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Impacts of Trade of Reclaimed Wastewater on Water Management in Palestine

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DEDICATION

This work is dedicated to those who always believed in me and encouraging me

To my family

To my parents especially my dear mother

To my three sisters; Mariam, Nana and Waed

To all my brothers especially my beloved brother Abd Al-Salam

To my children Sarah and Mohammed

To someone who has always been dear to my heart; to Ali Al-Sayyed

To all my colleagues and my friends, especially Shereen Zuhdi and Mahasen Al-Barghouti

To Palestinian Industrial Estate and Free Zone Authority (PIEFZA), where I work

To An-Najah National University, where I studied

To my beloved Palestine

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I do not forget my children (Sarah and Mohammed), who were a key reason to complete this search.

Finally, I thank all people that help me to complete this research.

الاقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل عنوان:

Impacts of Trade of Reclaimed Wastewater on Water Management in Palestine

تقييم أثر التبادل التجاري للمياه العادمة المستصلحة على إدارة مصادر المياه في فلسطين

أقر أن ما اشتملت عليه هذه الرسالة إنما هو نتاج جهدي الخاص باستثناء ما تمت الإشارة إليه حيثما ورد، وإن هذه الرسالة ككل أو جزء منها لم يقدم من قبل لنيل أية درجة أو بحث علمي أو بحثي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the Researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

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ABBREVIATIONS

WB	West Bank
WW	Wastewater
WWTP	Wastewater Treatment Plant
PWA	Palestinian Water Authority
PCBS	Palestinian Central Bureau of Statistics
MOA	Ministry Of Agriculture
MONE	Ministry Of National Economy
EQA	Environment Quality Authority
Km^2	Kilo meter square
mm	Millimeter
MCM / Mm^3	Million Cubic Meter
NWC	National Water Company
PLO	Palestinian Liberation Organization
USD	United State Dollar
lcd	Liters Per Capita Per Day
NIS	New Israeli Shekel
Dunums	1000 meter square
ARIJ	Applied Research Institute Jerusalem

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Abstract

Water scarcity is one of the most difficult problems facing Palestine. The lack of a available water resources and competition between different uses; domestic, agricultural and industrial is increasing year by year.

Reuse of reclaimed wastewater has great potential to alleviate water scarcity problems and improve crop yield. The treated wastewater resource is an environmental, social and economical good that needs to be managed in appropriate way. Palestine, as in most of the neighboring countries in the region, acknowledges the importance of this resource in improving the water deficit by reusing the reclaimed wastewater in agricultural production, industrial sector and recharging groundwater aquifers.

One alternative is to trade the reclaimed wastewater at some locations against water at other locations; or trade-offs this reclaimed wastewater. Trade of reclaimed wastewater has been among the different subjects that were addressed in different meetings and workshops as a commercial and/or political solution to the water scarcity problems in the region.

Data related to wastewater quantities, collection, treatment, transportation and reuse has been collected and analyzed as baseline

assessment. Pros and Cons analysis method has been used in the analysis as to study the, among other, trade impacts of reclaimed wastewater. Social, environmental and other possible impacts have been also addressed.

There are several ways and scenarios for trade of reclaimed wastewater as follows;

1. Trade or trade-off of Reclaimed Wastewater between Palestine and Israel.
2. Trade or trade-off of Reclaimed Wastewater among Palestinian Governorates.
3. Trade-off of Reclaimed Wastewater in Agriculture.
4. Trade of reclaimed wastewater in the industry.

Palestinian can decide the best choice according to the strategic plan because the trade of reclaimed wastewater even at the same governorate or between governorates for industrial purposes can be better for the long time, which can be better according to the sustainability vision, on the other side trade with Israelis can be better for the short time plans because this choice can offer an economical income for Palestinians which can help them to pass the financial difficulties they are facing at this time.

Reclaimed wastewater is an important unused natural source, it’s important to maximize the benefits that we could get by using such an important source .

Multi scenarios can be used depending on many factors: quantities of water, distance from Israel, nature of agriculture and industrial types in every governorate. The price of reclaimed wastewater is an important factor to make these scenarios are applicable.

Depending on the interviews with the related people and decision makers at the Ministries of Agriculture (MoA), Environment Quality Authority (EQA), Ministry of National Economy (MoNE) and Palestinian Water Authority (PWA), they all welcomed of the concept of trade of reclaimed wastewater.

CHAPTER ONE

INTRODUCTION

1. Introduction

1.1 General Background

Water scarcity is one of the most difficult problems facing Palestine. The lack of water resources and competition between different uses, domestic, agricultural and industrial, is increasing year by year. The pollution of water resources is also restricting the availability of water; the wastewater cesspits used by Palestinians are a source of groundwater pollution. The high water usage, as well as disposal of wastewater from Israeli settlements in the West Bank, is cited as contaminating the soil and further reducing the water resources available for the Palestinians **(Mcllwaine and Redwood, 2010).**

In 2012, the total amount of water consumed in the West Bank and Gaza provides each person with an average of 96 liters per capita per day (lcd) in Gaza (95% of Gaza water with an unaccepted quality), 72 lcd in the West Bank with an overall average of 82 lcd. Table (1) lists the water made available per person in West Bank during the years 2004-2010 **(PWA, Water Strategy, 2013)**.

Table (1.1) Water made available per person in West Bank (lcd)

Year	2004	2005	2006	2007	2008	2009	2010
West Bank	80	78	76	79	86	75	72

(PWA, Water Strategy, 2013)

The 82 lcd is not particularly a high value. It is one of the lowest rates in the Middle East.

In the West Bank the increase was from 2004 to 2008 at 1.2 lcd, but it decreased after that during the two year 2009 and 2010 at 1.5 lcd.

Reuse of treated (reclaimed) wastewater has great potential to alleviate water scarcity problems and improve crop yield. The treated wastewater resource is an environmental, social and economical good that needs to be managed in an appropriate way. Palestine, as in most of the neighboring countries in the region, acknowledges the importance of this resource in improving the water deficit by reusing the reclaimed wastewater in agricultural production, industrial sector and recharging groundwater aquifers.

As the water resources are not even distributed among the Palestinian cities and areas, the reuse of reclaimed wastewater may face obstacles due to water availability in addition to other social and economic factors. This means that reclaimed wastewater might

be needed to be transported from the wastewater treatment plants to the consumption centers.

One alternative is to trade the reclaimed wastewater at some locations against water at other locations; or trade-offs the reclaimed wastewater. Trade of reclaimed wastewater has been among the different subjects that have been addressed in different meetings and workshops as a commercial and/or political solution to the water scarcity problems in the region.

This thesis addresses the impacts of trade of reclaimed wastewater on the management of water resources in Palestine. It tackles the value of reclaimed wastewater and its trade as an alternate water resource.

1.2 Research Outline

The methodology applied in this research study is analytical. Data related to wastewater quantities, collection, treatment, transportation and reuse has been collected and analyzed as baseline data.

After that the interviews with institutions and relevant ministries are done to study their opinions to improve the decision-making, and inform them of the all scenarios.

Then Pros and Cons analysis method is used, it is a simple process for decision-making to compile a 'weighted' scored. Pro means 'for', and con means 'against'; advantages and disadvantages.

Pros and cons and 'weighted' decision-making method is one major method applied in the analysis as to study the impacts of trade of reclaimed wastewater on the water resources. Social, environmental and other possible impacts have been also addressed. It is a tool or techniques which decision-makers use to choose between the four thesis scenarios or alternatives of action and in deciding whether a proposed project should go ahead or not.

For several options can be assessed against differing significant criteria, or against a single set of important factors. In any case, factors/options can be weighted and scored appropriately.

In such situations we can assess different options according to a single set of criteria (the most important considerations), or we can allocate weighted/scored criteria differently to each option. The thesis makes a sheet for the identified options, then lists all the points that can think of for the option concerned compare the number or total score of the items/effects/factors between options and factors.

This will provide a reflection and indication as to the overall attractiveness and benefit of the option concerned. If we have scored each item we will actually be able to arrive at a total score, being the difference

between the pros and cons options totals. The bigger the difference between the total pros and total cons then the more attractive the option is. The biggest positive difference between pros and cons is the most attractive option or scenario.

Pros and Cons analysis mean the favorable and the unfavorable factors or reasons; advantages and disadvantages factors is undertaken to weigh the disadvantage of proceeding with a project against the benefits or advantages that would arise from it.

The pros of trade of reclaimed wastewater might include alternative water resources, environment protection, job creation, etc. The cons of trade of reclaimed wastewater would include the cost of treatment and transportation, social and health aspects and other factors. Identifying all the consequences of a trade of reclaimed wastewater is difficult because it involves predicting the future and dealing with uncertain interactions and interpretations between human activities and the ecosystems in which they take place.

The thesis has managed integrate the above factors and has employed these to assess the impacts of the trade and trade-off of reclaimed wastewater.

Decision-making is more natural to certain personalities, so these people should focus more on improving the quality of their decisions. Good decision-making requires a mixture of skills: creative development and

identification of options, clarity of judgment, firmness of decision, and effective implementation. Figure (1.1) show the flow chart of the research methodology.

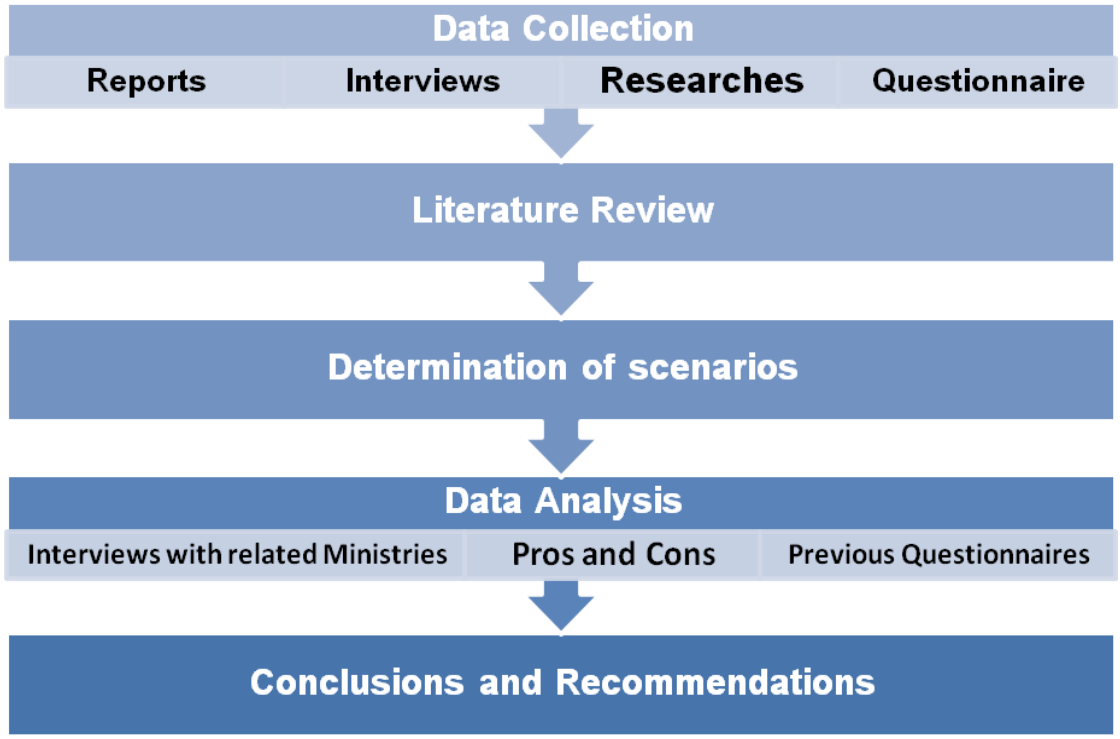

Figure (1.1) The flow chart of the research methodology

1.3 Research Objectives and Hypothesis

The main objectives of this research are:

1. Understand the value of wastewater trade and study its applicability in Palestine.
2. Address the impacts of trade of reclaimed wastewater on the management of the Palestinian water resources.
3. Enhancing reuse of reclaimed wastewater in Palestine.

The research Hypothesis and Question is:

"Introducing trade of the reclaimed wastewater in Palestine will enhance water resources management" is the hypothesis and the main question of this MSc thesis.

1.4 Motivations

The following are the research motivation:

1. Water scarcity in Palestine.
2. Reclaimed wastewater is an alternate water resource.
3. Recent development in wastewater treatment industry in Palestine.
4. Deterioration of the environment in Palestine and the urgent need for protection.

CHAPTER TWO

LITERATURE REVIEW

2. Literature Review

2.1 Introduction

Since 1967, Israel has occupied the rest of Palestine and has maintained a tight grip of control on available water resources. This control has been executed through military orders and discriminatory water policies that have denied Palestinians right of water. Construction of the Separation Wall, expansion of Israeli settlements, and destruction of the Palestinian water infrastructure are all facilitating Israeli hydro-hegemony in the region. This situation is further aggravated by over-abstraction and water diversions by Israel which has triggered water shortages to the extent that an acute water crisis has developed.

Following the 1995 Oslo Accords, Israel was allocated 80% of the West Bank aquifer's and the Palestinians were allocated only 20% **(Attili, 2012)**. This severe disparity in water resource allocation manifests into direct and indirect economic losses for Palestinians. Direct losses amount to the higher costs for water and indirect losses relate to lost agricultural production along with health problems related to poor water quality **(ARIJ, 2012)**. These losses are crippling economic growth and development in Palestine. Israel is accountable for these losses as it has neglected the 1995 Israeli-Palestinian Interim agreement, side-stepped international law, and violated Palestinian basic human rights.

To survive, it is urgent to consider other potential water resources in addition to seeking a solution for the Palestinian case and ending the Israeli occupation. Among the other solutions is to treat and reuse the wastewater. Different scenarios of reuse of reclaimed wastewater have been considered and tackled by different studies and literatures. In this thesis impacts of trade of reclaimed wastewater are addressed as to value the reuse of reclaimed wastewater resources by trading it among locations and localities in the region.

2.2 Water Resources in Palestine

2.2.1 Surface water resources

There are currently very few surface water resources in the West Bank. Most of the wadis flow only for a few weeks a year, usually as flash-floods after thunderstorms. Rain water is hard to use and capture as, in most Palestinian valleys, the complicated geological/ geographical features complicate the construction of large storage dams (few plains, karstic limestone substratum, political restrictions, etc).

The main surface water resource on the West Bank is the Jordan River, which is heavily used for irrigation and domestic water supply by Israel, especially upstream, Since 1967 the Palestinians do not have access to this water source. It is a trans-boundary resource, shared between Jordan, Syria, Lebanon and Palestine. However, the following facts should be considered:

• Jordan River; It mainly consists of two parts: the Upper Part that flows from the river headwaters (Hasbani, Banias and Leddan) into Lake Tiberias, while the Lower Part is the continuation of flow from Lake Tiberias to the Dead Sea at an altitude of 425 m below sea level. This huge reduction in flow is mainly due to diversion of the water by Israeli occupation of more than 500 million cubic meters through the National Water Carrier that extends south to the Negev, in addition to the construction of many dams upstream. Moreover, natural factors such as evapo-transpiration had an adverse impact on Jordan River flows. The Jordan River is threatened by the discharge of large quantities of untreated wastewater from Israeli illegal settlements located along and south of Lake Tiberias **(PWA, Water Strategy, 2013)**.

• West Bank wadis: The long-term average annual flow of flood water through wadis in the West Bank is about 165 Mm^3/y. Generally, the West Bank wadis are classified by the direction of flow into eastern wadis (towards the Jordan Valley and the Dead Sea) and western wadis (towards the Mediterranean). Currently, about 1 Mm^3/y is being harvested through several agricultural bonds in the Jordan Valley and the small scale dam (retention structure) in Al Auja Area **(PWA, Water Strategy, 2013)**.

2.2.2 Groundwater resources

Palestine is mostly reliant on groundwater where the majority of Palestinian water supply comes from this source either by wells or springs. The total renewable groundwater resources have been estimated as 578-814 Mm^3/year in the West Bank aquifer basins **(PWA, Water Strategy, 2013)**.

In the West Bank, groundwater resources are contained in deep (karstic) limestone and dolomite aquifers. Most large production Wells are 200-800 m deep and the water table lies between 100 and 450 m below the surface. These aquifers are commonly divided into three main aquifer-Basins (Western, Eastern and North-Eastern). The Western and North Eastern basins flow to the 1948 occupied Palestine (Israel) where it constitutes one of the main groundwater resources. Table (2) lists the estimates of the recharge into the main Palestinian aquifers **(PWA, Water Strategy, 2013)**.

Table (2.1): Recharge estimate for the main aquifers.

Aquifer-Basin	**Area within Palestine (Km^2)**	**Average rainfall (mm) 2010/2011**	**Recharge volume 2010/2011 (Mm^3)**	**Long-term average recharge 2010/2011 (Mm^3)**
Western Aquifer	1767	407	311	318-430
Northeastern Aquifer	981	433	134	135-187
Eastern Aquifer	2896	281	153	125-197
West Bank Total	**5644**	**347**	**598**	**578-814**

(PWA, Water Strategy, 2013)

The total recharge area is about 6000 km^2 contributing about 600-900 Mm^3 as an annual average.

2.2.3 Non-conventional resources

2.2.3.1 Reuse of treated wastewater

For West Bank, there are few activities or projects for reuse (small scale projects on community level are implemented such as Anza, Attil, Kharas). However, some reuse projects are proposed for North-West Nablus, Jericho, Tayaseer and Auja areas in the short-term vision. An additional water resource will become available through the scheduled developments of wastewater treatment plants. This resource is already under development in the Gaza Strip (with a scheduled production capacity of 10 Mm^3/year) in North Gaza **(PWA, Water Strategy, 2013)**.

2.2.3.2 Desalination of sea water

There is one sea water desalination plant located in the middle area of Gaza Strip (Deir El Balah) with a capacity of 600 m3/day (0.22 Mm3/year). The plant is working using two beach wells and is planned to be expanded to about 2600 m3/d (0.95Mm3/y) by the year 2014. A large sea water desalination plant with a capacity of 50 Mm3/year, as a first phase, is scheduled to be constructed by year 2017 and is to be located in the central part of Gaza Strip. The desalinated water will be mixed with abstracted groundwater and distributed to the consumers through the distribution facilities. By this additional water as well as other water and treated wastewater, it is expected that the coastal aquifer can recover to its original steady state.

The Gaza Strip borders the Mediterranean Sea, a nearly unlimited source of saltwater. This resource can be used for soft water production in Palestine, as it is in other Mediterranean countries (Israel, Algeria, Spain, Greece, etc.). Seawater desalination technologies are mature and there is a significant number of competing manufacturers of reliable equipment in the market (many of them with good track records of producing desalination plants of the same type as planned in Gaza).

The main constraints for the construction of large desalination plants in a low-income and blockaded country such as the Gaza Strip are:

- The cost of equipment;
- The running costs of the desalination plants (power, equipment renewal);
- Power production or import;
- Israeli restrictions on access to materials and equipments;
- Difficulties in attracting investors due to the conflict and risks of Israel targeting the installation as it previously did with the Gaza power station;
- Poor water distribution system efficiency; and
- Institution constraints.

PWA has identified a large desalination project for Gaza, with a 55 Mm3/year capacity by 2017 (to be expanded to 129 Mm3/year in the future). The plant site has been secured (along the coast) and preliminary negotiations are under way with development banks and donor organizations. Additional equipment could be installed on the same site or on other similar sites in the Gaza Strip. **(PWA, Water Strategy, 2013)**.

Sea water resources are not available for the West Bank, except as part of a long-term strategy of regional water resources management: desalinated water could be conveyed from Gaza to the West Bank or through an equitable agreement with the Israeli occupation. This could be also tackled as part of the trade and/or trade-offs concept of available water resources in Palestine.

2.2.3.3 Desalination of brackish groundwater

Small pilot desalination projects for Brackish Water exist mainly in the Jordan Valley established by the private sector with a total capacity of less than 0.5 Mm^3/year. These are used mainly for agricultural purposes. A large facility is planned downstream from the Fashka Springs, near the Dead Sea (with a scheduled production capacity of at least 22 Mm^3/year by the year 2022). This project will increase water supply for the southern part of the West Bank and will finally be extended to produce 40 Mm^3/year in the future **(PWA, Water Strategy, 2013)**.

Further developments in reuse of treated and reclaimed wastewater should be undertaken in both Gaza and the West Bank. This potential resource could be relatively large, but its development raises important issues that are yet to be resolved. Among these issues is the acceptance to reuse reclaimed wastewater as an alternate to available fresh water especially in the areas that are relatively rich in fresh water. This is the case in Tulkarm and Jericho.

Trade of reclaimed wastewater is presented here as a possible solution to the problem of rejection of reuse due to availability of fresh water. It suggests the trade of reclaimed wastewater against fresh water at other places. It also considerate transport of the available water to area suffering shortage in fresh water. The thesis address and analysis these issues in detail in the coming chapters. It also tackles its impacts on the water resources management.

2.3 Water Regulatory framework

2.3.1 Background

The violation of the right of the Palestinian to equitable and fair utilization of the shared water resources is contrary to the spirit and principles of customary international law and has long been one of the major obstacles to cooperation and the achievement of peace in the Middle East.

The “Oslo Declaration of Principles” in September 1993 signed and the agreements between Israel and Palestine has stressed:

- Cooperation among both parties for the management of the water resources and development of the water infrastructure.
- Equitable utilization for joint resources.
- Environmental protection and prevention of environmental risks, hazards and nuisances.
- Apply and ensure compliance with internationally recognized standards.
- Recognized the need to protect the environment and utilize natural resources on a sustainable basis.

2.3.2 Palestinian National Water Policy

The adoption of the elements of the National Water Policy in September 1995 represented the first step in addressing the important issues of water resources management and planning. The National Water Policy establishes the foundation for decisions regarding the structure and tasks of water sector institutions as well as water sector legislation. It also underpins the necessity of the sustainable development of all water resources and establishes the principle that water resources are a public property. Clearly, the development of the water resources of Palestine must be coordinated on a national level and carried out on the appropriate local level.

2.3.3 Water Resources Management Strategy

The overall development objective of the Water Management Strategy is to translate the messages from the National Water Policy into strategic imperatives. The strategy emphasizes the necessary aspects of water development as the establishment of a comprehensive framework for the sustainable management of Palestine's water resources, in addition to the development of an appropriate institutional set-up for reforming and strengthening the water sector in coordination with relevant stakeholders. This long-term and coordinated strategy for the water sector will be used as an overall basis for further planning relating to the activities and tasks associated with the water sector, with the main objective being the securing of an environmentally sound and sustainable development of the water resources through efficient and equitable water management. The eight key elements of the recently developed Water Resources Management Strategy are **(PWA, Water Strategy, 2013)**:

- Secure the Palestinian water rights.
- Strengthen national policies and regulations.
- Develop institutional capacity and human resources.
- Improve information services and assessment of water resources.
- Regulate and coordinate integrated water and wastewater investments and operations.
- Enforce water pollution control and protection of water resources.
- Develop public awareness and participation.

- Promote regional and international cooperation.

2.3.4 Water Law No. 3 for 2002

The objective of the water law of 2002, as stated in Article 2, is to "develop and manage the water resources, increasing their capacity, improving their quality and preserving and protecting them from pollution and depletion". This objective is fulfilled through:

i) The sustainable development of water resources based on environmentally sound and enabling bases;

ii) The provision and satisfaction of societal and individual needs for water in an optimal and equitable way; and

iii) The protection of all water resources from pollution to secure water quality, an environment not harmful to human health or well-being, and sufficient water for production and self-renewal."

2.3.5 Water Law for 2014

Stated the same objective of the water law of 2002. "All water resources are public owned", "this law aims to develop and manage the Water Resources in Palestine, to increase their capacity, to improve their quality, to preserve and protect them from pollution and depletion, and to improve the level of water services through the implementation of integrated and sustainable water resources management principles". The law has enabled to establishment of water utilities and water users

association. Water Sector Regulatory Council established in accordance with provision of this Law:

1. A Council named "The Water Sector Regulatory Council" shall be established by a decision of the Cabinet of Ministers and shall be regulated pursuant to this law. The Council enjoys a legal personality and is financially and administratively independent.

2. The main headquarter of the Council shall be in Jerusalem, and its temporary headquarter in any other place in Palestine; The Council's Board.

The objective of the Council is to monitor all matters related to the operation of water Service Providers including production, transportation, distribution, consumption and wastewater management, with the aim of ensuring water and waste water service quality and efficiency to consumers in Palestine at affordable prices. The Council shall enjoy the same exemptions and privileges applicable to ministries and governmental departments.

The law also determined in "Article Number 6" the purposes of using water and these purposes are: A. Domestic and residential, B. Agriculture and irrigation, C. Industrial, D. Tourism, E. Trade and commerce and F. Conservation of water-dependent ecosystems and aquatic habitats.

CHAPTER THREE

STUDY AREA

3. Study Area

3.1 Introduction

The name West Bank is a translation of the Arabic term ad-Daffa al-Gharbiya, given to the territory west of the Jordan River. The term was chosen to differentiate the west bank of the River Jordan from the east bank of this river.

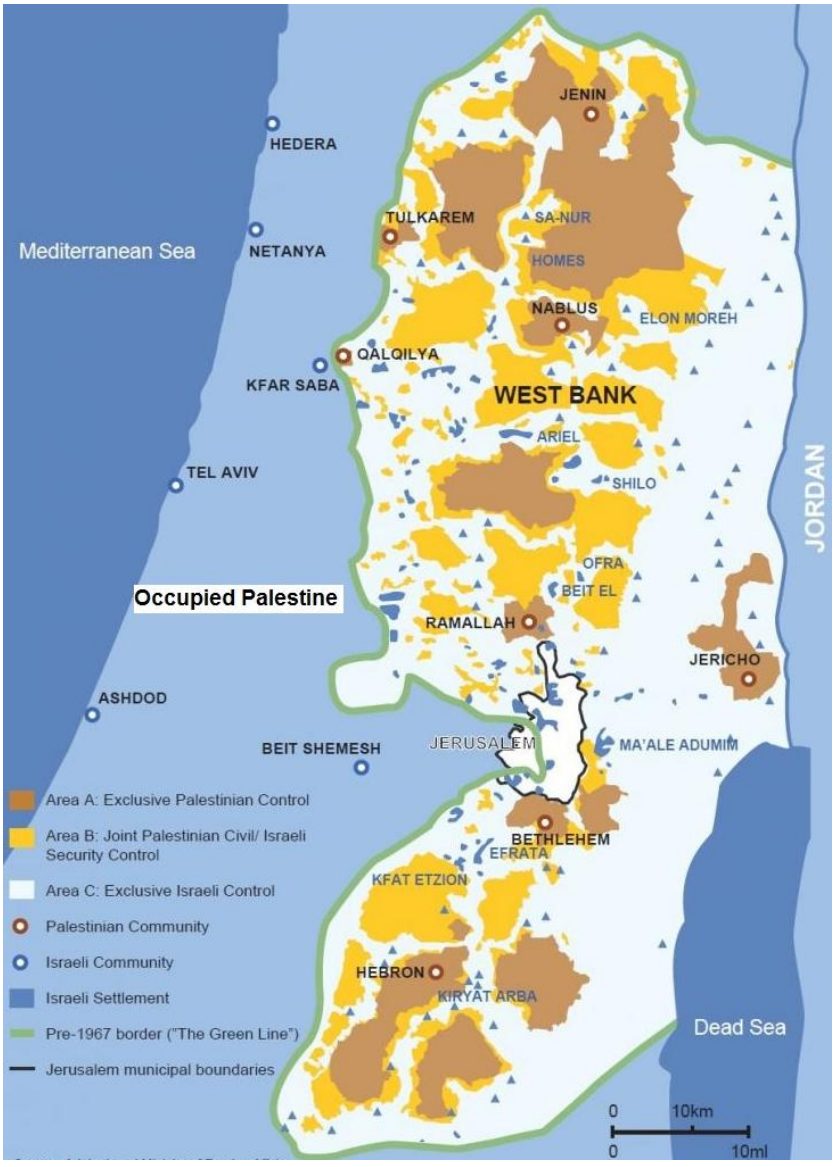

Figure (3.1) Study Area

In June 1967, the West Bank and East Jerusalem were occupied by Israel. The West Bank is under the Israeli military control.

Since the 1993 Oslo Accords, the Palestinian National Authority officially controls a geographically non-contiguous territory comprising only 11% of the West Bank (known as Area A) which remains subject to Israeli military incursions. Area B (28%) is subject to both Israeli military and Palestinian civil control. Area C (61%) is under full Israeli control. Israel's occupation of the West Bank is not recognized by any state.

In 2013, State of Palestine was accepted by United Nation (UN) as an observing member. In the November 29, 2012, the date of the International Day of Solidarity with the Palestinian People. The motion, the representative of Palestine to the United Nations. The vote was to give Palestine a non-member status at the United Nations. Basically, elevating the resolution of Palestine arranged a non-member entity to a member.

The broad population characteristics of Palestine are strongly influenced by political developments, which have played a significant role in the growth and distribution of population in the Governorates. According to Palestinian Central Bureau of Statistics (PCBS, 2013), a total population of 4.4 million live in the two geographical areas, 61.5% in the West Bank including Jerusalem and 38.5% in Gaza Strip.

3.2 Geography

West Bank with an area of approximately 5800 km^2 is made up of a hilly region in the West and the Jordan Valley in the East, and has generally rugged mountainous terrain. The total length of the land boundaries of the West Bank is 404 km^2. The terrain is mostly rugged dissected upland, some vegetation in west, but somewhat barren in the east. The elevation span between the shoreline of the Dead Sea at -408 m to the highest point at Mount Nabi Yunis, at 1,030 m above sea level. The area of West Bank is landlocked; highlands are main recharge area for the groundwater coastal aquifers.

3.3 Climate

The climate in the West Bank can be characterized as hot and dry during summer and cool and wet in winter. The climate in the West Bank is mostly Mediterranean, slightly cooler at elevated areas compared with the shoreline, west to the area. In the east, the West Bank includes the Judean Desert and the shoreline of the Dead Sea, both with dry and hot climate.

3.4 Palestinian Governorates

West Bank is divided into 11 governorates under the jurisdiction of the State of Palestine. Table (3.1) lists the Palestinian governorates in the West Bank and the population and area for each.

Table (3.1) Palestinian Governorates

Governorate	**Population**	**Area (km^2)**
Tulkarm	175,213	239
Tubas	65,771	372
Salfit	55,464	191
Ramallah and Al-Bireh	260,018	844
Qalqilya	120,753	164
Nablus	386,380	592
Jerusalem	462,521	344
Jericho	48,724	608
Jenin	556,212	583
Hebron	751,129	1,060
Beithlehem	257,515	644
Total	**3,609,700**	**5,671**

(PCBS, 2014)

3.5 Economy

The economy of Palestine is chronically depressed, with unemployment rates constantly over 20% since 2000 (19% in the West Bank in first half of 2013). The main reason for economic depression is the Israeli occupation.

According to a 2007 World Bank report, the Israeli occupation of the West Bank has destroyed the Palestinian economy, in violation of the 2005 Agreement on Movement and Access. All major roads (with a total

ength of 700 km) are basically off-limits to Palestinians, making it impossible to do normal business. Economic recovery would reduce Palestinian dependence on international aid by one billion dollars per year.

A more comprehensive 2013 World Bank report calculates that, if the Interim Agreement was respected and restrictions on the Palestinian are lifted, a few key industries alone would produce USD 2.2 billion per annum (about 23% of the 2011 Palestinian Growth Domestic Product (GDP)) and reduce by some USD 800 million (50%) of the deficit; the employment would increase by 35%.

3.6 Water consumption

According to the Palestinian Water Authority, the average Israeli domestic consumption of water is 300 liter per person per day, which is more than 4 times that of the Palestinian use of 72 liters per day. Some Palestinian villages live on even less water than the average Palestinian consumption, in some cases no more than 20 liters per person per day. According to the World Bank, water extractions per capita for West Bank Palestinians are about one quarter of those for Israelis, which have declined over the last decade.

This has decrease the available per capita water consumption over the latest's years in West Bank. The lack of access to addition water resources has forced the actions forwards reusing of reclaimed wastewater.

3.7 Water Tariff

Prices paid for water itself are different from water tariffs, a water tariff is a price assigned to water supplied by a public utility through a piped network to its customers. The term is also often applied to wastewater tariffs. Water and wastewater tariffs are not charged for water itself, but to recover the costs of water treatment, water storage, transporting it to customers, collecting and treating wastewater, as well as billing and collection (**Aslan, 2013**).

According to the recent developed water strategy (**PWA, Water Strategy, 2013**) water tariffs can be set by each water utility itself, according to:

(a) the full cost recovery principle.

(b) the costs analysis tools developed by Palestinian water authority.

(c) the actual running costs accounted for by the water utility itself.

The water tariff and the basis for its calculation by each water utility will be objected or approved the tariff by the water regulatory council. (**PWA, Water Strategy, 2013**).

The average tariff system in the West Bank governorate can be summarized in table (3.2), the maximum tariff includes Water Tankers prices (**Aslan, 2013**).

Table (3.2) Water Tariffs in the West Bank Governorate

Governorate	Average Tariff (NIS/m^3)	Maximum tariff (NIS/m^3)
Beithlahem	4.6	15
Hebron	5.4	20
Jenin	4.3	19
Jericho	2.5	5
Jerusalem	4.1	-----
Nablus	4.5	15
Qalqilia	4.1	18
Ramallah	4.1	9.7
Tulkarm	3.1	20

(Aslan, 2013)

3.8 Rainfall

The annual rainfall in the West Bank varies from about 650 mm in the western part to less than 100 mm in the east; the long-term annual average is about 454 mm. During the past 8 years, average accumulated annual rainfall increased in the northern and north western parts of the West Bank.

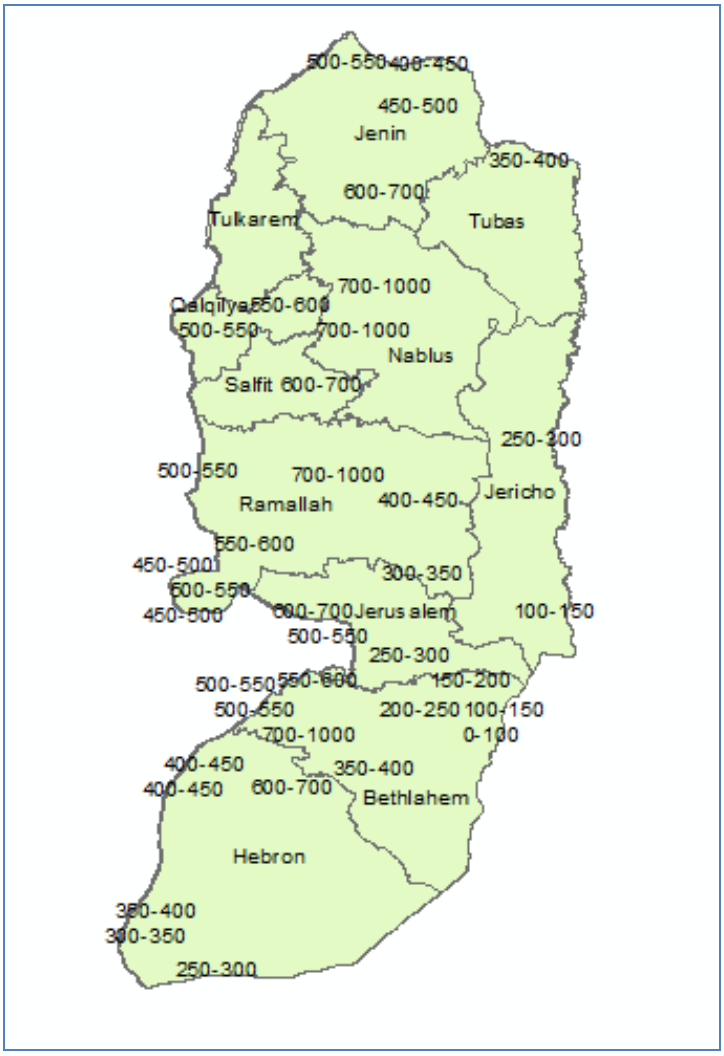

Figure (3.2) West Bank Rainfalls

In 2010/2011 however rainfall in the northern and western parts of the area peaked at only 538 mm/y, while in the east it was as low as 70 mm/y. The average annual rainfall for the year 2010/2011 for the entire West Bank was about 347 mm.

Annual rainfall normal display most extreme spatial distribution, the spatial rainfall variation is uneven, and the areas receiving different amounts of rainfall are not of the same size. Figure (3.3) shows the

historical records of annual average rainfall in the West Bank, (PWA, Annual Water Status Report, 2011).

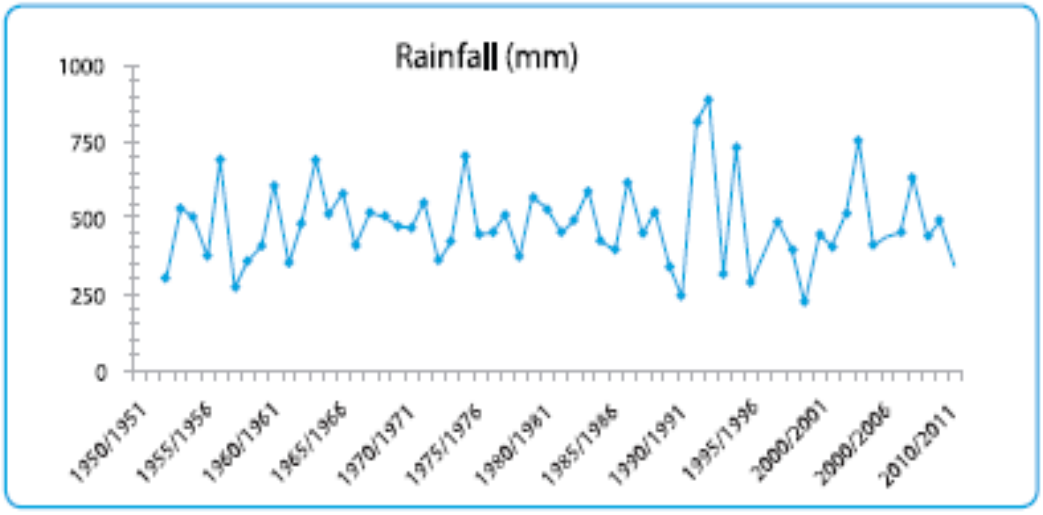

Figure (3.3) The historical records of annual average rainfall in the West Bank.

3.9 Agriculture in West Bank

Agriculture is an important cultural tradition vital to the economy of the West Bank. Farming has been a part of Palestinian life for thousands of years, not only providing communities with food and jobs, it is a source of pride and a means of self-sufficiency. From drier and drier seasons to ever-changing political obstacles, both physical and bureaucratic, farming in the West Bank faced major challenges to way of life and livelihoods.

Palestine is famous of growing olives, Almond, Citrus and grapes as fruit trees, distributed as follows: Olives mainly grow in Nablus, Jenin, Ramallah, and Tulkarm. Almonds mainly grow in Tulkarm, and Jenin, while Citrus grow mainly in Qalqilia, Nablus, Tulkarm, and Jericho, finally grapes are mainly produced in Hebron and Beithlahem **(PCBS, 2006/2007)**.

West Bank interest in producing different kinds of vegetables mainly Tomato, squash, cucumber, which depend on rain feed or irrigation, in most governorates the green house, is used to increase their productions **(PCBS 2006/2007)**. Wheat considered as a main type of field crops which mainly grows in Jenin, Hebron, and Tubas, irrigated by irrigation system or depended on rain fed.

Table (3.3) shows that every governorate in the West Bank with cultivated area of horticulture Trees, Vegetables and field crops **(PCBS: Agricultural Census, 2010)**.

Table (3.3) Cultivated Area of Horticulture Trees, Vegetables and Field Crops in the Palestinian Territory by Governorate, 2009/2010

Governorate	Total Area (Dunums)	Field Crops Area (Dunums)	Vegetables Area (Dunums)	Horticulture Trees Area (Dunums)
Jenin	**177,271.11**	55,366.29	19,186.20	102,718.62
Tubas	**65,087.52**	34,787.53	20,319.87	9,980.12
Tulkarm	**73,742.32**	3,548.88	8,475.26	61,718.18
Nablus	**120,920.81**	27,285.78	11,353.59	82,281.44
Qalqiliya	**48,234.91**	7,136.01	2,954.93	38,143.97
Salfit	**39,567.37**	631.42	413.82	38,522.13
Ramallah and Al-Bireh	**65,883.06**	6,618.02	1,925.16	57,339.88
Jericho and Al-Aghwar	**36,277.68**	2,971.19	26,299.34	7,007.15
Jerusalem	**10,704.50**	1,713.73	758.04	8,232.73
Beithlehem	**31,870.29**	4,702.78	1,583.80	25,583.71
Hebron	**156,743.04**	79,143.87	7,309.17	70,290.00

(PCBS: Agricultural Census, 2010)

According to the previous table, Figure (3.4) shows that the biggest cultivated areas in Jenin, Hebron and Nablus then Tulkarm, Ramallah and Tubas.

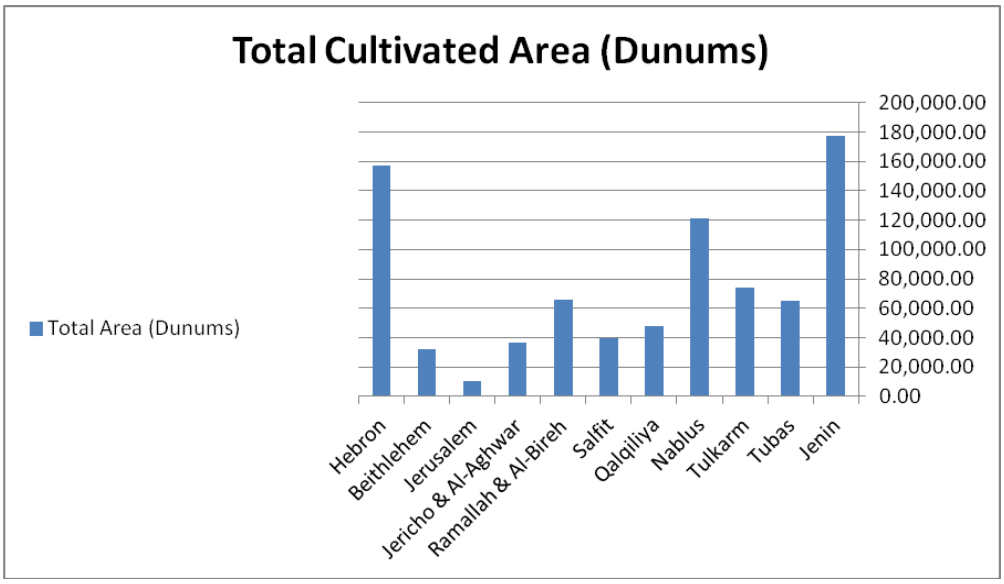

Figure (3.4) Total Cultivated Areas in West Bank Governorates

Jenin, Hebron and Nablus are the largest governorates that have the highest cultivated areas. Nevertheless, these three governorates are suffering water scarcity. Therefore providing addition water to these areas will enhance the agricultural activities because of that it is possible to think of using the reclaimed wastewater from these cities to their needs or from other cities, and that is what the thesis will talk about it later.

CHAPTER FOUR

DATA COLLECTION

4. Data Collection

Data collection consists of the data gathering mainly from the Palestinian Water Authority (PWA), the Palestinian Central Bureau of Statistics (PCBS), and other Palestinian ministers and municipalities.

4.1 Water Available Quantities

The quantities of water made available to the consumers vary from region to region. These quantities reflect the local water resource available, as well as the investments made over recent years to improve the water service reliability and water quantities in some cities.

The northern and southern parts of the West Bank are particularly affected by lack of water. This is mainly due to the Israeli restrictions that prevent Palestinians from utilizing their water resources, drilling new wells, rehabilitating existing wells and transporting water from one region to another.

Table (4.1) explains that 51.3 MCM was utilized for agriculture while the remaining 88.3 MCM was utilized for domestic, public, commercial and industrial uses (which will be referred to hereafter as “water utilized for domestic uses”). This resulted with low quantities of water supplied in the West Bank **(PWA, Annual Water Status Report, 2011)**.

Table (4.1): Total Supplied Amount (for Agricultural and Domestic Uses), 2011

Governorate	Total Resources (MCM)	Supply based on use	
		Domestic Use	Agricultural Use
Jenin	6.8	5.7	1.1
Tubas	7.4	1.5	5.9
Tulkarm	15.1	5.2	9.9
Nablus	17.1	15.0	2.1
Qalqiliya	10.9	4.7	6.2
Salfit	2.5	2.5	0.0
Jericho	27.9	3.8	24.1
Ramallah and Jerusalem	22.8	21.3	1.5
Beithlehem and Hebron	29.1	28.6	0.5
Total West Bank	**139.6**	**88.3**	**51.3**

(PWA, Annual Water Status Report, 2011)

Palestine has serious water problems in that it is denied its access to water rights, whilst Israel abstracts water from the West Bank for ever expanding settlements and sells what little remains back again to Palestinians. Palestinian attempts to maximize and redistribute available supplies are hampered by a total control of Israel and severe restrictions in the building or rehabilitation of water infrastructure.

Due to the water scarcity, many communities in the West Bank hire water tankers for their supply. This is reflected in the average

tariff per governorate, which is relatively high in Hebron, Jenin and Tubas, i.e. in those governorates where many communities are obliged to use water tankers, with tariff rising up to 20 ILS/m^3, and in some communities even more **(PWA, Water Strategy, 2013)**.

The majority of those West Bank inhabitants with no piped water supply are located within the following 4 governorates:

- Hebron Governorate, 31 communities (27,551 inhabitants) are still not served by water supply networks and pay very high tariffs for tanker water; the water piped to customers amounts only to 55 lcd;
- Jenin Governorate, 9 communities (19,013 inhabitants) are still without access to water supply networks and pay very high tariffs for tanker water; the water piped to customers amounts only to 41 lcd;
- Nablus Governorate, 16 communities (47,235 inhabitants) are still not served by water supply networks and pay very high tariffs for tanker water; the average water piped to customers at the governorate level amounts to 84 lcd, as Nablus city itself is well serviced.
- Tubas Governorate, 8 communities (13,653 inhabitants) are still not served by water supply networks and represent 24.1% of the governorate population.

Figure (4.1), plots needed quantities for each governorate using a bar chart. It is clear that the governorates (Nablus, Hebron, Jenin and Ramallah) have the highest needed quantities of water, this mean we should concentrate in this research on these cities.

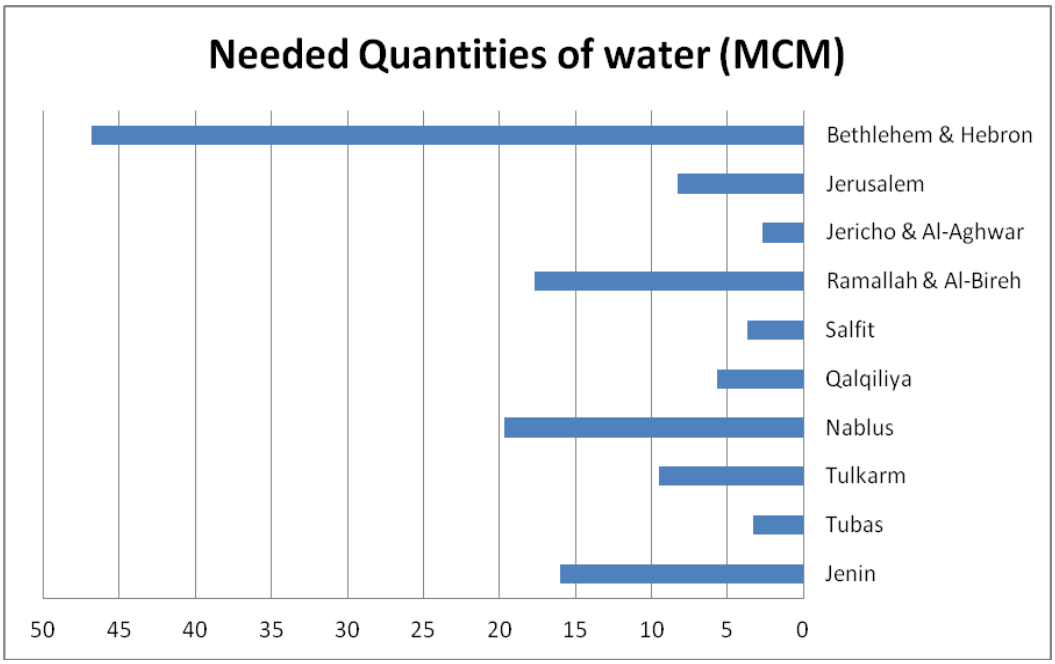

Figure (4.1): Needed Quantities of water for each governorate

4.2 Bulk supply from Mekorot

Over 34% of the West Bank's water supply comes from water imported from Mekorot systems **(PWA data, 2012**). To a certain extent, these imports offset the constraints imposed by the Israeli government regarding the construction of new wells, and import levels have been increasing over the last few years.

Figure (4.2), plots the annual quantity of water purchased from Mekorot for domestic use (in Mm^3/year). **(PWA, Water Strategy, 2013)**.

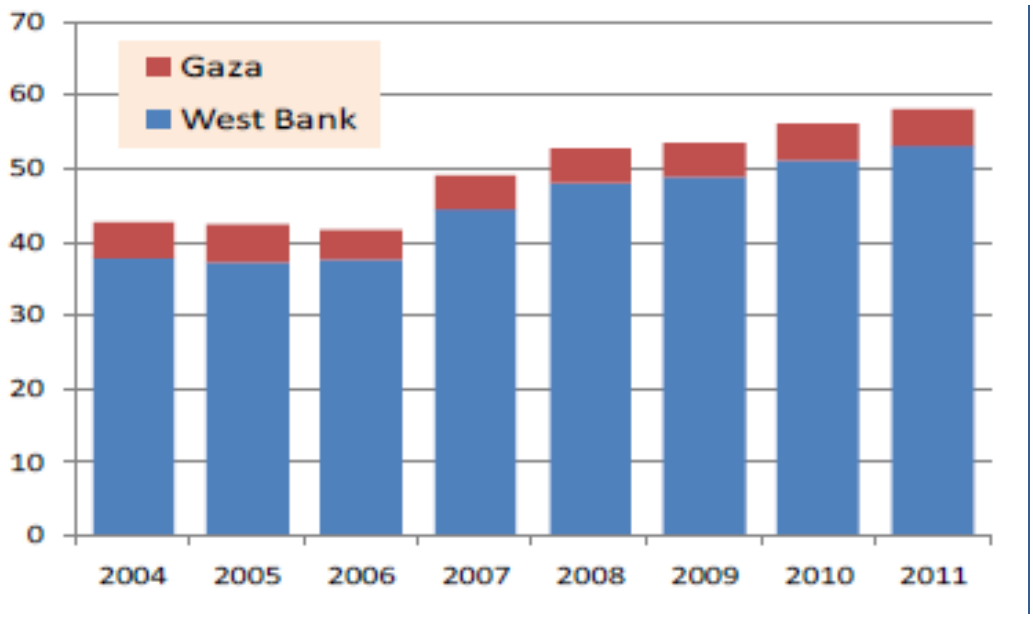

Figure (4.2): Annual quantity of water purchased from Mekorot for domestic use (Mm^3/year).

4.3 Wastewater Quantities

As to the water supply report (PWA, 2011), the wastewater quantities generated yearly in the West Bank are estimated at approx 62 MCM annually at a daily rate of about 170 Ml/day including municipal and industrial wastewater. In addition 35 MCM annually; 96 Ml/day of untreated wastewater are discharged by Israeli settlements and industrial zones into the West Bank environment. Less than 5% of the wastewater is generated from industrial activities like in Nablus, Ramallah and Hebron. Table (4.2) lists the estimated generated wastewater in 2011 from the different governorates.

Table (4.2) Estimated Annual Generated Wastewater (MCM) in the West Bank governorates

Governorate	Population (10^6)	Estimated WS	Into Israel	Into Wadi	Treated	Cesspits	Estimated Wastewater
Jenin	0.281	5.7	1.10	0.00	0.00	2.90	3.99
Tubas	0.057	1.5	0.00	0.11	0.00	0.94	1.05
Tulkarm	0.169	5.2	1.46	0.00	0.00	2.18	3.64
Nablus	0.348	15	4.02	3.21	0.00	3.27	10.5
Qalqiliya	0.100	4.7	2.19	0.00	0.00	1.10	3.29
Salfit	0.065	2.5	0.00	0.29	0.00	1.46	1.75
Ramallah	0.310	17.6	0.80	0.44	1.83	9.25	12.32
Jericho	0.047	3.8	0.00	0.00	0.00	2.66	2.66
Jerusalem	0.147	4.7	0.40	0.26	0.00	2.63	3.29
Bethlehem	0.194	11.3	1.17	1.64	0.00	5.10	7.91
Hebron	0.620	17.3	3.83	0.42	0.00	7.86	12.11
Total WB	**2.338**	**89.3**	**14.97**	**6.38**	**0.00**	**41.17**	**62.51**

(PWA, 2011)

Figure (4.3), plots these data using bar chart. It is obvious that three large cities or governorate (Nablus, Hebron and Ramallah) more than 10 MCM each.

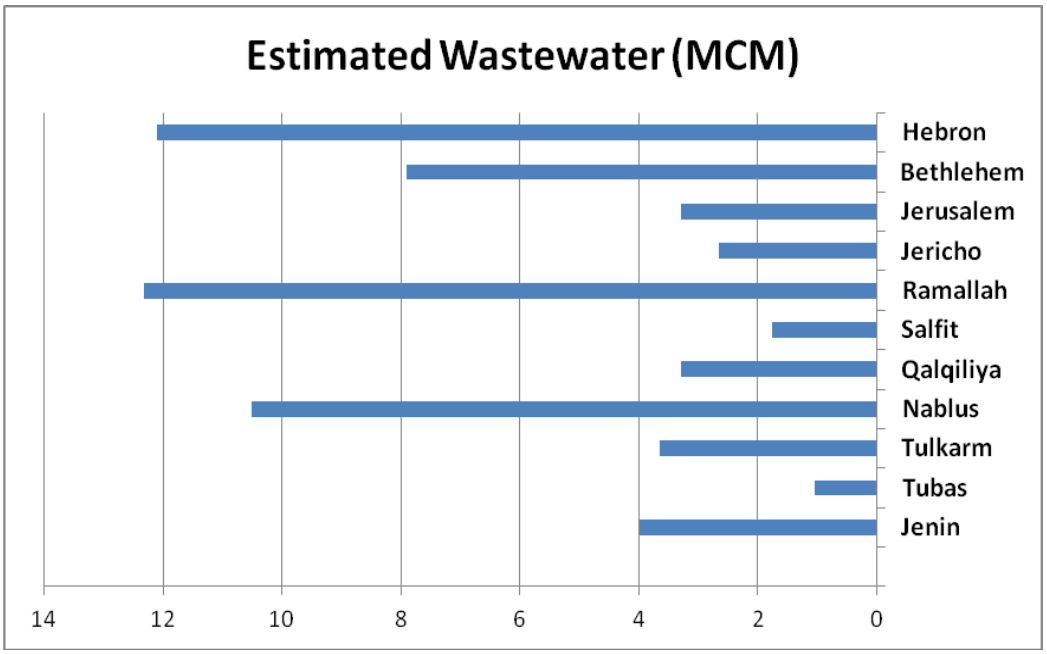

Figure (4.3) Estimated Wastewater Quantities

The collected quantities from these wastewater collection systems are either treated in Palestinian central treatment plants like Al-Bireh or small collective treatment plants like Zeita and Attil or are dumped into surface water streams (Wadis) and then either treated in Israeli treatment plants like Jenin, Tulkarm, West Nablus, Beit Jala, and Hebron, or disposed into Wadis.

Around 15 MCM annually of wastewater is collected from several areas in the year 2011 is dumped in wadis, and then treated in wastewater treatment plants inside the green line. At the expense of the Palestinian people, and treatment costs are directly deducted every month by the Israeli government from the Palestinian

clearance account without any positive valuation of the treated waters. This water is reused by the Israelis.

The estimated quantities of wastewater generated from Palestinian communities and treated in Israel are summarized in Table (4.3) **(PWA, 2011)**.

Parts of the influent which has infiltrated into the soil before reaching to the treatment plants depends on the soil characteristics and distance. One of the research aims to reduce the quantities of Wastewater flowing in trans-boundary streams by constructing large scale treatment plants.

Table (4.3) The Estimated Generated Wastewater in the West Bank wadis and treated in Israel

No	Name	Service Area	Name of WWTP	M^3/Day	MCM/ year
1	Wadi Al-Moqatta	Jenin City and Jenin Camp	Gilbo WWTP	3,000	1.10
2	Wadi Zumer	West Nablus, Ein Beit Alma Camp and some adjacent communities		4,000	1.46
		Tulkarem city, Tulkarem camp and Nur Shams Camp		11,000	4.02
3	Wadi Al-Zuhur	Qalqilia City	Ner Elyaho WWTP	6,000	2.19
4	Wadi Suriq	Ramallah City	Suriq WWTP	3,300	1.20
5	Wadi Beit Jala	Beit Jala and some parts of Bethlehem City		3,200	1.17
6	Wadi Al-Samen	Hebron City and Kiryat Arbaa Colony	Shoket WWTP	10,500	3.83
	Total				**14.97**

(PWA, 2011)

Among the other objectives that will be achieved by the research in case the trade of reclaimed wastewater is applied, is the reduction of the wastewater quantities that find inside 1948 occupied Palestine and is reused by Israel.

More than 6 MCM of untreated wastewater estimated to be generated from several communities in the year 2011 disposed into several streams that flowing to the east and north east of the West Bank. Table (4.4) shows the estimated generated wastewater that disposed in local streams (PWA, 2011).

Table (4.4) The Estimated Generated Wastewater in the West Bank local streams and non treated

No.	Stream (Wadi)	Measuring Point	m^3/day	MCM/year
1		Salfit	800	0.29
2	Wadi Al-Sajour	East Nablus, Askar and Balata Camps, Azmut, Salim and surroundings	8800	3.21
3	Wadi Al-Haramiya	Al Jalazoun Camp and surroundings	1200	0.44
4	Wadi Al-Nar	Beit Sahur and Beitlehem	4500	1.64
5	Wadi Sair	Al'Aroub Camp	1150	0.42
6	Wadi Far'a	Far'a Camp	300	0.11
	Total			**6.11**

(PWA, 2011)

The other generated wastewater is stored in cesspits in the rural areas, where the estimated wastewater dumped into cesspits is around 41 MCM (112 Ml/day). Around 2 MCM (54 Ml/day) is collected in Al-Bireh and surrounding refugee camps and treated in Al-Bireh WWTP and then dumped into Wadi Al-Qilt without reuse. In addition to a few quantities treated in small scale collective systems and reused locally, but this amount considered as negligible compared to the total generated wastewater.

4.4 Wastewater treatment in West Bank

There are only few central wastewater treatment plants constructed that are operating. These are in Nablus, Tulkarm, Jenin, Al-Beireh, Ramallah. These primary treatment lagoons have formed the only significant wastewater treatment in recent years. Nablus West wastewater treatment plant has been put in operation since June 2013. The ponds that were built in the mid-1970s had not been improved or upgraded until the advent of the Palestinian National Authority and the creation of the PWA in 1996. Despite the increase in wastewater quantities flowing into those ponds and plants they were all operating beyond their maximum capacities. The result of this has led to partially treated wastewater being discharged in areas surrounding these plants. The result of this has been multiple environmental and sanitary problems.

Figure (4.4) shows that the status of connection sewage network, wastewater treatment plants in the study area **(PWA,2012)**.

Throughout this period, wastewater from Palestinian cities has been and is still discharged into West Bank Wadis and natural waterways. In some cases, water even flows inside of the green line, where it is collected and treated in treatment plants built originally to treat Israeli Wastewater or plants build specifically to treat the Palestinian wastewater crossing the border.

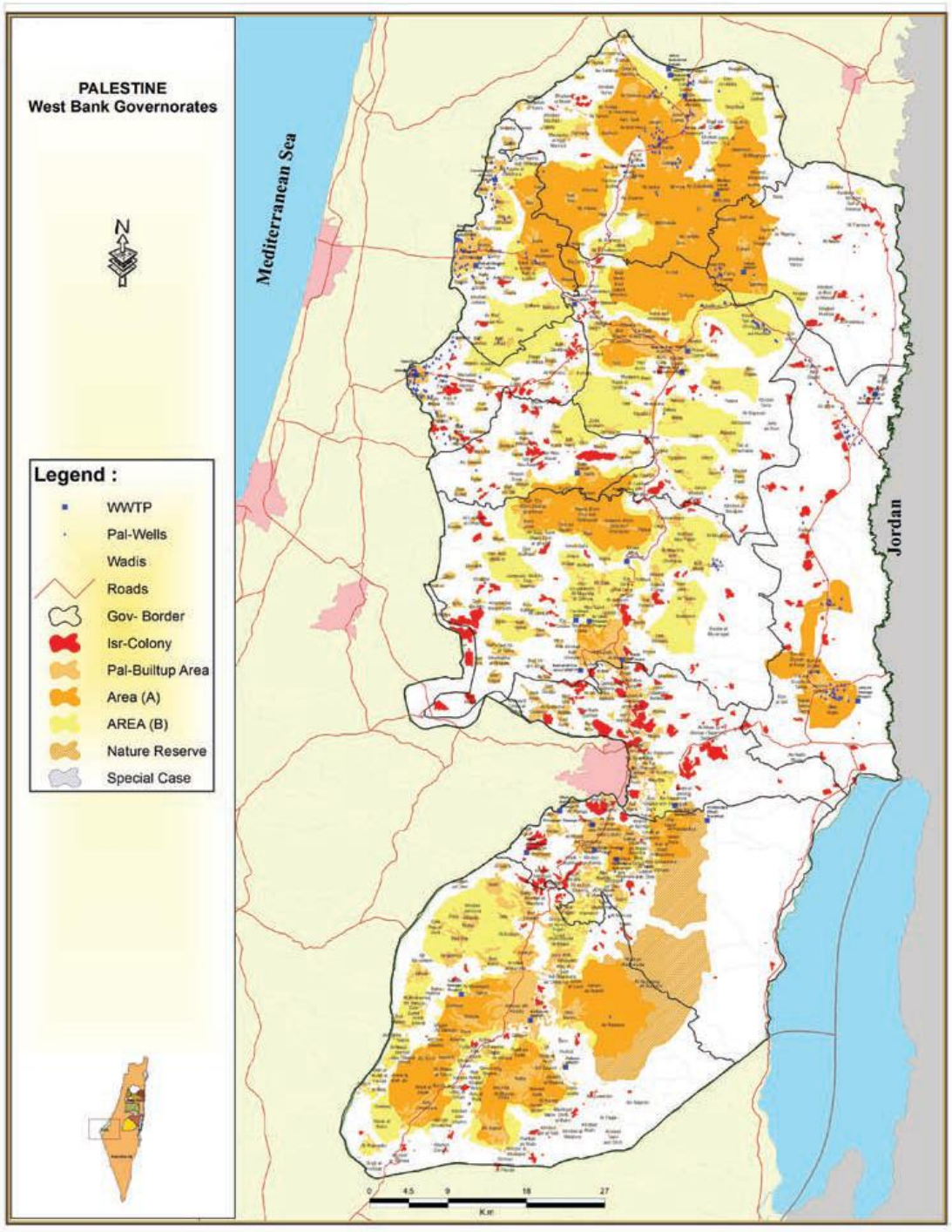

Figure (4.4) Status of Connections to Sewage Network in West Bank

The PNA has built one treatment plant at Al Bireh in 2000 in the West Bank. This plant has a treatment capacity of up to 2 MCM 5.5 Ml/day. West Nablus is also under operation, and it expected to

start construction at Ramallah (Ain Jeriout), Hebron, Jericho, Tubas and Nablus East. In addition, there will be some de-centralized plants in rural areas is now under construction in Anza, Beit Dajan, Sarra, Hajja, Beit Hasan, Tybeh- Rammoun. Construction is expected to start in Misilya, Al-Aroub, and the Biethlehem Industrial Zone.

In the following, the status of each treatment plant will be described according to the type of treatment (central, collective, and on-site).

Table (4.5) outlines the location of the existing, under rehabilitation and construction centralized wastewater treatment plants the operational year and status of the plants **(PWA, Annual Water Status Report, 2011)**.

4.4.1 Central Wastewater Treatment Plants

There are only few central wastewater treatment plants (WWTPs) that are operating, located in Nablus Al-Bireh, Ramallah, and Jenin cities in addition to the Tulkarm pre-treatment wastewater plant. The WWTP in Jenin rehabilitated and started operation in October 2012. A new central WWTP is now under operation to serve the western area of Nablus city and the nearby five villages with the support of the German Government. This is being funded through the German Development Bank (KfW), figure

(4.5) show the location of the wastewater treatment plants within the study area.

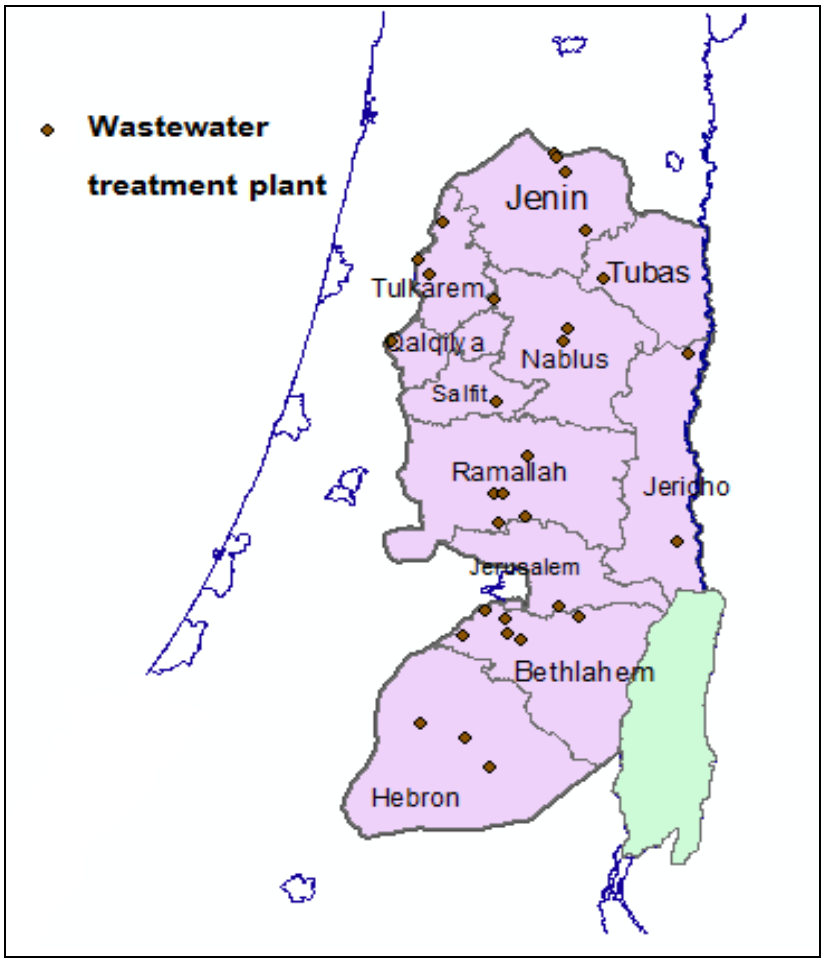

Figure (4.5) Wastewater treatment plant location in West Bank

Table (4.5) Existing urban WWTP in the West Bank

Location	Capacity PE	Served %	Current Load PE	Flow m^3/d	Treatment System	Year of operation	Status	Comments
Al-Bireh	50,000	85.8	42,900	5000	Extended aeration	2000	Operational	Upgraded 2008
Ramallah	25,000	100%	26,110	2,400	Aerated Lagoons	1975r	Overloaded	Rehabilitated
Nablus	150,000	82.9	124,350	15000	Activated sludge	2013	Operational	-
Nablus East	85,000	80.0	68,000	7450	-	-	Under detailed Design	-
Hebron	257,000	82.1	210,997	24,265	-	-	Planning Phase	-
Tulkarem	75,000	35.5	26,637	4000	Anaerobic ponds	1972	Not operating well	Rehabilitated 2004
Salfit	25,000	65.6	16,400	1,394	Planned ASS	2000	Pending	-
Jericho	45,000	80.0	36,000	6,600	Extended aeration	-	Under Operation	-
Jenin	40,000	86.5	34,580	3,000	Aerated Lagoons	1972	Under rehabilitation	Upgraded 1994
Bethlehem	84,000	91.2	76,608	8,810	No WWTP	-	Pending	-

(PWA, 2011)

Several donors committed to help the Palestinian to improve the wastewater sector in terms of collection, treatment, reuse and capacity building. Table (4.6) shows the status of the ongoing projects in West Bank (name, service area, donor, budget, type of the project) **(PWA, Annual Water Status Report, 2011)**.

Table (4.6) Wastewater projects under preparation, implementation and completed

No.	Wastewater Project	Donor	Design Capacity (m3/d)	Estimated Cost	Status	Population	Components
1	Jenin, Misilya village	AFD	400	2.8 M€	Under construction	4000	Collection system, WWTP, Reuse system
2	Tubas, Tayaseer	EU	3000	22 M€	Under detailed design	25000	Collection system, WWTP, Reuse system, Capacity Building
3	Ramallah, Betunia-Ein Jariot	KFW	10000	27 M€	Design phase	59000	Collection system, WWTP, Reuse system
4	Hebron, WWTP	WB and AFD	15000	38 M$	Feasibility study and EIA	300000	Collection system, WWTP, Reuse system,
5	Rehabilitation of Jenin TP	KFW	9000	1.5 M€	Completed	55000	Rehabilitation of existing WWTP
6	Tulkarm Sewerage Project	KFW	-	19 M€	Under construction	75000	Collection system, trunk line, pre-treatment
7	Anza, Beit Dajan, Hajja, Sir, At-Taybah, Rammun	EU	200-400	9.0 M€	Under construction	20000	Collection system, WWTP, Reuse system, Capacity Building

8	Al-Yamun, Qabatiya, Ya'abad, Azzun, Tarqumiya, Dura	USAID	18000-30000	Each (20-25 M $)	Design completed	150000	Collection system, WWTP, Reuse system, Capacity Building
9	Beit Hasan sewerage project	Spain	100	0.31 M $	Design phase	8000	Construction of WWTP and collection
10	Al'Aroub WWTP project	Spain	1200	1.5 M€		-	Construction of WWTP
11	Habla, Baqa, Barta'a	Japan	-	6.2 M $	Completed	22000	Collection system
12	North East Jerusalem WW project	Finland	-		Sanitation and baseline study	30000	Collection system, WWTP, Reuse system, Capacity
13	Rawabi Regional sewerage project	USTDA	-	0.5 M $	Feasibility study	-	Collection system, WWTP, Reuse system, Capacity Building
14	West Beithlehem villages water supply and sanitation project	WB	-	3.65 M $	TOR for the Feasibility study	25000	Collection system, WWTP, Reuse system, Capacity Building
15	Upgrading existing small scale WWTP in Rural Area	Austria	-	0.22 M€	Implementation phase	20000	Rehabilitation of existing WWTP

16	Artas sewage project	BTC	-	0.6 M€	Completed	5000	Collection system and poster station
17	Hebron Industrial area WW project	USAID	-	1.5 M $	Implementation phase	-	Cleaning industrial zone from slurry generated by stone
18	Beithlehem Industrial Zone WWTP	AFD	-	Phase1: 0.5 M€ Phase2: 3.5 M€	Constructed, waiting for sewage	Phase 1: 100 Phase 2: 500	Collection system and WWTP
19	Al-Rihan Neighborhood WW project	Private	-	-	Construction phase	500	Collection system and WWTP
20	Al-Tireh Neighborhood WW project	Private	-	3.8 M $	Construction phase	2000	Collection system and WWTP
21	North Gaza Beit Lahiah	Private	-	1.5 M $	Construction phase	500	Collection system and WWTP

(PWA, 2011)

It is clear from previous tables that there are big draws in more than one governorate in Palestine towards the establishment of wastewater treatment plant, especially those projects funded from donors, which require the study of more than one way to take advantage of this reclaimed wastewater, and this is one of the motivators that led me to try to take advantage of this water commercially.

CHAPTER FIVE

TRADE OF RECLAIMED WASTEWATER IN PALESTINE

5. Trade and Trade-off of Reclaimed Wastewater In Palestine

5.1 Introduction

Trade is the economic fundamentals that are just as important as the rest of the other economic activities being help in securing freedom for basic goods for the domestic market, and create competition in the market. Palestinian trade is different from the rest of the other countries at a time that we are in desperate need for free trade, baptizing the Israeli side to put economic policy planned to impose restrictions and put obstacles in order to paralyze the Palestinian economy and the Israeli economy attachable.

The concept of deriving beneficial uses from treated municipal and industrial wastewater coupled with increasing pressures on water resources has prompted the emergency of wastewater reclamation, recycling, and reuse as integral components of water resource management. The inherent benefits associated with reclaiming treated wastewater for supplemental applications prior to discharge or disposal include preservation of higher quality water resources, environmental protection, and economic advantages. A major catalyst for evolution of wastewater reclamation has been the need to provide alternative water sources to satisfy water requirements for irrigation, industry, urban non-potable and potable water applications due to unprecedented growth and development in many regions of the word. Water shortages, particularly during periods of drought, have necessitated stricter control measures on rates of water

consumption and development of alternative water resources. This thesis will address in several ways and scenarios for trade of reclaimed wastewater as follows;

1. Trade or trade-off of Reclaimed Wastewater between Palestine and Israeli side.

2. Trade or trade-off of Reclaimed Wastewater among Palestinian Governorates.

3. Trade-off of Reclaimed Wastewater in agriculture.

4. Trade of reclaimed wastewater in the industry.

Figure (5.1) shows thesis scenarios for the trade of reclaimed wastewater. To study the possibility of the application of these options have been used method of interviews to support this research; several interviews with the related ministries have been done, and each scenario will be addressed in details with determination of the benefits and constraints of each option and the opinion of the related ministries for each options and the possibility of the application of this option in Palestine.

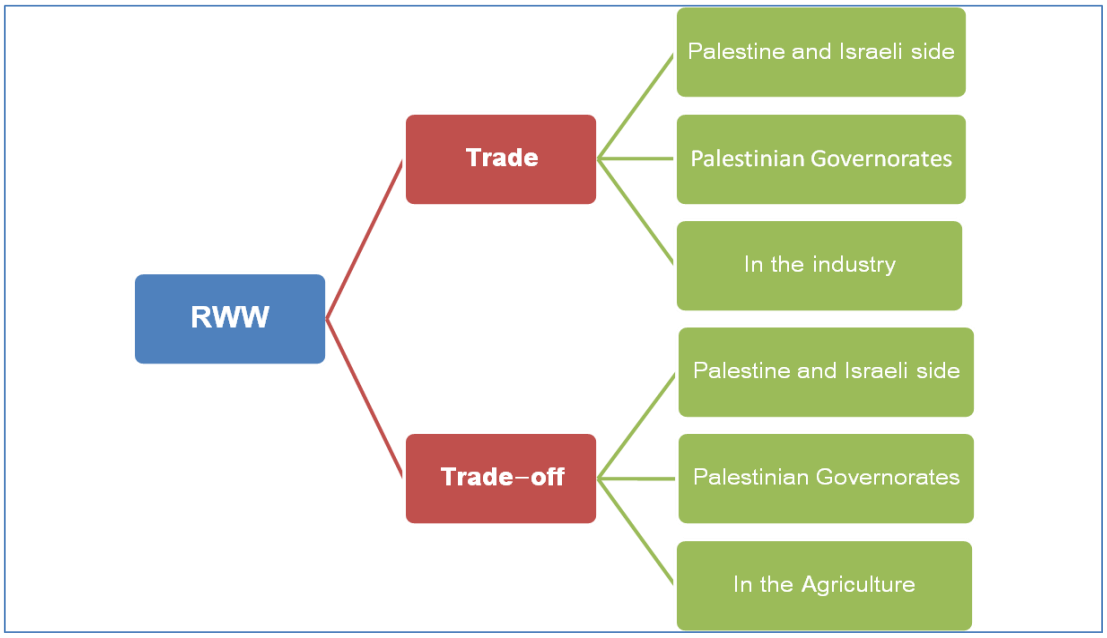

Figure (5.1) Trade of reclaimed wastewater scenarios

5.2 Trade or trade-off of Reclaimed Wastewater between Palestine and Israeli side

Trade of reclaimed wastewater between Palestine and the Israeli side is a transport of reclaimed wastewater to Israel for selling them as a kind of trade, or trade-off this reclaimed wastewater; the trade-off is the replacement of reclaimed wastewater from the Palestinian area to inside Israel, exchange for fresh water in the same Palestinian governorate or in another governorate that contains water shortages. This fresh water come by allowing the Israeli side using larger amounts of Palestinian wells controlled by them, or to allow drilling more depths. This cannot be done without agreements or memoranda of understanding between Israeli side and Palestine on a government level with donor countries supporting.

Figure (5.2) show the study area with borders and the suggested water movement.

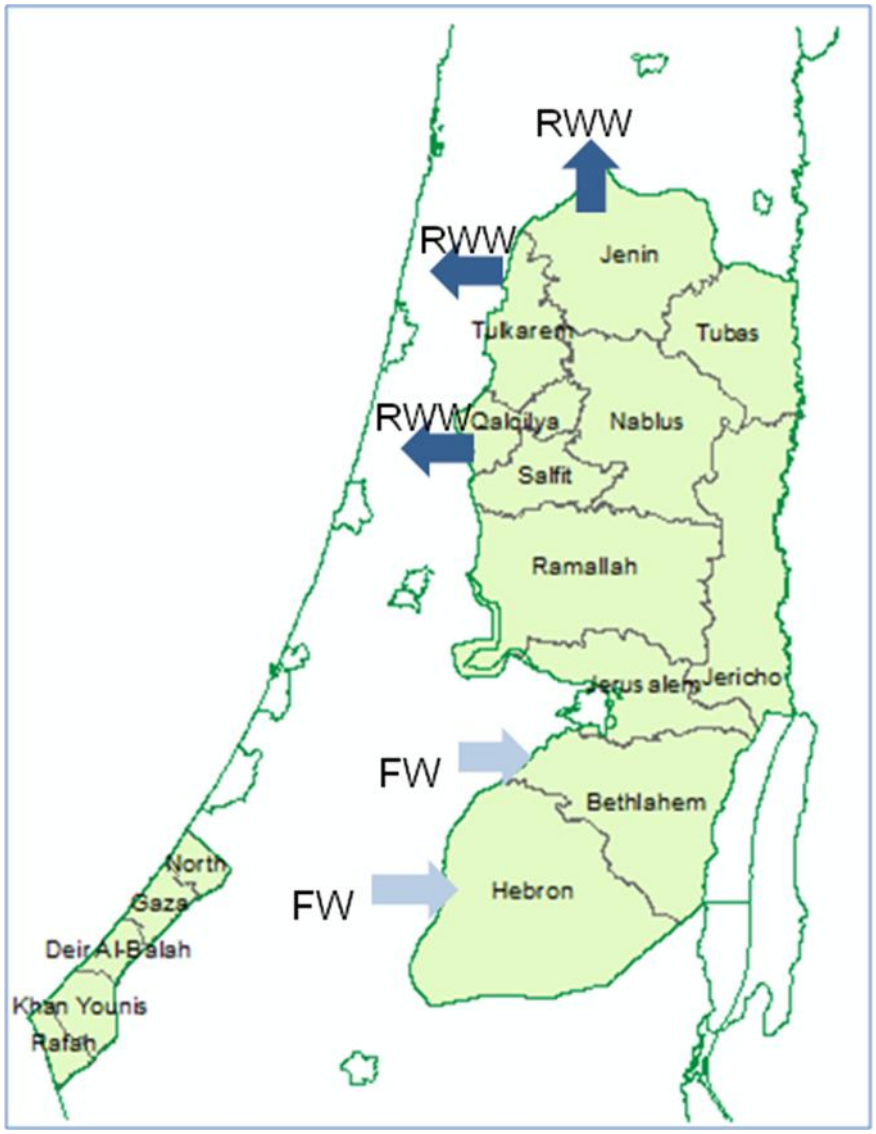

Figure (5.2) West Bank with suggested water movement

The figure suggest to transport the reclaimed wastewater from Tulkarm, Jenin and Qalqilya to Israeli side exchange for money as trade or exchange for fresh water in Hebron or Beithlehem as trade-off.

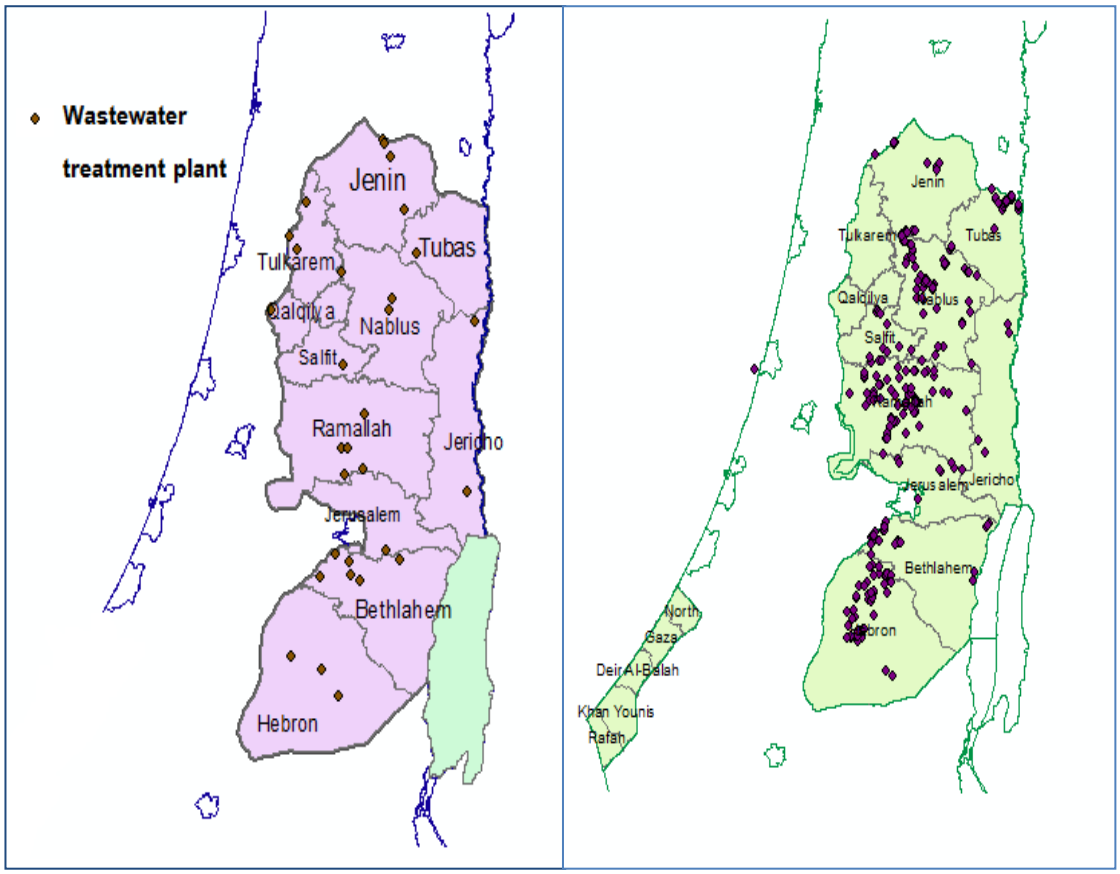

Figure (5.3) West Bank with wells and wastewater treatment plants

From the figure (5.3) we can note that there are many governorates of West Bank that have fresh water wells and at the same times they have shortage of fresh water like Hebron and Nablus; at the same time there is a wastewater treatment plants in the West Bank governorates that relatively have enough fresh water like Tulkarm and Ramallah; we can use the idea of trade-off of reclaimed wastewater between Palestine and Israeli side to allow us for using our wells in the governorates that have shortage in water, exchange of the reclaimed wastewater from that they haven't.

The trade of reclaimed wastewater between the Palestine and Israeli side is considered one of the most important options, which

represents a logical and realistic option because of the nature of the relationship between them with Israel controls of land, sea and air of the Palestine.

5.2.1 The benefits for this option are:

1. Palestinian reclaimed wastewater that produced from the wastewater treatment plant is not used any way, and the main objective of the treatment of wastewater is environmental objective only, any return or use for this reclaimed wastewater add a value to the Palestinian budget.

2. Israel using the Palestinian wastewater for free, they treat this wastewater inside Israel and use the treated water in their agriculture and then they forced Palestinian to pay taxes for this wastewater.

3. Israel uses wastewater effectively, including agriculture, industry, and therefore, They already have all necessary requirements and equipments (networks, reservoirs and others) for using reclaimed wastewater, and therefore the cost of the use of treated wastewater will be limited to the cost of the transport, also the Israel's use of reclaimed wastewater is acceptable option unlike the Palestinian people because of the psychological and religious factors.

4. Almost the cost of treatment projects in Palestine from donor countries, so there is no establishment cost from Palestinian budget for Palestinian wastewater treatment plants.

5.2.2 The obstacles for this option

1. It depends on the Israeli side approval, because of the control of the Israeli side, they get wastewater from the Palestinian valleys for free without any return and also they already have Israeli wastewater treatment plant and ready for processing.

2. High cost of transport water into Israel, where an estimated cost of transporting one reclaimed wastewater tank (size 15 tons) on average (1700 NIS) almost and (size 30 tons) is the average of (3,000 NIS) (the cost for transportation only without any addition cost like labor...), it is about (100 NIS/ m^3) depending on the area and the near of distance, so the high cost of transport may cause value limitation of this option to cover transportation expenses only.

3. Needed for political negotiations and agreements with the Israeli side to this kind of trade, these negotiations and agreement done usually by a so-called (Joint Water Committee), this committee is part of the governance that have been developed under the Oslo agreements for an interim period length of a five-year arrangement, and was due to expire in 1999, but they still exist today because of the failure to reach a permanent agreement. The

role of the Joint Water Committee to oversee the water resources in the West Bank, with the exception of the Jordan River Article (40).

Joint Water Committee is composed of delegates representing the Israeli Water Authority, the Palestinian Water Authority, and must be approved by both parties to do most of the West Bank in the ongoing water sector activities. But the two parties in unequal powers and the right of control. Palestinians must obtain the approval of the Joint Water Committee on any project related to the extraction of water from the mountain water supplies, and any other water-related projects, including micro-activities. And the Israeli delegates in the Committee rejected or blocked tens of requests made by the Palestinian side to implement water projects, and when they approved in many cases they delayed for long time. There are other proposed projects did not even Palestinian Authority to submit to the Commission because they felt that the Israeli side will not approve in any way due to previous attempts.

Obtaining the approval of the Joint Water Committee is only first obstacle that must be overcome on the Palestinians to implement water projects in the West Bank. If they get the approval, it must also get additional permits from the Israeli army before begin any work in Area C of the West Bank. This is not limited to the projects, such as wells or pumping stations or reservoirs, sewage treatment, and which established in Area C, but

also includes other projects, such as the establishment of main water valves or repaired, and which is aims to provide water distribution or networks compilation of sewage networks in areas A and B in the case of passing through the region C. The consequences of this enormous implications because Area C represents about 60 percent of the territory of the West Bank.

4. In the long term this option is incompatible with the principle of sustainability of available resources and the preservation of the future generations right, because they are currently experiencing a shortage financial resources to cover their basic needs, and this option is good choice, provided that they are not part of long-term strategy, must be always seek to independence and recover our water rights.

5.2.3 Interviews for this option

Regarding the interviews conducted with the relevant ministries and asked them about the possibility of this scenario or not, and if there is any previous agreements with Israeli side in the trade of reclaimed wastewater, either for money (Trade) or for freshwater (Trade-off) the member of the Joint Committee in Palestinian Water Authority **(PWA)** confirmed that there was an internal discussion in Palestinian Water Authority only for trade exchange with Israel, which is the possibility of supplying reclaimed wastewater from Tulkarm area in return for supplying

Hebron freshwater by Israel (3:1) three cubic meters of reclaimed wastewater from Tulkarm to Israel in exchange for a one cubic meter fresh water from Israel to Hebron, but this suggestion did not enter into study or negotiating with Israeli side through the Joint Water Committee.

The **Environment Quality Authority (EQA)**, stressed that the information in this regard weak, but they mentioned that there was arrangements only but not agreements, and there is an existence of the agreement to use the reclaimed wastewater that produced by Western Nablus treatment plant inside Israel, but unfortunately without any economical return.

Regarding to Western Nablus Plant the farmers are waiting for the quantity of reclaimed wastewater in Deir Sharaf village of west of Nablus, at the same time the reclaimed wastewater throw again in the same waste valley, which it collected before treatment. The reason is the differences between the responsible official bodies about the ownership of this reclaimed wastewater and attempts to sell it to farmers .

Upon analyzing the information for the project and documents, it is clear that the problem is bigger than the control of the plant reclaimed wastewater or to invest these waters in the reclamation of agricultural land, but there is (8 million NIS) from Palestinian public treasury every month go to Israel because of sewage

treatment in the west governorates only, what is processed from sewage water to irrigate farmland controlled, note that Palestinian farmers use the drinking water to irrigate their crops, which means that the Palestinian losses are complex and multiply.

The Palestine Investment in reclaimed wastewater extracted from the West Nablus treatment plant alone, provide a value of (7.5 million NIS/ year), go to the Israeli side, in contrast, the exploitation of these reclaimed wastewater leads to repair five thousand donum of land in that region **(Alhayat new newsletter, 6765, 2014)**.

on the other hand **Ministry of Agriculture (MoA)** and **Ministry of National Economy (MoNE)**, reported that there is no agreements between Israel and Palestine to pay money in exchange for the wastewater entering the Israeli side.

Palestinian Water Authority (PWA) believes that there is nothing to prevent this idea (trade of reclaimed wastewater with Israeli side), they are always trying to look for alternatives in the subject of water scarcity, they are fully prepared to work all technical studies and negotiating with the Israeli side and that what is consistent with their strategic plan for the best use of the Palestinian resources.

Environment Quality Authority (EQA) stated that this subject legally unhandled, so it is need the legislative by water law or the laws that specializes in the management and control of wastewater, or environmental law or agriculture, legislation and regulations that are issued based on these laws.

These environmental and legal terms, cannot be added before the technical and economic aspects studies, if the technical and economical values are positive then the legal and regulatory aspects can be solved.

Ministry of National Economy (MONE) believes that this idea may contribute to solving the problem of water in Palestine, in addition to the economical benefits of the subject.

All the previous ministries see that the most important obstacles of this scenario is the Israeli side, one of expectations they will use this project with sharing the settlements and this is unacceptable to us as Palestinians, where is the recognition of their existence, which is illegal. This is in addition to the possibility of using force to use these reclaimed wastewaters, as happened previously in the landfill in Hebron. And also they may not approved because the flow of untreated wastewater that become from Palestinian governorates will stop.

Finally it is important and very necessary to think about the use of reclaimed wastewater in Palestine, especially to increase the

number and size of treatment plants projects, so this thesis could be the first step to put the debate on this subject, also it need to media and awareness, In addition to the need for environmental impact assessment studies.

5.3 Trade of Reclaimed Wastewater among Palestinian Governorates

Proposed the idea of the trade of reclaimed wastewater between Palestinian governorates is a process that has several aspects that either reclaimed wastewater transport from the governorates that have water to the governorates that have scarcity of water to be used in several targets; the most important is the agriculture (for example Jericho and Ramallah) and thus provide the poor water governorate to use the fresh water for drinking purposes only.

Figure (5.4) West Bank Governorates

In this scenario it should be try as much as possible to choose the nearby governorates to reduce the cost of transportation of reclaimed wastewater as much as possible. Figure (5.5) shows the suggested movement of reclaimed wastewater among Palestinian governorates.

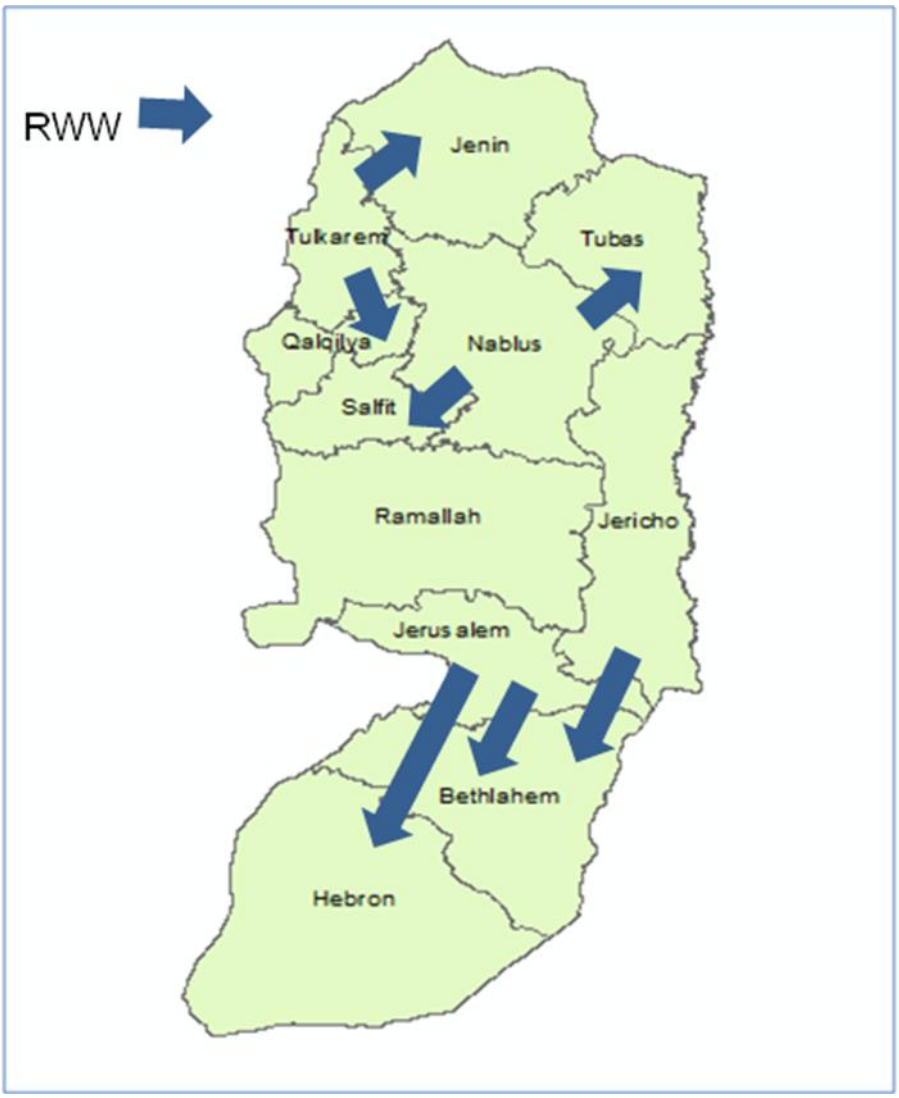

Figure (5.5) Trade of reclaimed wastewater among Palestinian governorates

It is possible for example to sell the reclaimed wastewater from Tulkarm to Jenin and Qalqilya, from Nablus to Tubas and Salfit, from Jericho to Beithlehem and from Jerusalem to Beithlehem and Hebron and so on.

5.3.1 The benefits for this option are:

This option provides an important return value to Palestine and for the following reasons:

1) Shortage of water resources in Palestine governorates, the use of reclaimed wastewater in the governorates that need water from the governorates where there have water is one of the options within the long-term solutions to address the problem of water shortages.

2) Using the reclaimed wastewater it is saving in a similar amount of fresh water, and is adding the quantity and quality contribute to the solution or alleviate the problem of water shortage in Palestine, which clearly appear in some Palestinian cities during the summer semester, especially that the effects of water problems will be more deficit within ten years.

3) The trade of reclaimed wastewater among Palestinian governorates will be a good option to distribute water in the governorates to make some kind of balance between them, for the application of this option, the costs of (transport, labor, spaces uses...) must be studied carefully before deciding the optimal choice.

4) This option is based on the principle of sustainability of resources and optimum utilization of available resources, both in terms of environmental or in terms of a local alternative to the shortage in Palestine and that because of number of factors:

- Large natural growth in the population in Palestine, where the rate of population growth in Palestine up to 3.6%, which is higher than the rates in the world.

- The growing needs of the human being as a result of development in human life, including water, for example, by the fact that there is a growing need for public gardens, parks and green areas were in the past these requirements is not necessary, but now it's become one of the important conditions that should be taken into consideration when planning to expand or build the cities.

- Over use of water, which needs to raise awareness at the national level about water scarcity and impacts of this problem on the future.

- Israeli control of water supplies sources in Palestine, Samer Zakarneh, in an article entitled "The water crisis in Palestine" said that 85% of water in the aquifer is dominated by Israel, which is equivalent to "500-600 million cubic meters", and 70% of the settlements in the West located on the eastern basin reservoir in the West Bank, and 45% of these settlements are located on the very sensitive areas for feeding the reservoir mountain in the West.

- There is a lack of water balance; the amount of water consumed is "130 million cubic meters", but the annual feed water "80 million cubic meters", annual attrition rate " 2.5%".

- Palestinians buy from Israeli company "Mikkarot" 50% of their water needed to cover the deficit in the water.

5.3.2 The obstacles for this option:

1. Psychological and religious obstacle for using of reclaimed wastewater, particularly in agriculture, Palestinian people psychologically still not acceptable of dealing with this idea. Although it allowed under Palestinian law "within certain conditions".

2. The most important quantity of fresh water used in agriculture and food industries, Palestine as one of the developing countries are still mainly based on national income on agriculture.

3. Many of Palestinian exports "crops and Agro-industries" exported to the Arab and Islamic countries so using of reclaimed wastewater may influence the acceptance of these countries, and therefore the impact on the Palestinian market and exports. Dr. Mohammed Al Rosan warned in his study published in Al-Dostour Journal on 07/27/2005 of this effect, and also warned about the affected of Jordan markets with the trade with the other countries as a result of use of the reclaimed wastewater, also he warned in this article from the Misuse of reclaimed wastewater in agriculture.

4. The cost from the reclaimed wastewater transportation, labors and the additional huge tanks in both governorates, and also the

separate water network systems, then of course we need the additional maintenance cost.

5.3.3 Interviews for this option:

It is important to know that this option is very related to the next option that about the trade-off of reclaimed wastewater in agriculture; because the most important use of reclaimed wastewater in agriculture sector. With regard to interviews and ministers opinion regarding this scenario **all the ministries** see that this is possible after studying all the economic, social and religious factors, but legally this issues should be treated.

Ministry of Agriculture (MOA) see that there is a difficulty in the exchange between the spaced governorates geographically but with nearby governorates relatively; such as Ramallah and Jericho it is possible, either about the exchange of the crops kind there are some crops that can be transmitted but some of them we can't because of the suitable climate, so the crop climate is very important to success of agriculture and this, of course, can't be applied to all agricultural crops.

The most consuming of maximum amount of agricultural water (fresh water) between Palestinian governorates are: Tulkarm, Qalqilya, Jenin, Tubas, Jericho and the Jordan Valley. And statistics about the consumption of fresh water, the following tables, Table (5.1) show the number of agricultural holdings where irrigated agriculture in the Palestinian territories as the main source of irrigation and conservation.

Table (5.1): number of plant and Mixed Holding in the Palestinian Territory by main source of irrigation and governorate, 2009/2010.

Governorate	Main Source of Irrigation												المصدر الرئيسي للري	المحافظة
	المجموع Total	أكثر من مصدر More Than One Type of Main Source of Irrigation	غير مبين Not Stated	مصادر أخرى Other Sources	تنكات Tanks	الشبكة العامة Public Network	ينابيع أو عيون Springs	برك وخزانات وبئر تجميع Tanks, Ponds and Collective Well	بئر نزاز Dug Well	سيول ووديان جانبية Streams and Valleys	بئر جوفي – ارتوازي Artesian Wells	بعلية Rainfed		
Palestinian Territory	**97,069**	**5,797**	**4,615**	**117**	**578**	**3,237**	**433**	**642**	**581**	**42**	**12,956**	**68,071**	الأراضي الفلسطينية	
West Bank	**80,029**	**5,583**	**857**	**42**	**484**	**1,382**	**433**	**518**	**51**	**26**	**2,591**	**68,062**	الضفة الغربية	
Jenin	**13,141**	924	66	-	199	62	11	70	6	3	411	11,389	جنين	
Tubas	**2,397**	230	42	3	12	170	3	94	3	1	95	1,744	طوباس	
Tulkarm	**7,491**	690	87	4	46	178	11	49	2	8	675	5,741	طولكرم	
Nablus	**12,143**	683	72	2	22	75	150	36	2	5	101	10,995	نابلس	
Qalqiliya	**4,518**	690	66	-	15	72	1	9	-	4	700	2,961	قلقيلية	
Salfit	**4,476**	347	5	-	-	33	-	9	1	-	12	4,069	سلفيت	
Ramallah & Al-Bireh	**9,887**	658	41	-	20	106	18	38	2	-	43	8,961	رام الله والبيرة	
Jericho & Al- Aghwar	**808**	26	47	8	9	122	156	61	6	3	360	10	أريحا والأغوار	
Jerusalem	**2,018**	84	51	-	5	29	1	9	-	-	6	1,833	القدس	
Bethlehem	**6,208**	441	165	16	10	221	25	45	4	1	56	5,224	بيت لحم	
Hebron	**16,942**	810	215	9	146	314	57	98	25	1	132	15,135	الخليل	
Gaza Strip	**17,040**	**214**	**3,758**	**75**	**94**	**1,855**	-	**124**	**530**	**16**	**10,365**	**9**	قطاع غزة	
North Gaza	**3,706**	47	796	17	31	221	-	20	84	5	2,484	1	شمال غزة	
Gaza	**2,253**	8	542	30	16	308	-	4	139	1	1,205	-	غزة	
Deir Al- Balah	**2,537**	22	419	11	19	150	-	8	89	4	1,815	-	دير البلح	
Khan Yunis	**5,495**	95	1,503	10	18	722	-	76	71	4	2,988	8	خانيونس	
Rafah	**3,049**	42	498	7	10	454	-	16	147	2	1,873	-	رفح	

(PCBS, 2014)

We can notice from the table (5.1) that the most important source for irrigation in west bank is the rain which covers about 85%, after that there is the irrigation depending on more than one type of sources of irrigation which covers 5583 of the mixed holding, and that formed 6% of the total holding.

Hebron governorate which formed the biggest number of holdings in West Bank (21.1%), it depends firstly (after rains which formed 89%) on more than one source (4.7%) and secondly on public network (1.8%) from all the irrigation sources, after that there is not stated sources with a percentage of (1.2%). But if we have a look to Jenin governorate we can see that the most important source of irrigation (after rains which formed 86.6%) is more than one source (7.03%) and secondly artesian wells (3.12%).

From the table above the average of the most important source of irrigation in all the governorates depends on two important sources which are artesian wells and public network.

Table (5.2) shows the Palestinian agricultural holdings by the kind of crops and the type of irrigation.

Table (5.2) number of agricultural holdings which have field crops in the Palestinian Territory by type of irrigation and type of crops 2009/2010

Type of Crop	Type of Irrigation	نمط الري	نوع المحصول
	مروي Irrigated	بعلي Rainfed	
Wheat	248	13,629	قمح
Sorghum	162	119	ذرة بيضاء
Barley	68	5,036	شعير
Oats	-	1	شوفان
Broom Corn	1	73	ذرة مكانس
Dry Garlic	48	37	ثوم يابس
Dry Onion	263	268	بصل يابس
Onion Tuber	23	4	بصل قثار
Seed Onion	1	1	بصل بذور
Peanut	4	3	فول سوداني (فستق عبيد)
Safflower	2	79	عصفر
Sesame	1	637	سمسم
Sun Flower	5	17	عباد الشمس
Cichorium	4	2	شيكوريا –هندباء
Anise	4	388	يانسون
Dill	17	-	عين جرادة
Meramieh	40	58	ميرمية
Ment	74	21	نعناع
Thyme	219	242	زعتر
Chamomile	6	14	بابونج
Black Cumin	1	28	قزحة
Cumin	-	13	كمون
Other Beverage Crops	12	8	محاصيل مشروبات أخرى
Kidney Bean	3	1	فاصولياء (يابس)
Broad Bean	38	451	فول (يابس)
Chick Peas	10	848	حمص (يابس)
Dry Cowpea (green)	4	6	لوبياء (يابس)
Lentil	4	406	عدس
Peas	5	134	بازيلاء
Fenugreek	1	50	حلبة
Vetch	-	917	عرسنة
Sern	1	1,679	بيقيا
Rampling Vetch	-	21	جلبانة

Crop	Type of Irrigation	نمط الري	المحصول
	مروي Irrigated	بعلي Rainfed	
Mixed Crops	-	3	محاصيل مخلوطة
Sugar Beet	-	1	شمندر سكري
Sugarcane	13	2	قصب السكر
Clover	62	1,228	برسيم
Tobacco	5	116	تبغ
Local Tobacco	2	190	دخان بلدي هيشي
Tombak	-	1	تمباك
Other Field Crops	1	27	محاصيل حقلية أخرى

(PCBS, 2014)

From the table above table (5.2) we can see the rained dry onions holding are nearly the same as irrigated holdings (263 irrigated and 268 for rained), the thyme is almost the same, the percentage between irrigated and rained are nearly the same (219 irrigated and 242 rained holdings).

But in some other crops we can find a gap between the irrigated and the rained holdings such as wheat (248 irrigated in comparative with 13629 rained).

Despite that the most important source of irrigation for all the crops is nearly rain, but it's still there is a very big quantities of water which can be saved if we replace the water with reclaimed wastewater for the types of crops which Palestinian law accept and to improve the productivity of crops.

Jericho and the Jordan Valley area, despite the abundance of water, but the **Ministry of Agriculture (MOA)** considers it is from the most of Palestinian governorates that need an alternative source

of water for irrigation purposes due to high salinity, and because of it is an agricultural area need for an alternative source of water.

Also the Palestinian farmer interested in the extent of physical and economic agriculture yield, whether that from fresh water or reclaimed, according to the type of crop with the possibility to irrigated with this reclaimed wastewater or not, so there could be the possibility to accept the change of his agricultural crop (Horticulture who used to be planted) in the case of wastewater has been providing with free or cheap price compared with fresh water, while allowing to irrigate his alternative crop with reclaimed wastewater without any kind of health or environmental aspects.

5.4 Trade-off of Reclaimed Wastewater in Agriculture

Trade-off of reclaimed wastewater mean that in simple way is the wastewater reuse in agriculture, or as had mentioned in scenario number one; is the replacement of reclaimed wastewater exchange for fresh water. In general, most of the people agree that the social traditions and customs practiced in the West Bank do not accept the reuse of the treated wastewater in any sector. Despite that, raw wastewater has been used by farmers without control in some areas of the West Bank, 69.6% of the farmers and 66.7% of the public, considered that reuse of treated wastewater is not acceptable by social traditions and customs in the West Bank. However, 70.5%

and 78.5% of the farmers and the public respectively, said that if the area suffered from a draught season, they are willing to utilize the reclaimed wastewater in any purpose, except for drinking **(Al-Kharouf, 2003)**.

Al-Kharouf tabulate the conclusions of the farmers and public levels, in table (5.3) the table shows the proposed hypothesis and the findings concluded from his questionnaire and analysis.

Table (5.3): Hypothesis Findings of the Farmers and Public Perception questionnaires

No.	Hypothesis	Finding
1	From religion point of view, people seem to be prejudiced against wastewater reuse.	This proposition is supported by the data, most of the respondent people think that Islam will still consider the treated wastewater as unclean, despite treated according to standards.
2	People believe that the wastewater reuse is not acceptable by the social traditions and customs.	This proposition is supported by the data. Respondent people think that our traditions urge us to avoid using treated wastewater.
3	Acceptability of using treated wastewater will decrease with increased potential for unrestricted agriculture or human contact or ingestion.	The proposition is supported by the data. The percentage of those who accept the fruit to be irrigated with treated wastewater is more than those who accept it for vegetables eaten cooked. The least acceptance percentage was for the irrigation of vegetables eaten raw.
4	People do not accept reusing treated wastewater in agriculture.	The proposition is not supported by the data, only 36.5% of respondents accept the proposition.
5	People do not trust experts in the wastewater and treatment.	The proposition is not supported by the data, although about 50% accept it.
6	Wastewater treatment and reuse will attract more support amongst respondents connected with Sewage and Water networks rather than those not connected.	This proposition is consistently upheld by the data, although the degree of acceptance between those who are not connected varies according to the type of water supply.
7	Wastewater treatment and reuse will attract more support amongst respondents who take action to save water than amongst those who do not.	The proposition is not supported by the data. There is no relation between those who make action to save water and the degree of acceptance of the process.

8	Wastewater treatment and reuse will attract more support amongst respondents who own home gardens rather than those who do not.	The proposition is not supported by the data. There is no relation between those who own gardens and acceptance or non-acceptance of the process.
9	Respondents who know more about treatment and reuse will be more likely to accept the process.	The proposition is not supported by the data. On the contrary, it was found that 92.7% of the farmers who claim that the information provided to them is insufficient while only 87.1% of those who get sufficient information support the process.
10	Acceptability of treatment and reuse will be less amongst those who are adhered to the religion than those who are not.	The proposition is supported by the data. There is a relation between the religion and the acceptance or non-acceptance of the process.
11	Treatment and reuse will attract less amongst those who believe that the traditions and customs reject the reuse of the treated wastewater.	The proposition is supported by the data. There is a relation between the social traditions and the acceptance or non acceptance of the reuse.
12	Treatment and reuse will attract more amongst those who do not obtain sufficient water quantities for their livelihood than those who do not.	The proposition is not supported by the data.
13	Treatment and reuse will attract more amongst respondents who say that water price is a heavy burden than those who do not.	The hypothesis is supported by the data. Although the degree of acceptance is not related directly with the degree of acceptance that water price is a burden.

(Al-Kharouf, 2003)

From the above table we can note that there are a lot of assumptions for using the reclaimed wastewater in agriculture that everyone thinks it's correct but it is the opposite, as there are many hypotheses have not based on data or real information.

Actually, according to the scenarios number two and three the reclaimed wastewater can use in agriculture whatever among governorates or in the same governorate to save the fresh water for drinking purposes only. Figure (5.6) show the West Bank land use, it is clear that there is many kind of land use of the study area governorate can use the reclaimed wastewater as an option for solving the water scarcity.

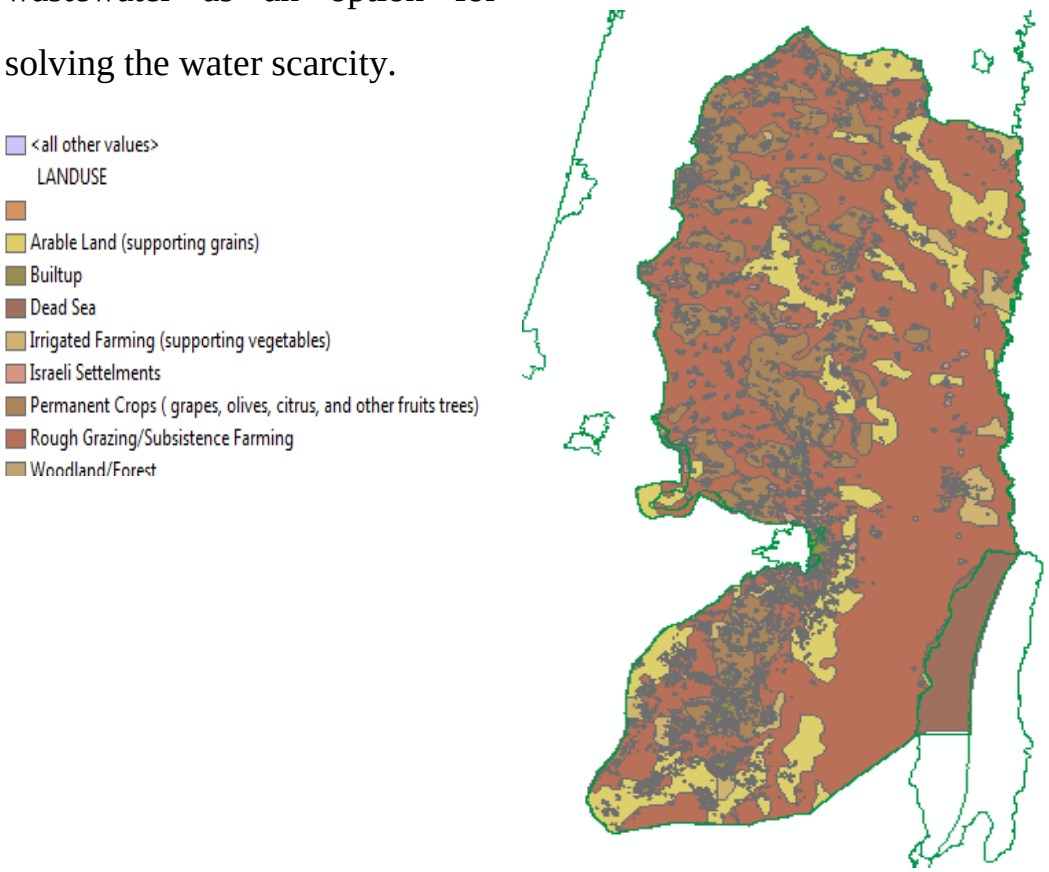

Figure (5.6) West Bank land use

The figure (5.7) show that the movement of trade-off of reclaimed wastewater in the governorate for the agricultural purposes.

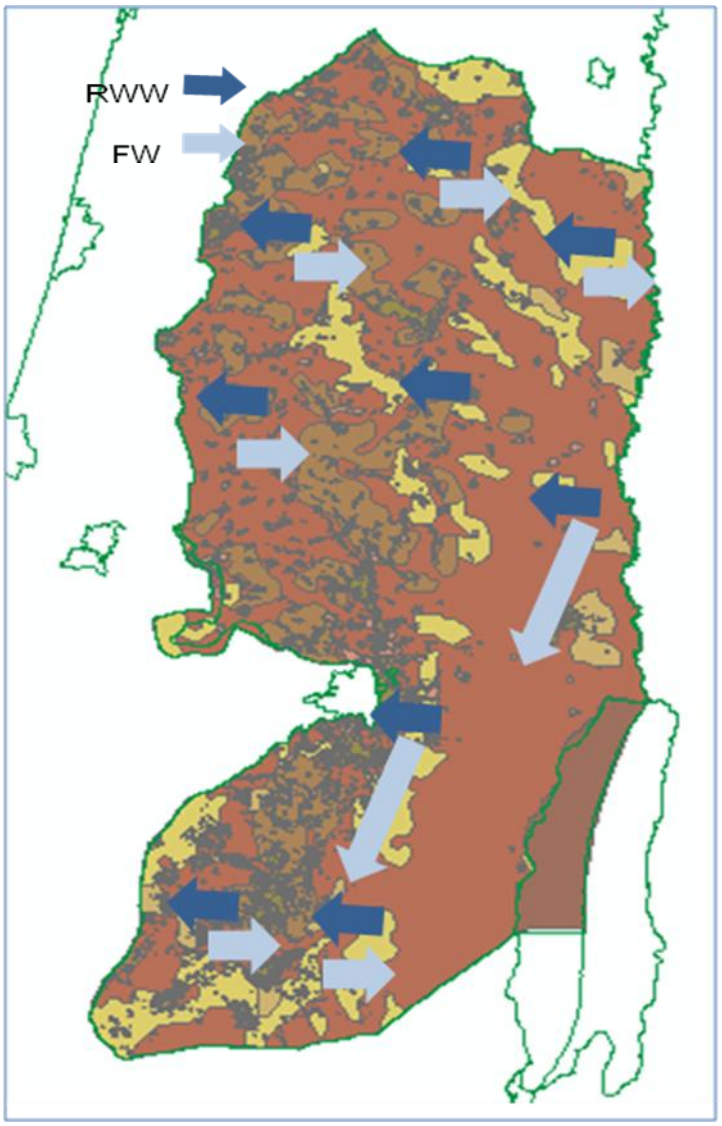

Figure (5.7) trade-off of reclaimed wastewater in the agriculture

For example Jericho governorate can use the reclaimed wastewater in the agriculture to save the fresh water (trade- off), or it can transport it to other governorate for agricultural uses also (trade among other governorate).

5.4.1 The benefits for this option are:

1. Provide fresh water, because we can used a good percentages (around 50%) from reclaimed wastewater in irrigation instead of fresh water.

2. disposal of the wastewater in economically way at the time of disposal of these water without any return, which is no systematic uses of the effluent from wastewater treatment plants.

3. Kind of environmental protection.

4. This scenario is one of the long-term strategic options because it is internal Palestinian solution.

5.4.2 The obstacles for this option

1. The main challenge is to address the potential social implications on the basis of a comprehensive local stakeholder analysis that identifies local powerbrokers, land owners and tenants. The perception of the community towards reuse of reclaimed water should be changed through a comprehensive awareness and information campaign. This challenge can be addressed by a consortium consisting of the main Palestinian institutions involved in the reclamation and reuse sector.

2. Standards for reclaimed water use in agriculture; Standards for agriculture reuse are the result of the combined years of experience of many countries and key studies on the different aspects of water

reclamation and reuse. Relevant standards for reuse in the field of public health protection, environmental protection and agricultural sustainability.

3. Land classification; Land areas should be assess of potential land available for application of reclaimed wastewater and analyze in detail to determine of potential irrigable lands. we need to analysis of topographic maps and aerial photography and a detailed field delineation, analyzed soil samples.

4. Crop selection; evaluation of selection of The suitability of the cropping patterns on the basis of compliance with reuse guidelines, the results of the land classification, tolerance.

5.4.3 Interviews for this option:

Ministry of Agriculture (MOA) confirmed that the farmer had enough awareness of the importance of using the reclaimed wastewater instead of using freshwater in agriculture, but he is prefers freshwater use, but the existed reclaimed wastewater at a price 1-1.5 NIS/ m^3 with transportation cost, or less, it can be used, specially the farmers who need to water source because of the scarcity of water in their area. A small percentage of farmers who have water source accept of using reclaimed wastewater for irrigation, in addition to the lack of need for irrigation, such as rain-fed crops.

MOA also see that the success or un-success factors for this trade-offs scenario are:

- The absence of a special tariff system for reclaimed wastewater used in agriculture.

- The lack of successful models or stories between the farmers that replace their freshwater with the treated wastewater.

- The weakness of qualified human resources allocated in the guidance for the reuse of reclaimed wastewater.

- Noncompliance with specifications wastewater own (FAQ mandatory 2012-34) by treatment plants.

- The weakness of the governmental and nongovernmental control over the health and environmental safety.

- Weakens the political situation where the use of reclaimed wastewater in the retrieval of the right of Palestinian water rights.

- Lack of awareness of Palestinian citizens about the need to solve the problem of water shortage and involve them responsibility.

MOA see that the most important agricultural crops that can be irrigated by reclaimed wastewater and accepted by the Palestinian farmers are:

- Fruit trees (Apples, figs, grapes, palm etc ...)

- Forest trees (like pine).

- Ornamental plants.

- Forage crops (Alpha Alpha, clover ...)

And also **MOA** see that the idea of trade-offs of reclaimed wastewater scenario is possible to be a part of the water scarcity solution, which contributes to the treatment of water shortage suffered by Palestine and the extent of its contribution to the solution. The ministry believes that the using of reclaimed wastewater in agriculture can use not less than 50% instead of freshwater, such as palm trees, but the only problem remaining in the restrictions imposed in the environmental instruction mandatory 34-2012 crops permitted for irrigation.

Regarding the determinants of wastewater treatment use to irrigate crops that are used as food for carnivores animals they must be:

- Quality of reclaimed wastewater matching stations with instructions 34-2012 mandatory technical terms.

- To ensure that there is no health or environmental damage in terms of the use of this water in drip irrigation pipes.

- The wastewater treatment plants should be constructed near the agricultural land.

- No previous experience in the same idea.

The determinants of the use of treated wastewater to provide for the animals poultry drinking water, such as sheep and cows, it is not allowed according to the technical instruction mandatory 34-2012 as there are fears about safety of the animals despite matching the quality of the water that the animals drink, but he was prevented use it without studying or actual experience study.

There are many working papers and theses are working in **MOA** and they applied the reclaimed water on crops (such as; alfalfa and olive trees) and they are waiting for the results. This is in addition to the presence of the following studies to examine treated wastewater in agriculture and these studies are:

- Master thesis "reuse of treated wastewater for agricultural purposes in Ramallah area of obstacles and ways of strengthening, Al-Quds University, Sustainable Rural Development Institute, 2014".

- Master thesis "incentives and constraints for domestic plants to treat gray water in Palestinian rural areas, Bir Zeit University, 2012".

- Master thesis "rule cleanse the use of wastewater in Islamic jurisprudence, An-Najah National University, 2012".

The current and future plans of the **Ministry of Agriculture** for the exploitation of treated wastewater came in the strategy of the Ministry, the agricultural sector, "shared vision", item No.(2):

"Resource Management in the Palestinian areas, efficiently and in a sustainable manner is achieved by placing several policies, including: increasing the availability of water supply and improve the management and rehabilitation achieved this infrastructure, water sources and increase the available water resources for agriculture".

Also this scenario In line with the **Palestinian Water Authority** Strategic Plan about the optimal exploitation of Palestinian resources, 2013.

The reuse of reclaimed wastewater is essential to meet the expanding water demands of the agricultural sector in the West Bank and therefore should be part of the integrated management of the available and future water resources. The reclaimed wastewater is an integral component of the planning and meets the long-term strategy of water resources development in the West Bank.

This planning requires a multidisciplinary approach that incorporates analysis of local and institutional stakeholders, hydrology, irrigation and civil engineering, agronomy, soil classification and land reclamation and programs for water reuse regulation, public awareness and institutional capacity building.

As there is a vast global knowledge base in the field of reclamation and reuse, consisting of standards and guidelines, examples of "best-practice" projects and numerous centers of reuse expertise, Palestinian institutions should use this knowledge base as a basis for increased institutional capacity. Through practical research at experimental and pilot projects, that applies global knowledge to water reuse in the Palestinian situation, institutions should establish a local knowledge and database that contains data on agronomic, environmental and public health aspects of reclaimed water use. A strong institutional capacity is the basis for the capacity building of Palestinian farmers and the future of sustainable water reuse.

5.5 Trade of reclaimed wastewater in the Industry

Trade of reclaimed wastewater in the industry simply is used these water in industrial sector instead of fresh water. As yet, there are no large industrial facilities (chemical plants, cement factories, etc.) that consume high volumes of water in Palestine. Most industries are just small factories that use the urban water supply network as their sole source of water. Many of these industries are billed as conventional customers (as are many shops). The water operators in Ramallah and Nablus estimate that these small industries use 3% of the total urban water supply. At country level, 3% of urban water equates to 3.1 Mm^3/year in the West Bank and 3.0 Mm^3/year in Gaza.

In addition to the urban water supply systems, some industrial facilities use private wells. Almost all of these wells are registered as irrigation wells, as PWA has not issued abstraction rights for industry wells. According to PWA estimates, the current industrial consumption is very low, as farmers already struggle to find sufficient water to irrigate their land and are thus unwilling to resell this water to industry **(PWA, Water Strategy, 2013)**.

The 3% ratio is lower than the ratios observed in neighboring countries. This can be explained by the constraints that industry in Palestine has been facing over the past 40 years (difficulties accessing land, markets, suppliers, etc.).

5.5.1 The benefits and obstacles for this option

Once the political constraints are removed, the market opportunities for Palestinian industries are expected to increase as more investors will venture to develop small factories. Nevertheless, heavy industry requiring huge amounts of water (paper, chemical, mining, etc.) will still be constrained by the limited water resources available.

The demand for water for industry will rise and most of these industrial plants will be supplied by the to-be-established Regional Water Utilities; and wherever possible, the treated wastewater will be a source to meet the demand for water in some industries.

The reclaimed wastewater can be used to cover the needs of the infrastructure industry such as streets, retaining walls and construction projects, which represent a good alternative in case the work to make people aware, specifically for the religious aspect.

The next table, Table (5.4) shows the relative distribution of economic installations in Palestine as a way of access to water and economic activity for 2013, according to the Palestinian Central Bureau of Statistics (**PCBS, 2013**).

Table (5.4) Relative Distribution for economical activities in Palestine with respect to the way of access water and economic activity

Economic Activity	The way of access to water				
	Public Network	Collectives Well	Water Tanks	Artesian Wells	Summation
Palestine	84.0	1.3	13.6	1.1	100
Industrial Activities	85.1	1.2	9.7	4.0	100
Construction	85.9	1.8	11.1	1.2	100
Wholesale and retail trade	82.3	1.3	15.6	0.8	100
Transport and storage	87.2	0.0	12.8	0.0	100
Information and Communication	94.7	0.3	5.0	0.0	100
Services	86.5	1.5	11.8	0.2	100

(PCBS, 2013)

And the next table, Table (5.5) shows the quantity of consumed water in economic activities and the average water consumption rate for every

activity according to the type of activity in year 2013 in the Palestinian Central Bureau of Statistics (**PCBS, 2013**).

Table (5.5) Consumed water quantity for economic activities in Palestine with respect to the type of activity.

Economic Activity	**Quantity of consumed water (1000 m^3/month)**
Palestine	4489.9
Industrial Activities	946.0
Construction	29.5
Wholesale and retail trade	2103.6
Transport and storage	24.8
Information and Communication	22.5
Services	1363.5

(PCBS, 2013)

In the tables above its clear that treated wastewater is not used any way for any purpose neither for related to food industry nor none related, and it’s clear that Palestinians are using fresh water for all types of industries which bears the public budget an additional burden. Using reclaimed wastewater for industries which are not related to food can help public government to find resolutions for two real problems, lack of financial resources and lack of water resources.

Reclaimed wastewater can be used for the whole constructions industries with 29500 m^3 /month, and also can be used for a part of industrial activities which consume 94600 m^3/month, to cancel the society rejection even according to psychological or religious reasons we can use the reclaimed water only for none related to food industries.

Services which consumes 1363500 m^3/month can use reclaimed water in a very specific and small areas because the widest scope of services in Palestine is food services (such as restaurants). Figure (5.8) show the suggested movement of the reclaimed wastewater in the cities to use it in the industry, and also show the wastewater treatment plants in the governorates; so it is possible to use the reclaimed wastewater among the same governorate or to sell this water from the other governorates to save the fresh water.

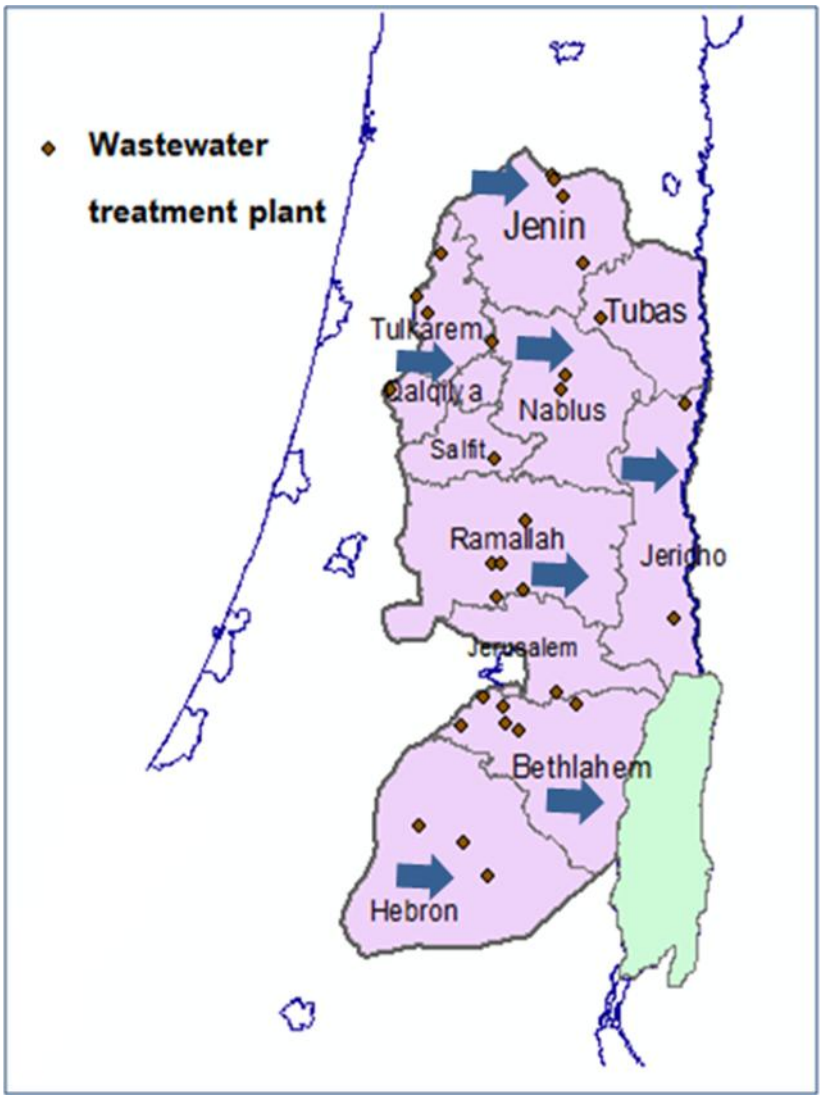

Figure (5.8) reclaimed wastewater in the industry among the governorate

West Bank have three industrial areas or parks these are: Jericho, Beithlehem and Jenin, and also there is a plan in the future to develop other industrial parks in Tulkarm, Nablus and Hebron; the industrial parks can use the reclaimed wastewater in some kind of the industry; especially every industrial park have a wastewater treatment plant, the association that develop and manage these industrial parks is PIEFZA (Palestinian Industrial Estate and Free Zone Authority). PIEFZA is a governmental

organization working on the establishment of advanced industrial zones with the highest international standards seeking to attract foreign and domestic investments to the targeted industrial estates in a strategic manner to be one of the well known investment promotional agencies operating in the Middle East region. Figure (5.9) show the West Bank Industrial Park.

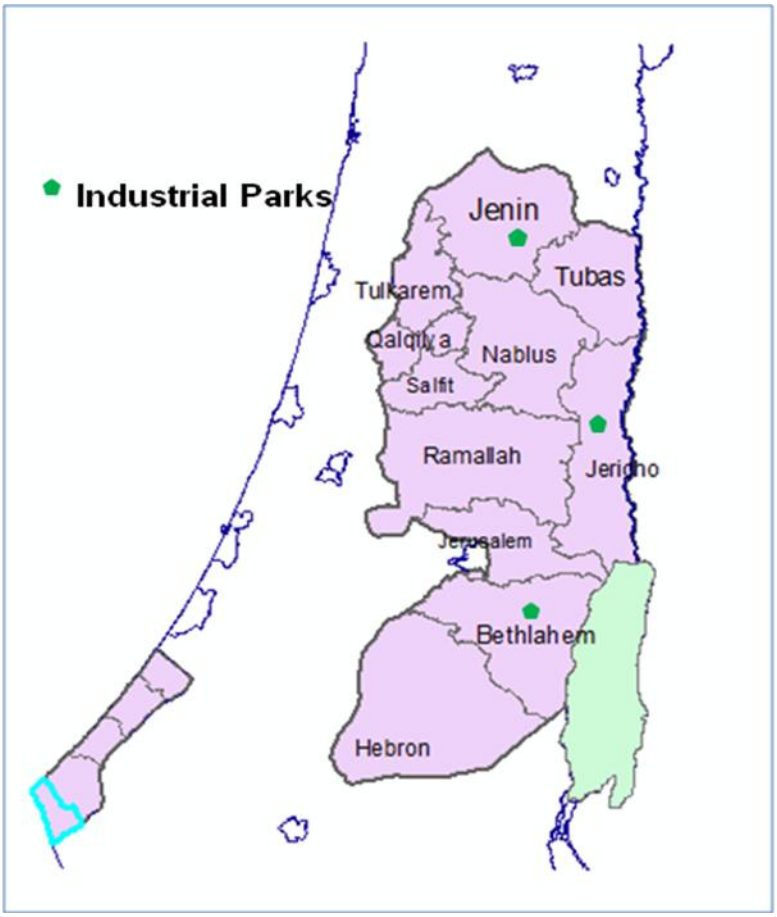

Figure (5.9) PIEFZA industrial parks in West Bank

They aim of PIEFZA to be one of the leading institutions providing a distinctive advanced investment environment for industrial estates to contribute in the sustainability of the Palestinian National economy.

The mission of PIEFZA is to contribute in raising the living standards and cut down the unemployment domestic rate by creating, developing and managing advanced industrial estates through unique partnership and full cooperation with the private sector hand by hand to have a highly competitive eco-friendly industrial estates through highly qualified, fully skilled and specialized staff. And the goal are: Successful development of the industrial sector through increasing its competitive advantage and provide unique favorable investments conditions to upraise domestic and foreign investments.

PIEFZA as a governmental organization can help to courage of using the reclaimed wastewater in the industry, especially it have a good relation and facilitation with the Israeli side. Also it can use the reclaimed wastewater in the irrigation of industrial parks green areas, according to PIEFZA law, industrial park should be consider in the environment because of that it should be have wastewater treatment plant, and in the same time every industrial estate should have 20% at least of green areas, also every industrial park in PIEFZA located near agricultural areas so, they can use the reclaimed wastewater for irrigation of the agricultural areas near the industrial estates (such as irrigation of palm trees in Jericho near to JAIP “Jericho Agro Industrial park”), and also it is easy to use the reclaimed wastewater in some kind of industries at the same industrial park.

5.5.2 The interviews for this option

According to the ministries interviews the **Environment Quality Authority (EQA)** reported that there are factories already using the reclaimed wastewater in their plants such as; (NAPCO Aluminum Factory in Al-junied near Nablus); where the plant contains an integrated system for water recycling and preliminary processing, As there is in Hebron governorate, as well as (the Royal Plastic Factory) where he uses reclaimed wastewater.

There are also marble and stone factories group in Hebron in which the work of the project to several villages by the Americans association (black and vetch), where the Cabinets of Ministers approved a decision to this effect to be the work of an integrated technical system for water recycling and use in the industry, where in the previous disposed of these waste water resulting through the valley to Israel and then there are treated these wastewater, causing it to pay extra for Israel because of this waste, which led to the work of this project in order to avoid this additional tax.

In this regard the Cabinets have been issued a decision No.25 for the year 2010, upon the recommendation of the **Environmental Quality Authority** to impose laws on factories and rainwater and put filters and separated wastewater system, this system is a "system of environmental conditions for stone and marble factories tiles and ready concrete", this system consists of 26 legal substance, which is part of the Palestinian

Environmental Law of the system and has a need for a processing unit for industrial wastewater for the granting of environmental approval.

For example, the visit of Al-Teera wastewater treatment plant has been done, which uses technology (membrane), the outflow of this plant is 2000 m^3/ day, the produced reclaimed wastewater is high-quality but it will be disposed again into the valleys of sewage without using, from here the importance of the study was that there is a very good size of wastewater treatment plants projects, so why we do not use this benefit of this reclaimed water; it is possible that to be important source of national income, in addition to that many part of these projects also hold bearing capacity building and training costs for Palestinian workers from these projects, for example the western Nablus wastewater treatment plant.

CHAPTER SIX

DATA ANALYSIS AND OUTPUTS

6.1 Introduction

The scientific method of the research is (**Pros and Cons Analysis**) for each of the scenario and then to determine if the value of the scenario is positive or not, and also to determine the best scenario have the maximum weight, several economical, social, political and environmental factors had been addressed.

Pros and Cons analysis, is a systematic process for making difficult decisions that involve a lot of factors by which the advantages and disadvantages of the scenario well measure and compare for the governmental decision makers. The analysis Provide a reliable basis in the comparison between scenarios. This process is built on the basis of the comparison between the expected total advantages (Pros) of each option against the total expected disadvantages (Cons), to see whether the advantages outweigh the disadvantages.

So it will be as much as possible to try to limit the advantages of each scenario from the proposed scenarios versus the disadvantages of this scenario, in addition to the possibility of a more than one scenario in the trade or trade-off of reclaimed wastewater even follow all the previous options.

6.2 Pros and Cons Analysis for scenarios

Before making any decision related to trade or trade-off of reclaimed wastewater we should take into account the aspects related to both advantages and disadvantages for the proposed scenarios.

In the previous chapter we determine the benefits (advantages) and obstacles (disadvantages) for every scenario, this chapter will tabulate these factors for comparison between them. This analysis steps are:

1. Making a table that has all the factors and indicators as a columns. and all the scenarios as a rows.

2. Giving a weight for every factor that affect in the scenario, the weight varies from -4 to +4

3. Counting the number of pros and cons. By assigning each Pro and Con a weight, it can get a better sense of where the balance really lies.

4. The highest number means it is an extremely important factor in the decision.

5. Completing a table for all the options that we are considering.

6. The total number of points in the weights column are contribute and then determine and compare the results.

The Pros and Cons analysis indicators are economical, political, environmental, development and social for every scenario.

Table (6.1) Pros and Cons analysis for all scenarios

Scenarios of trade and trade-off of RWW	Indicator	Economical indicators							Political indicators				Environmental indicators		
	Scenario	Translation costs	WW network costs	Storage costs	Tankers costs	Reflect on the relation with neighbor countries	Job opportunities	Economical income	Israeli control	Rejection agreements	Decision freedom	Controlling the national sources	Clean agriculture using fresh water	Land and plants poisoned	Better environment
	Trade with Israel	-3	-2	-1	-3	*	+2	+2	+1	*	+2	+2	+1	+2	+1
	Trade between governorates	-3	-2	-1	-2	-2	+2	+2	+3	*	+2	+3	+2	+2	+2
	Trade-off with Israel	-4	-2	-1	-3	*	+3	+3	+1	*	+1	+2	+2	+2	+2
	Trade-off between governorates	-4	-2	-1	-2	-2	+3	+3	*	*	+2	+2	+2	-1	+1
	Trade-off for Agricultural use at the same governorate	-1	-2	-1	-1	-3	+1	+2	*	*	+3	+2	-2	-2	+1
	Trade as industrial water	-1	-2	-1	-1	*	+1	+1	*	*	+2	+2	+3	+2	+2

Scenarios of trade and trade-off of RWW	Indicator	Development indicators				Social indicators					Total
	Scenario	Resources sustainable	Decrease the fresh water losing	Save the new generations rights	Improve the income average	Social rejection depending psychological reasons	Social rejection depending on religious reasons	Illegal within local laws	Effectiveness for the neighbor countries	Effecting the Palestinian reputation	Total
	Trade with Israel	+3	*	+3	+1	*	*	*	*	*	+11
	Trade between governorates	+3	+3	+3	+1	-2	-2	*	-2	-2	+10
	Trade off with Israel	+3	+2	+3	+2	*	*	*	*	*	+16
	Trade off between governorates	+3	+2	+3	+2	-1	-1	*	-2	-2	+5
	Trade off for Agricultural use at the same governorate	+3	+3	+3	+2	-2	-2	-1	-2	-2	+1
	Trade as industrial water	+3	+3	+3	+2	*	*	*	*	*	+19

6.3 The Outputs and Comparison between the scenarios

As we can notice from the above table that the best choice according to the Pros and Cons analysis is the trade of reclaimed wastewater at the same governorate for industrial uses, because of that choice decrees the costs of transportation (it is the same as trade off for agricultural uses at the same governorate), but without holding the disadvantages of poisoned the land and plants and the bad effects on reputation at the neighbor countries; with that choice Palestinian are more free to make their own decisions in comparison with the other choices that related to Israelis.

The second best choice is trade off with Israelis because this choice can offer fresh water for Palestinians without holding of any of the bad effects for the environment or Palestinian society because the reclaimed wastewater will not be used for any purpose at the Palestinian areas, in addition to support the peace idea with Israeli side.

The third best choice is trade with Israel because within this choice is good for the economical income and it can offer jobs opportunities, and also during to this choice Palestinians will have money and they will have nothing to lose at this stage they already have reclaimed wastewater without any benefits; also this choice can support the peace with Israeli side (two countries solution).

Palestinian can decide the best choice according to the strategic plan; because the trade off, even at the same governorate or between governorates for industrial purposes, can be better for the long term; which

can be better according to the sustainability vision and the freedom of the State of Palestine, on the other side trade with Israelis can be better for the short term plans; because this choice can offer an economical income for Palestinians which can help them to pass the financial difficulties that they are facing at this time, but it's not a good choice for the long term because water as a limited natural source more important for the long term than the financial sources.

6.4 Impacts Address of Trade of Reclaimed Wastewater

6.4.1 Social

Al-Kharouf, 2003 find that most of the experts (89%) and (91.3%) of the institutions believe that the psychology is the main reason for non accepting the reuse, 59.8% of the experts and 54.3% of the institutions stated that the society incorrect understanding of the religion concerning this subject, make the society prejudiced against the reuse of the treated wastewater. They believe that the conservative societies do not accept the reuse. On the other hand, 30.7% of the experts and 34.6% of the institutions believe in the opposite.

However, 71.4% and 74.6% of the respondent experts and institutions respectively, think that the reuse of the treated wastewater is accepted by the religion if the resulting effluent was not harmful to the human health.

This result coincides with the (fatwa) that was issued in 1978 about the subject. However, only 16.7% of the experts said that they do not know what the opinion of Islam in the subject.

Only 54.3% of the experts and 56.7% of the institutions said that there reference in the wastewater treatment and reuse will be abided to any decision issued by the official religious authorities. About 40% of the experts refuse to let the religion interfere in this subject. They consider this issue as a pure scientific issue, and the religion does not contradict with science.

From the analyzed **Al-Kharouf, 2003** questionnaires, The detailed analyses of the all factors which resulted from the questionnaires it should be notified that the expression (Institutes) is used to represent the respondent individuals, decision makers, and politicians who work in governmental or non-governmental organizations. It was found that the opinion of the experts and those who work with the institutions that the main reason for not accepting the reuse is psychological. In this context, the experts and institutions proposed that there is a relationship between the social traditions and customs from one side, and the psychological aspects from the other side. These two factors interact in a way such that there is no distinct boarder between the two sides.

In the public and farmers levels, it was found that most of the people agree that the social traditions and customs practiced in the West Bank do not accept the reuse of the treated wastewater in any sector. 88.9% of the

respondent experts in the West Bank said that the main reasons for rejecting the reuse of the treated wastewater are psychological reasons. Although the wastewater is treated, but it is very difficult to forget the original nature of this water was before treatment.

The opinions of the experts and the institutions were different from the public and farmers, the following wastewater management responsibilities are the most important concerns, in which the experts and the institutions think that public must participate in the following aspects ranked in descending order in terms of its importance according to experts and institutions opinions:

- Reuse considerations and Environmental Impacts.
- Health Impacts.
- Management and administrative Aspects.
- Financial Aspects.
- Technical Aspects.
- Legal Aspects.

6.4.2 Economical

According to Al-Kharouf study 84.3% of the respondent experts considered the water bill a heavy burden on the budget of the society. However, between 89.7% and 86.6% of the experts said that our water and wastewater institutions need financial support and public participation. In

order to maintain continuous and sustainable rehabilitation and improvement of the water networks and wastewater facilities, the local society must be willing to financially participate in the system improvement. On the other hand, 78.0% of the respondent experts stated that they agree on the wastewater treatment and reuse if it ends up of lowering the water prices. 80.3% said that it should provide additional quantities of water, and 74.8% said that it must provide recreational areas.

6.4.3 Political

(Al-Kharouf, 2003) Said that 96% of the experts and 98.4% of the institutions agreed that the Israeli manipulation on the natural water resources is one of the important reasons for unstable political situation in the Palestinian territories. Although they understand that the reuse of the treated wastewater is to augment the fresh water resources, 71.6% of the experts and 73.2% of the institutions stated that Palestinians must not think of an alternative of the natural resources. The Palestinians initially must achieve their confiscated natural water rights; then they start innovation supplementary resources.

Using alternative supplementary resources will encourage Israel to manipulate the Palestinian water rights. However, 93.7% of the experts and institutes believe that wastewater will be one the important future supplementary water resources that should be taken into consideration.

6.4.4 Health

According to **Al-Kharouf, 2003**; 83.5% of the respondent experts and 80.3% of the institutes stated that water shortage leads to epidemic diseases. However, about 90% of the experts and the institutes said that if the septic tanks and pits continue seeping, this will be a main reason for the diseases. Almost all the respondent experts and institutions stated that if the wastewater is treated, the public health will be improved. About 87% of the respondent experts and institutions said that the farmers grow different crops using raw wastewater.

The results emphasize the experts and the related institutes are very worried about the wastewater situation in the West Bank. They raised an alarm about the issue. They understand the economic situation, but they said that this issue can be solved on individual level. Percolating pits should be frequently emptied; any potential over flow should be prevented. This will improve the public health situation.

Concerning the health issues related to the irrigation with raw wastewater, 46.4% of the experts declared that there is a serious public health problem. Thorough analyses of this issue using crosstabs show the following:

- 60% of the respondent experts from Hebron district agreed with that.

- 75% of the experts who live in Tulkarem and Qalqilia agreed.

- 50% of the experts who live in Nablus agreed.

- 44% in Jenin and Tubas agreed.

- 40% in Jerusalem district agreed.

- and only 25% agreed in Ramallah district.

6.4.5 Religious and Cultural Aspects

Al-Kharouf, 2003 said that despite most of the experts (89%) and (91.3%) of the institutions believe that the psychology is the main reason for non accepting the reuse, 59.8% of the experts and 54.3% of the institutions stated that the society incorrect understanding of the religion concerning this subject, make the society prejudiced against the reuse of the treated wastewater. They believe that the conservative societies do not accept the reuse. On the other hand, 30.7% of the experts and 34.6% of the institutions believe in the opposite.

However, 71.4% and 74.6% of the respondent experts and institutions respectively, think that the reuse of the treated wastewater is accepted by the religion if the resulting effluent was not harmful to the human health. This result coincides with the (fatwa) that was issued in 1978 about the subject. However, only 16.7% of the experts said that they do not know what the opinion of Islam in the subject.

Only 54.3% of the experts and 56.7% of the institutions said that there reference in the wastewater treatment and reuse will be abided to any decision issued by the official religious authorities. About 40% of the experts refuse to let the religion interfere in this subject. They consider this issue as a pure scientific issue, and the religion does not contradict with science.

CHAPTER SEVEN

CONCLUSIONS and RECOMMENDATIONS

7.1 Conclusions

This study shows these conclusions;

1. Reclaimed wastewater is an important unused natural source, it is important to maximize the benefits that we could get by using such an important source.

2. More than one scenarios can be used in Palestine, many factors affect in the option that will use by decision makers, these factors like: quantities of water, distance from Israel, nature of agriculture and industrial types in every governorate.

3. For sustainable development the best scenarios can be even trade-off between governorates or trade between governorates or trade-off at the same governorate whatever the purpose of use.

4. For the short term trade-off or trade with Israelis can be good scenario, so that it can offer a financial support which can help Palestinians to face budget difficulties .

5. Price of reclaimed wastewater is an important factor to make these scenarios applicable.

6. The most important industrial sector that reclaimed wastewater can be used in is the constructions sector.

7. Depending on the interviews with the related people and decision makers at the ministries of agriculture, environment, economic and water Authority, they all welcomed the suggestion of reclaimed wastewater as an alternative solution to the water scarcity in Palestine.

8. It is important to note that the maximum percentage of fresh water uses in Palestine is for the personal and agricultural uses, reclaimed wastewater can be used for all the other purposes.

9. Reclaimed wastewater can be used without ignoring the society and religion factors.

10. There is a growth of the treatment projects that produced a large amount of reclaimed wastewater should be considered.

11. The public awareness about reuse of reclaimed wastewater in agriculture is very weak. Most of the Public respondents do not understand the physical meaning of reuse. They think that religion and social traditions are prejudiced against the wastewater treatment and reuse.

12. It is very important to take advantage by using the reclaimed wastewater in industrial sector.

7.2 Recommendations

As a result of the study, the following recommendations are considered important regarding the trade or trade-off of reclaimed wastewater in Palestine;

1. The official support is important to achieve the best results and to maximize the benefits that can be achieved.

2. It is important to organize an awareness campaigns that can improve the society acceptability of reclaimed water using in the different sectors.

3. Reclaimed wastewater is an important resource as an alternative choice instead of fresh water, but it is important to prepare economical, technical and social studies that can help the decision makers to make the appropriate decisions.

4. Reclaimed wastewater can be used in irrigation of the green areas at the industrial parks.

5. Palestine Estate should have national unified strategy in the sector of water resources management especially reclaimed waste water which is considered an important water resource should be used.

6. Palestine Estate should work hardly to get more donors to support this project because of its importance for both of environment and economic.

7. Qualified and specialized staff in reclaimed wastewater issues is an important factor of succeeding this project.

8. Successful stories of using reclaimed waste water can be a good method to help society to accept using of reclaimed water.

9. The private sector should be involved within this project.

10. The project must addressed in the terms of legality.

11. The applying of research idea should not be conflict with our water rights.

12. We should determine before the applying this project who own the reclaimed wastewater?? Ministry of Local Governorate (MoLG) within the municipalities or Palestinian Water Authority (PWA) or any other parts; because this water ownership issues are a problems can appear or face the applying of thesis idea in the next future.

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كلية الدراسات العليا

تقييم أثر التبادل التجاري للمياه العادمة المستصلحة على إدارة مصادر المياه في فلسطين

إعداد

أحلام فايز محمد بشكار

إشراف

د. حافظ قدري شاهين

قدمت هذه الأطروحة استكمالا لمتطلبات درجة الماجستير في هندسة المياه والبيئة بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.

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الملخص

ندرة المياه هي واحدة من أصعب المشاكل التي تواجه دولة فلسطين وذلك مع عدم وجود موارد للمياه والتنافس المستمر والزيادة السنوية المستمرة في الاستخدامات المختلفة المحلية، الزراعية والصناعية.

يمكن اعتبار إعادة استخدام مياه الصرف الصحي المعالجة كمصدر للتخفيف من آثار مشاكل ندرة المياه وتحسين إنتاجية المحاصيل الزراعية في حال استخدامها في مجالات الزراعة، إن مورد مياه الصرف الصحي المعالجة هو مورد بيئي، اجتماعي واقتصادي جيد يحتاج إلى أن يدار بطريقة مناسبة.

فلسطين، كما هو الحال في معظم الدول المجاورة في المنطقة، تعترف بأهمية هذه الموارد في تحسين العجز المائي عن طريق إعادة استخدام مياه الصرف الصحي المعالجة في الإنتاج الزراعي والقطاع الصناعي وإعادة شحن المياه الجوفية.

ما يعرضه البحث هو امكانية التجارة في هذه المياه العادمة المستصلحة أو المقايضة كاستبدالها بمياه عذبة او استخدامها في الزراعة اما محليا بين محافظات الوطن أو بين فلسطين والجانب الاسرائيلي وذلك كحل سياسي لمشاكل ندرة المياه في المنطقة.

تم جمع كافة البيانات المتعلقة ب كميات مياه الصرف الصحي الناتجة في فلسطين وكذلك استعراض حجم المشاريع في تنقية المياه العادمة من جمع ومعالجة ونقل وإعادة استخدام.

إن المنهج العلمي المتبع في الدراسة هو دراسة الايجابيات والسلبيات حيث تم عرض اربع خيارات لتجارة المياه العادمة وهذه الخيارات هي:

1. تجارة المياه العادمة المستصلحة أو مقايضتها بين دولة فلسطين والجانب الإسرائيلي.
2. تجارة المياه العادمة المستصلحة أو مقايضتها بين المحافظات الفلسطينية.
3. مقايضة المياه العادمة المستصلحة واستخدامها في الزراعة.
4. استخدام المياه العادمة المستصلحة في الصناعة.

وقد تمت المفاضلة بين الخيارات الاربعة المطروحة عن طريق تحديد الايجابيات والسلبيات في تحليل الدراسة، مع بيان الآثار التجارية الأخرى من مياه الصرف الصحي المعالجة، تم أيضا تناول الاثار الاجتماعية والدينية، البيئية، السياسية، الصحية وغيرها من الآثار المحتملة وتم اعطاء وزن او علامة لكل خيار، حيث أفضل الخيارات التي تحص على اعلى وزن.

من منهجية البحث المتبعة ايضا عمل مقابلات مع عدة وزارات فلسطينية التي لها علاقة بموضوع تجارة المياه العادمة المستصلحة وهذه الوزارات هي:

1. سلطة المياه الفلسطينية.
2. سلطة جودة البيئة.
3. وزارة الزراعة.
4. وزارة الاقتصاد.

وذلك كونها من اصحاب القرار في موضوع التجارة في المياه العادمة المستصلحة ، وقد كان هناك ترحيب كبير في الفكرة الخاصة بالبحث من كافة اصحاب القرار الذين تم مقابلتهم.

بعد مفاضلة كافة الخيارات يعرض البحث الخيار الأفضل لاصحاب القرار وذلك وفقا للخطة الاستراتيجية التابعة لكل وزارة مختصة ومعنية، فمثلا تم التوصل أن خيار تجارة مياه

الصرف الصحي المعالجة في نفس المحافظة أو بين المحافظات للأغراض الصناعية يمكن أن يكون أفضل على المدى البعيد، والتي يمكن أن تكون أفضل وفقا لرؤية الاستدامة، من جهة أخرى التجارة مع الجانب الإسرائيلي يمكن أن يكون أفضل الخيارات لخطط زمنية قصيرة لأن هذا الخيار يمكن أن يقدم دخل اقتصادي للفلسطينيين بالاضافة الى التخلص من الضرائب التي تفرضها اسرائيل على المياه العادمة الناتجة من الأراضي الفلسطينية والتي يمكن أن تساعدهم على اجتياز الصعوبات المالية التي تواجهها في الوقت الحالي ، كما يدعم هذا الخيار السلام مع اسرائيل وخيار الدولتين من ناحية سياسية.

إن مياه الصرف الصحي المعالجة مصدرا طبيعيا هاما غير مستخدم بشكل فعال بحيث يمكن الاستفادة منه على صعيد الوطن فمن المهم تعظيم الفوائد التي يمكن أن نحصل عليها باستخدام هذا المصدرا الهام خصوصا لما تعانيه فلسطين من مشاكل في ندرة المياه آخذة بالازدياد مع الزمن.

يوضح البحث سيناريوهات متعددة يمكن استخدامها معا او استخدام افضلها ولكن ذلك مرتبط بعدة عوامل مثل: كميات المياه العذبة المتوفرة في المحافظات، المسافات الجغرافية بين المدن الفلسطينية وبين الجانب الإسرائيلي، طبيعة الزراعة ، أنواع الصناعية في كل محافظة، أسعار واجور النقل والتكاليف المترتبة على استخدام اي سيناريو من السيناريوهات المطروحة، هذا بالاضافة الى سعر مياه الصرف الصحي المعالجة الذي هو عامل مهم لجعل هذه السيناريوهات كافة قابلة للتطبيق.