58	10.91	10.70	139.93
2013	52.53	29.78	32.22	5.77	10.22	11.16	141.68
2014	52.34	31.11	32.84	5.96	9.53	11.62	143.40
2015	52.15	32.45	33.42	6.15	8.83	12.09	145.08
2016	51.96	33.86	33.98	6.34	7.62	13.06	146.82
2017	51.70	35.27	34.49	6.53	6.34	14.11	148.51
2018	51.58	36.82	34.93	6.72	5.53	14.64	150.22
2019	51.39	38.38	35.32	6.91	4.81	15.18	151.99
2020	51.20	39.91	36.40	7.10	4.20	15.72	154.54

Source: PWA and Palestinian National Center for Information

Appendix C: Prioritizing Alternatives by AHP

Pair wise Comparison Reciprocal Matrix

criteria	C	IF	O&M	SI	S	WC	PI	U	F
C	**1**	3.0303	2	0.5	3.0303	2	1	2	0.5
IF	0.33	**1**	1	0.2	2	1	1	3.0303	1
O&M	0.5	1	**1**	0.2	1	2	0.33333	2	0.5
SI	2	5	5	**1**	0.5	2	2	2	2
SI	0.33	0.5	1	2	**1**	1	1	5	0.5
WC	0.5	1	0.5	0.5	1	**1**	0.5	2	0.33333
PI	1	1	3	0.5	1	2	**1**	1	0.2
U	0.5	0.33	0.5	0.5	0.2	0.5	1	**1**	3.0303
F	2	1	2	0.5	2	3	5	0.33	**1**
	8.16	**13.86**	**16**	**5.9**	**11.73**	**14.5**	**12.8333**	**18.3603**	**9.06364**

C-Cost
IF- Implementation and Flex.
O&M- Maintenatance &operation
SI- Social Impact
S- Sustainability
WC- Water Conservation &reuse
PI- Project Importance
U- Uncertainty
F- Consequence of Failure

										Priority Vector
0.1225	0.2186	0.125	0.0847	0.2583	0.1379	0.07792	0.10893	0.05517	**1.1892**	**0.132134**
0.0404	0.0721	0.0625	0.0339	0.1705	0.069	0.07792	0.16505	0.11033	**0.8018**	**0.089084**
0.0613	0.0721	0.0625	0.0339	0.0852	0.1379	0.02597	0.10893	0.05517	**0.6431**	**0.071452**
0.2451	0.3607	0.3125	0.1695	0.0426	0.1379	0.15584	0.10893	0.22066	**1.7538**	**0.194869**
0.0404	0.0361	0.0625	0.339	0.0852	0.069	0.07792	0.27233	0.05517	**1.0376**	**0.115292**
0.0613	0.0721	0.0313	0.0847	0.0852	0.069	0.03896	0.10893	0.03678	**0.5883**	**0.065367**
0.1225	0.0721	0.1875	0.0847	0.0852	0.1379	0.07792	0.05447	0.02207	**0.8446**	**0.093842**
0.0613	0.0238	0.0313	0.0847	0.017	0.0345	0.07792	0.05447	0.33434	**0.7193**	**0.079926**
0.2451	0.0721	0.125	0.0847	0.1705	0.2069	0.38961	0.01797	0.11033	**1.4223**	**0.158034**
1	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**9**	**1**

Alternative Pairwise Comparison with respect to Criterion 1 (Cost):

	Alt. 1	**Alt. 2**	**Alt. 3**					
Alt.1	**1**	2	2	0.5	0.5714	0.4	1.47143	**0.490476**
Alt.2	0.5	**1**	2	0.25	0.2857	0.4	0.93571	**0.311905**
Alt.3	0.5	0.5	**1**	0.25	0.1429	0.2	0.59286	**0.197619**
	2	3.5	5	1	1	1	3	**1**

Alternative Pairwise Comparison with respect to Criterion 2 (Implementation & Flexibility):

	Alt. 1	Alt. 2	Alt. 3					
Alt.1	**1**	2	1	0.4	0.4444	0.375	1.21944	**0.406481**
Alt.2	0.5	**1**	0.6667	0.2	0.2222	0.25	0.67222	**0.224074**
Alt.3	1	1.5	**1**	0.4	0.3333	0.375	1.10833	**0.369444**
	2.5	4.5	2.6667	1	1	1	3	**1**

Alternative Pairwise Comparison with respect to Criterion 3 (Operation and Maintenance):

	Alt. 1	Alt. 2	Alt. 3					
Alt.1	**1**	0.5	0.4	0.1818	0.25	0.11765	0.54947	**0.183155**
Alt.2	2	**1**	2	0.3636	0.5	0.58824	1.45187	**0.483957**
Alt.3	2.5	0.5	**1**	0.4545	0.25	0.29412	0.99866	**0.332888**
	5.5	2	3.4	1	1	1	3	**1**

Alternative Pairwise Comparison with respect to Criterion 4 (Social Impact):

	Alt. 1	Alt. 2	Alt. 3					
Alt.1	**1**	2	1	0.4	0.5	0.33333	1.23333	**0.411111**
Alt.2	0.5	**1**	1	0.2	0.25	0.33333	0.78333	**0.261111**
Alt.3	1	1	**1**	0.4	0.25	0.33333	0.98333	**0.327778**
	2.5	4	3	1	1	1	3	**1**

Alternative Pairwise Comparison with respect to Criterion 5 (Sustainability):

	Alt. 1	Alt. 2	Alt. 3					
Alt.1	**1**	0.6667	0.5	0.2222	0.2105	0.23077	0.66352	**0.221173**
Alt.2	1.5	**1**	0.6667	0.3333	0.3158	0.30769	0.95682	**0.318938**
Alt.3	2	1.5	**1**	0.4444	0.4737	0.46154	1.37967	**0.459889**
	4.5	3.1667	2.1667	1	1	1	3	**1**

Alternative Pairwise Comparison with respect to Criterion 6 (Water Conservation and Reuse):

	Alt. 1	Alt. 2	Alt. 3					
Alt.1	**1**	2	1	0.4	0.4	0.4	1.2	**0.4**
Alt.2	0.5	**1**	0.5	0.2	0.2	0.2	0.6	**0.2**
Alt.3	1	2	**1**	0.4	0.4	0.4	1.2	**0.4**
	2.5	5	2.5	1	1	1	3	**1**

Alternative Pairwise Comparison with respect to Criterion 7 (Project Importance):

	Alt. 1	Alt. 2	Alt. 3					
Alt.1	**1**	0.5	0.3333	0.1667	0.25	0.1	0.51667	**0.172222**
Alt.2	2	**1**	2	0.3333	0.5	0.6	1.43333	**0.477778**
Alt.3	3	0.5	**1**	0.5	0.25	0.3	1.05	**0.35**
	6	2	3.3333	1	1	1	3	**1**

Alternative Pairwise Comparison with respect to Criterion 8 (Uncertainty):

	Alt. 1	Alt. 2	Alt. 3					
Alt.1	**1**	2	0.3333	0.2222	0.4	0.18182	0.80404	**0.268013**
Alt.2	0.5	**1**	0.5	0.1111	0.2	0.27273	0.58384	**0.194613**
Alt.3	3	2	**1**	0.6667	0.4	0.54545	1.61212	**0.537374**
	4.5	5	1.8333	1	1	1	3	**1**

Alternative Pairwise Comparison with respect to Criterion 9 (Consequence to Failure):

	Alt. 1	Alt. 2	Alt. 3					
Alt.1	**1**	1	2	0.4	0.2	0.6	1.2	**0.4**
Alt.2	1	**1**	0.3333	0.4	0.2	0.1	0.7	**0.233333**
Alt.3	0.5	3	**1**	0.2	0.6	0.3	1.1	**0.366667**
	2.5	5	3.3333	1	1	1	3	**1**

Alternative Priority Vectors of Pairwise Comparison with respect to each criteria

	crit.1	crit. 2	crit.3	crit.4	crit.5	crit.6	crit.7	crit.8	crit.9
Alt.1	0.4905	0.4065	0.1832	0.4111	0.2212	0.4	0.17222	0.26801	0.4
Alt.2	0.3119	0.2241	0.484	0.2611	0.3189	0.2	0.47778	0.19461	0.23333
Alt.3	0.1976	0.3694	0.3329	0.3278	0.4599	0.4	0.35	0.53737	0.36667

Composite Global Priorities

	crit.1	crit. 2	crit.3	crit.4	crit.5	crit.6	crit.7	crit.8	crit.9
	0.1321	**0.0891**	**0.0715**	**0.1949**	**0.1153**	**0.0654**	**0.09384**	**0.07993**	**0.15803**
Alt.1	0.4905	0.4065	0.1832	0.4111	0.2212	0.4	0.17222	0.26801	0.4
Alt.2	0.3119	0.2241	0.484	0.2611	0.3189	0.2	0.47778	0.19461	0.23333
Alt.3	0.1976	0.3694	0.3329	0.3278	0.4599	0.4	0.35	0.53737	0.36667

Alternative 1	**0.3467**
Alternative 2	**0.2937**
Alternative 3	**0.3596**