An-Najah National University
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Assessment of Palestinian Water Sector Strategy Under Different Energy Sources Using Water Allocation System “WAS”

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Dedication

I dedicate my thesis to my dear parents, may Allah give them welfare in recompense their help early until this achievement, and my darling wife, may Allah enable me to repay them.

Acknowledgements

First of all, I thank God Almighty who guided me to complete this research and complete it to the fullest. Thanks to my Dr. Anan Fakhri Jayyousi for his supervision, guidance, and constructive advise, who assured me the care and effort in my success to reach this degree of production, God prolong his life. Special thanks also go to my defense committee. Thanks to my parents and my family who have ensured me with diligent care and diligence throughout my life until this achievement. I have a great thank you and may Allah guide me to their kindness. Special thanks to the staff of An-Najah National University and staff of Palestinian Water Authority, who gave me every help until I completed my research.

الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان

Assessment of Palestinian Water Sector Strategy Under Different Energy Sources Using Water Allocation System "WAS"

أقر بأن ما شملت عليه الرسالة هو نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل أو أي جزء منها لم يقدم من قبل لنيل أي درجة أو لقب علمي أو بحثي لدى أي مؤسسة علمية أو بحثية

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 degrees or qualifications.

Student's Name:	**اسم الطالب:**
Signature	**التوقيع:**
Date	**التاريخ:**

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List of Abbreviations

FAO	Food Agriculture Organization
GIS	Geographic Information System
ha	Hectare
IWRM	Integrated Water Resources Management
km^2	Square Kilometer
LCA	Life Cycle Assessment
l/c/d	Liter per capita per day
m^3	Cubic Meter
MCM	Million Cubic Meter
MW	Megawatt
PCBS	Palestinian Central Bureau of Statistics
PERC	Palestinian Electricity Regulatory Council
PWA	Palestinian Water Authority
PV	Photovoltaic
PWSS	Palestinian Water Sector Strategy
WAS	Water Allocation System
WEAP	Water Evaluation and Planning Software
WEN	Water Energy Nexus

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Abstract

Water resources in Palestine are limited. Palestine consists of 16 Governorates; 11 governorates in the West Bank in the eastern part of Palestine to the west of Jordan River and 5 governorates in Gaza Strip which are described as the southern region of the Palestinian coastal plain on the Mediterranean. Palestine suffers from the increasing in both the population and the per capita water consumption.

The objectives of this research are to assess the Palestinian Water Sector Strategy developed in 2014 for a period of 30 years using Water Allocation System (WAS) and inputting various energy sources and prices, and to evaluate the feasibility of water-energy nexus. The assessment is come out through inputting the demand data, supply data, available infrastructure; desalination plants, freshwater links between governorates, and recycling plants into the Water Allocation System (WAS) Model then to run the and show the results. The evaluation of the feasibility of water-energy nexus is come out through calculating energy prices under different energy sources; solar energy in the West Bank, and natural gas in the Gaza Strip.

The results of the three scenarios, existing situation 2015, future situation 2030, and future situation 2030 under different energy sources showed that freshwater links between governorates should be available since it decreases

the shadow prices in the Palestinian governorates. The desalinated quantities of water in Gaza Strip should be 540 MCM under freshwater links and desalination cost of 0.509 USD/m^3 by the year 2030, and 817 MCM under freshwater links and the natural gas as energy source which decrease the desalination cost to 0.419 USD/m^3.

Based on the results of three scenarios, the conveyance lines between the Palestinian governorates to transport water in two way; from the origin to the destination, and from the destination to the origin when it necessary is a necessary management option, In addition, the wastewater reuse in all Palestinian governorates as potential future water resource is a preferable management option too. Moreover, the renewable energy sources, particularly solar energy for desalination and pumping in the West Bank, and natural gas for desalination and pumping in Gaza Strip is also preferable option to make desalination efficient.

Chapter One

Introduction

1.1 General background

Water resources in Palestine are limited. The Israeli occupation controls the water resources in Palestine, and utilized high amounts of water resources and this is expected to be more serious in the near future as both the population and the per capita consumption are increasing. Moreover, water resources are threatened by water pollution due to the inadequate wastewater disposal which further decreases water quality and, therefore, availability (Nazer et al, 2008).

Water allocation systems serve to equitably apportion water resources among users; protect existing water users from having their supplies diminished by new users; govern the sharing of limited water during droughts when supplies are inadequate to meet all needs; and facilitate efficient water use. Effective water allocation becomes particularly important as demands exceed reliable supplies. As water demands increase with population and economic growth, water allocation systems must be expanded and refined (Wurbs, 2013).

Palestine climate varies from arid to semi-arid regions. Water resources availability varies also from one governorate to another. Palestine consists of 16 governorates; 11 governorates in the West Bank and 5 governorates in Gaza Strip. Data on conventional and non-conventional water resources in

Palestinian governorates have been collected and used in the water allocation system tools (WAS) for assessing the availability and reliability of water resources, and define the optimal utilization of potential water resources in Palestine. The WAS based on the allocating of the flow of the water to the water users to produce the greatest net benefits for all users and the data and other assumptions. There are two fundamental concepts of the WAS model. First, the scarcity of water, the scarcity of water prompt the people to pay more amounts for access a small share of water. Second, water can have a social value that exceeds its private value, as in the districts that like the agriculture, and the subsidy that may be provided by the government for agriculture. The WAS model takes these social values of water into account.

1.2 Research Objectives

The main objectives of this research are:

1. To assess the Palestinian Water Sector Strategy developed in 2014, for 2034 using Water Allocation System (WAS) and inputting various energy sources and prices.
2. To evaluate the feasibility of water-energy nexus.

1.3 Research motivation

To the best of my knowledge previous efforts of optimal distribution of water resources did not consider the nexus of water and energy, and the effect of energy prices on the optimal distribution of water resources. This issue needs to be investigated in light of the new potential energy sources including the potential natural gas resources in Gaza Strip. In addition, previous developed models need to be updated in terms of supply and demand data. This research will try to bridge these gaps.

1.4 Study Area

1.4.1 Location

Palestine is located in south west Asia and is considered a link between the continents of Asia and Africa, the West Bank is located in the eastern part of Palestine to the west of Jordan River. It consists of eleven governorates that are Jenin, Nablus, Tulkarem, Qalqilia, Tubas, Salfit, Jericho, Ramallah, Jerusalem, Bethlehem, and Hebron. The Gaza Strip is described as the southern region of the Palestinian coastal plain on the Mediterranean. It consists of five governorates that are North Gaza, Gaza, Dier Al-Balah, Khanyunis, and Rafah.

The area of historical Palestine is 27,009 km^2, while the area of West Bank is 5655 km^2, and the area of Gaza Strip is 365 km^2 (PCBS, 2015). The West Bank and Gaza Strip form about 22% of Palestine area.

Figure1 shows the West Bank and Gaza Strip Governorates.

Figure 1.1: West Bank and Gaza Strip Districts.

1.4.2 Climate

Palestine climate is Mediterranean and varies from semi-arid to arid; the maximum amount of rainfall is through winter from December to February. The annual rainfall distribution in the West Bank ranges from 220 mm to 920 mm, and the annual rainfall in Gaza Strip is 350 mm.

Figure 2: The Rainfall Distribution in the West Bank

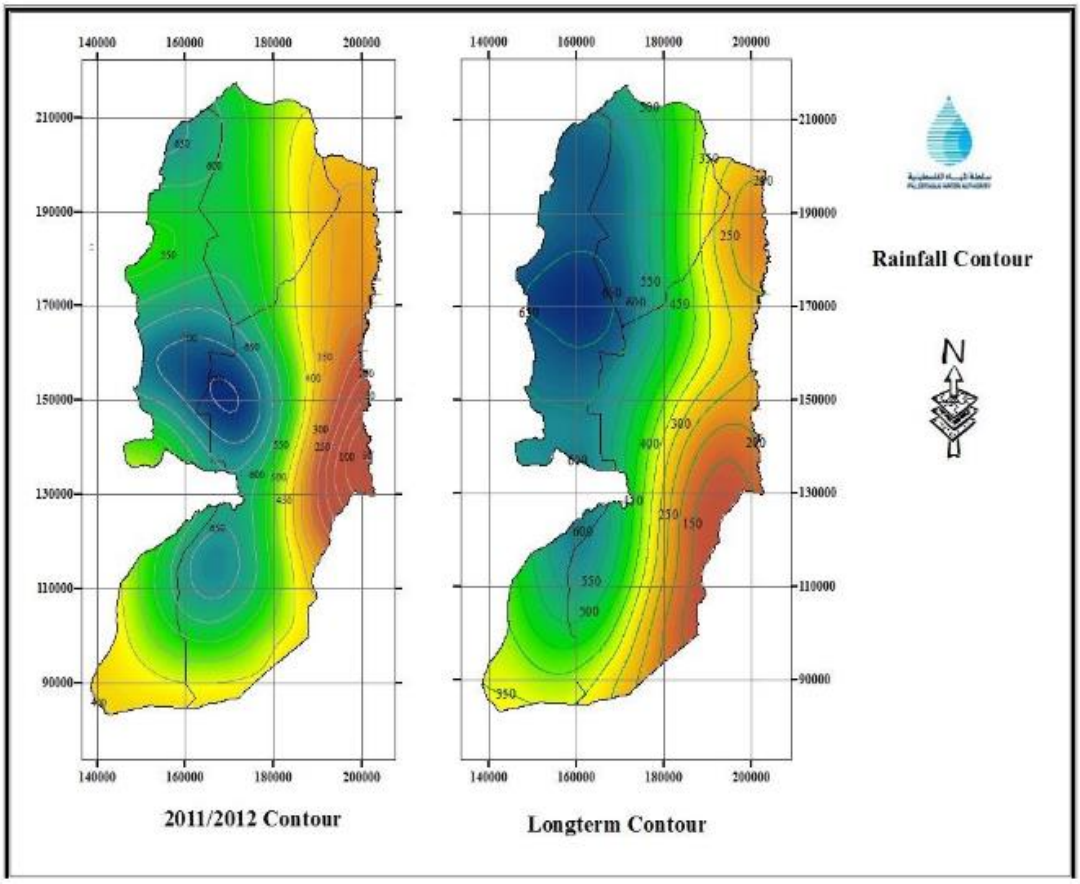

Figure 1.2: Rainfall contour maps for the West Bank, 2011/2012 season and long term average (Annual Water Resources Status Report, 2013).

1.4.3 Agriculture

Rainfed farming predominates in the West Bank and covers about 94 percent of the total cultivated area, mostly in the Western Highlands, while in the Gaza Strip more than half of the cultivated land is irrigated. In 2003, the total irrigated land in the Occupied Palestinian Territory amounted to about 24,000 ha. Of this area 11,400 ha are in Gaza Strip, 5,400 ha in the semi-coastal area of the West Bank and about 7,000 ha in the rest of the West Bank, primarily in the Jordan Valley. Irrigated crops include citrus fruits, various kinds of vegetables, including tomatoes, cucumbers, eggplants cauliflower and others. Strawberries and cut flowers are also grown. Rainfed crops include olives (over 80 percent of all perennials), grapes, figs, almonds, plums, cereals and pulses.

Water in the West Bank is derived from two sources, wells and springs, while the Gaza Strip it is entirely dependent on wells. In 2005, 125 million m³ of the water withdrawn for irrigation came from wells (40 million m³ in the West Bank and 85 million m³ in the Gaza Strip) and the remaining 49 million m³ came from springs in the West Bank. In 2005, groundwater accounted for 408 million m³ and reused treated wastewater accounted for 10 million m³ (FAO, 2008). Table 1.1 below shows the agricultural use of water in Palestine for the year of 2015.

Table 1.1 Palestinian Water Wells and it's Annual Pumping Quantity in Palestine by Governorate for agricultural use(1).

Governorate	Agricultural Use (million m³)
Palestine	**120.6**
West Bank	**35.6**
Jenin	0.9
Tubas	1.3
Tulkarem	11.4
Nablus	1.9
Qalqilia	7.4
Ramallah & Al-Bireh and Jerusalem	-
Jericho & Al-Aghwar	12.7
Bethlehem & Hebron	-
Gaza Strip(2)	**85**

(1) Data exclude that part of Jerusalem, which was annexed forcefully by Israel following it's occupation of the West Bank in 1967.

(2) Data about annual quantities from agricultural wells in Gaza Strip is estimated.

(-)Nill

Source: Palestinian Water Authority, 2016. Water Information System. Ramallah - Palestine.

1.4.4 Industry

There are 17,057 institutions that are working in industry in Palestine, which employs 86,253 workers. The size of the achieved production of industrial activities is US$ 4,102.9 million, the intermediate consumption is US$ 2,390.6 million, and the size of added value is 1,712.4 USD millions (PCBS, 2015).

Recently, in October, 2017 manufacturing activities recorded an increase of 3.67% compared to the previous month, with a relative importance of 83.19% of total manufacturing activities.

Water supply, sanitation and waste management and treatment activities recorded a decrease of 6.42% with a relative importance of 0.78% of total industry activities.

1.4.5 Water situation

Groundwater is the main source of water for Palestinians in the occupied Palestinian territory (West Bank and Gaza Strip). It provides more than 90% of all water supplies. The main aquifer systems can be divided into four distinct units; the Western Aquifer Basin with total recharge of 335-450 MCM/yr, the North-eastern Aquifer Basin with total recharge of 130-200 MCM/yr and the Eastern Aquifer Basin with total recharge of 100-172 MCM/yr for the West Bank, and the Coastal Aquifer with total recharge of 55-65 MCM/yr for Gaza (Aliewi, 20007), where the groundwater is available at much shallower depth. Figure 3 shows the groundwater aquifers in Palestine.

Figure 1.3: Groundwater aquifers in Palestine. Source: Fanack after UNEP, 2002**.**

Following the 1967 occupation, Israel has controlled all shared water resources including surface and groundwater, and has utilized more than 85% of these resources, leaving only 15% for Palestinian use. The surface water in Occupied State of Palestine is represented by several seasonal wadis, as well as the Jordan River, which is currently controlled and used exclusively by the Israelis.

Due to the above mentioned, the Occupied State of Palestine is among the countries with the scarcest renewable water resources per capita; average domestic water consumption is only 72 l/c/d in the West Bank, and 96 l/c/d in Gaza but with water quality much below international standards. This is far below the per capita water resources available in other countries in the

Middle East and in the world, constraining economic development, increasing running costs leading to health problems. More than half of the available groundwater is used for domestic water supply, severely limiting the available volume for irrigated agriculture and industry.

The water situation in Gaza is much worse than in the West Bank. The Coastal Aquifer in the Gaza Strip receives an annual average recharge of 50-60 MCM/y mainly from rainfall, while the annual extraction rate of this aquifer complex is estimated at about 178.8 MCM. These unsustainably high rates of extraction have led to lowering the groundwater level, the gradual intrusion of seawater and upwelling of saline groundwater (PWA, 2012).

1.4 Methodology

1.4.1 Research methodology

The methodology of the research is divided into seven main steps as depicted in the following flowchart:

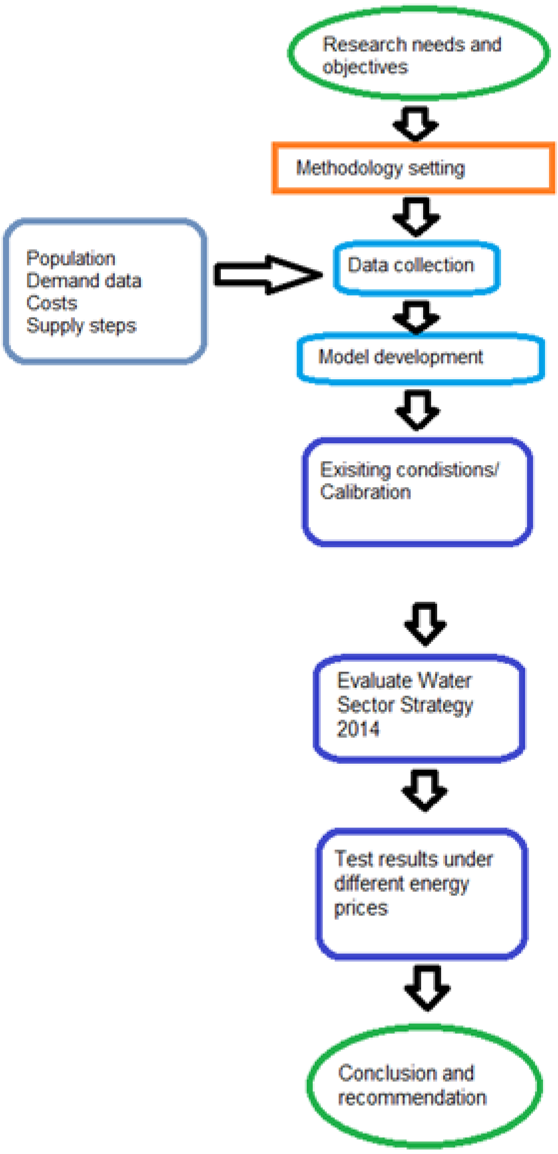

Figure 1.4: Research Methodology Flowchart

1. Review the previous existing literature regarding water sector strategy, energy sources and prices, and potential assessment tools.
2. Collect the data, population, energy and water: demand, costs, and supply, and other related data.
3. Using Water Allocation System (WAS) to test water management options listed in Palestinian Water Authority sector strategy and compare it with strategy predicted numbers.

4. Using water allocation agreed as a result of comparison in the third step that mentioned above and energy sources and prices options/scenarios set in the second step as a new input in Water Allocation System (WAS) to obtain optimized conditions.
5. Compare results obtained in the fourth step to reach the best water allocation-energy sources and prices for the water strategy.

1.4.2 The WAS Model

1.4.2.1 WAS Concepts

The WAS based on the allocating of the flow of the water to the water users to produce the greatest net benefits for all users and the data and other assumptions. These flows are related to a system of prices (shadow prices) for water in many different locations. A competitive market of the prices and the quantities of the allocated water would reach if both the private willingness to pay and the social value of water as reflected in the social policies are included in demand considerations.

There are two fundamental concepts of the WAS model. First, the scarcity of water, the scarcity of water prompt the people to pay more amounts to access a small share of water. Where water is not scarce, it is not valuable.

Second, water can have a social value that exceeds its private value, as in the districts that like the agriculture, and the subsidy that may be provided by the government for agriculture. The WAS model takes these social values of water into account, the WAS model accept the constraints from the user, and optimize the net benefits subject to those constraints.

The country is divided into governorates in the model, the data for demand by households, agriculture, and industry; population, demand elasticity, and demand multipliers, supply; supply steps, and supply multipliers, desalination plants, intra-district leakage, and infrastructure including; fresh water links, transport costs, recycled water links, recycled water transportation costs, recycling plants, environmental charges and setasides, recycled constraints and social policy inserted into the model.

In data preparation one must distinguish between the concepts of demand and consumptions. Demand means how much water users would want to consume if they could get it at the stated price. Consumption is an estimate of how much they will (or do) in fact consume given actual availability. Consumption includes supply features. Demand does not. Failure to distinguish these when collecting data will lead to major errors in the use of WAS(Water Economics Project, 2007).

WAS model requires the understanding of the net benefits and the shadow values of water which called shadow prices in the economic literature, but using the term of “values” to distinguish them from the prices charged to consumers (Water Economics Project, 2007).

Net Benefits:

The amount of water that a hypothetical household willing to buy at different prices is shown in Figure 1.5 below

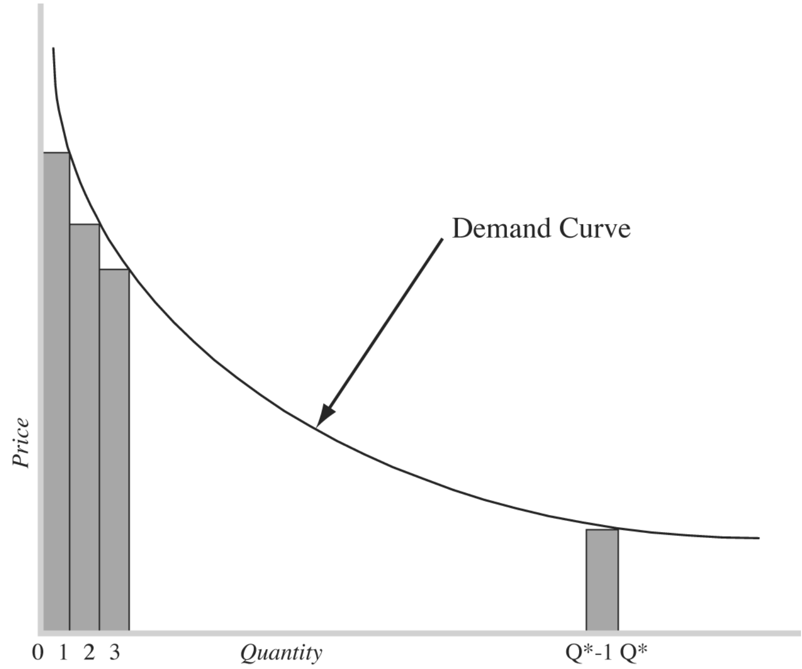

Figure 1.5: Demand Curve (Water Economics Project, 2007).

Demand curve is considered downward sloping curve, which indicate the high value of the first small units of water, that may be considered for drinking and cooking, while the latter units have less value than the first units.

The household should have a quantity of Q*, but the question is how much that household may pay for the first few units of water; the horizontal axis of the demand curve consists of many intervals, here we mean the first interval from 0 to 1, and its price is presented by a point on the demand curve. The area of the leftmost vertical strip in figure 1.5 is the amount to be paid. As well the area of the second-to-left vertical strip in figure 1.5 is the amount to be paid for the second unit, and so on until reaching Q*.

The household would be willing to pay total amount to get Q*, which approaches the area under the demand curve to the left of Q* as the unit size decreases.

As we use figure 1.5 to represent the aggregate demand curve of all households in a district. The gross (private) benefits from the water flow Q* can then be represented as the total area under the demand curve to the left of Q*.

When we subtract the costs of providing Q*, we will derive net benefits from Q*. This is shown in figure 1.6 below, the cost of providing an additional unit is presented by the line which labeled “marginal cost”. Additional units cost more as more expensive water sources are used; since the water suppliers may buy water from non conventional water sources as private firms. We can find the net benefit from providing Q* to the households by subtract the area under the marginal cost curve to the left of Q* of the area under the demand curve, it is presented by the shaded area in the figure 1.6 below,

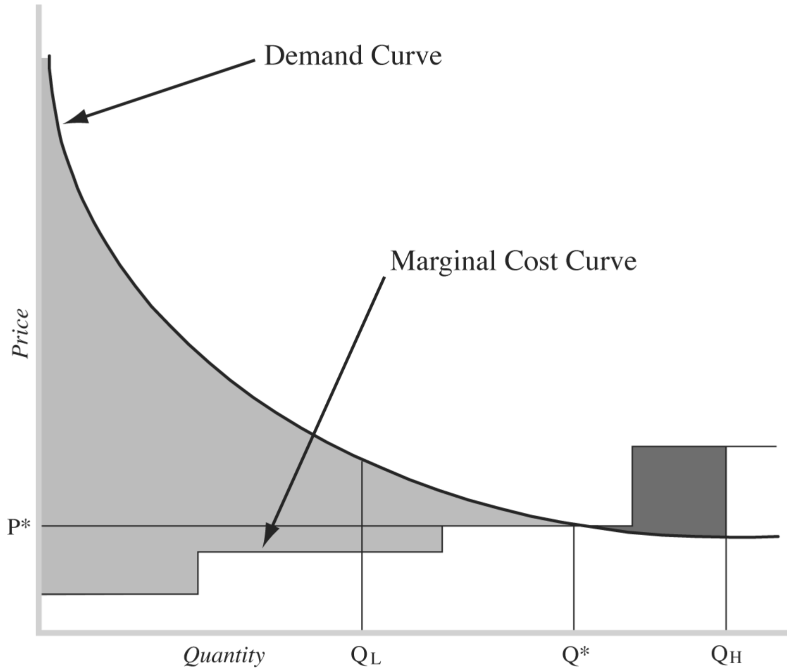

Figure 1.6: Net benefit (Water Economics Project, 2007).

The amount that should be delivered to maximize the net benefits is Q*. If one would deliver an amount Q_L, a smaller shaded area will be produced. However, the households consuming Q_L would be willing to pay more for additional units (marginal value) than the cost of such additional units (marginal cost). If one would deliver an amount Q_H, a negative value (the darker area) will be produced, which interpret the fact that households consuming Q_H would not be willing to pay the cost of providing the last few units. So, Q^* is the optimal amount of water to deliver.

Capital Costs:

The WAS model handles the related issues, cost-benefit calculations for proposed new infrastructure, and capital costs into alternative ways, are:

1. Lump sum.
2. Per-cubic-meter basis.

Capital Costs As A Lump Sum:

Direct Cost-Benefit Analysis. In this method the capital costs are entered in for a comparison with benefits. This may be done through the interface.

The advantages and defects of the capital costs as a lump sum method:

1. This method is very easy to use, since it does not require the separate calculation of per-cubic-meter capital costs, and depend on the actual quantity used.
2. The shadow values in the scenario with the projected infrastructure will not accurately reflect all costs involved.

3. It will not choose which projects to build from a menu of possible projects (Mayyaleh, 2014).

Capital Costs As A Per-Cubic-Meter Basis:

The per-cubic-meter capital cost of the proposed infrastructure is included in this method as a cost associated with the use of that infrastructure. The model will use the infrastructure if and only if the new infrastructure's benefits exceed its costs (including capital costs) in the assumed steady state conditions.

The advantages and defects of the capital costs as a per-cubic-meter basis are:

1. The shadow values of water will show the per-cubic-capital costs of the new infrastructure as units of dollars per cubic meter. The values will appear relatively natural in terms of prices.
2. The prices that charged to users are not the shadow values, since the capital costs of existing infrastructure must not be included, they are not included in the shadow values. So that we will never consider the shadow values are same as the prices charged to users.
3. The fact of the inclusion of the capital costs of the new projects in the shadow values does, however, achieve high accuracy for the shadow values as measures of the value of the marginal cubic meter than the case in which such costs are not included in the shadow values.
4. The best advantage of using the capital costs as a per-cubic-meter basis method that there is no need to test one proposed project, or several proposed projects at a time. By setting the costs of all proposed

projects, and seeing which ones are used in the model solution, one can decide which projects should be built in the presence of the others (under the assumed steady-state conditions).

5. The capital costs as a per-cubic-meter basis method can be made to calculate both the annual net benefits and the present discounted value of the net benefits, not to generate the total benefits of the new infrastructure for direct comparison with its capital costs. This can be done by clicking on the “Cost-Benefit Calculations” button on the main menu of the WAS model.

1.4.2.2 Using the WAS

The first screen appear when you open the Water Allocation System model is called initial screen, the next screen is the main menu of the program, this section illustrates the options that exists in the main menu of the program, and prepare the data needed to input in the program for Palestine country in the section, 3.2.

To move to the main screen of WAS, the user should press the “OK” button in the initial screen. The main screen containing the data inputting options; demand, supply, desalination plants, intra-district leakage, infrastructure including fresh water links and its transport costs, recycled water links and recycled water transport costs, recycling plants environment charges and setasides, recycled constraints and social policy.

The above options that mentioned are considered as model input. On the other hand, the main screen include the model output, to run the model the user should click on the " OPTIMIZE" button, then the user can see the results in different forms like Tabular, Cost-Benefit Calculations, and Schematic program results. The area of the file menu enable the user from save the current scenario, load scenario, delete scenario, and to quit from the WAS program. Moreover, the help menu in the right bottom of the main menu provide the user by using WAS v3.6, WAS updates, district names, and about WAS. Figure 1.7 shows the main screen of WAS program which allow user through them to modify data and run the model.

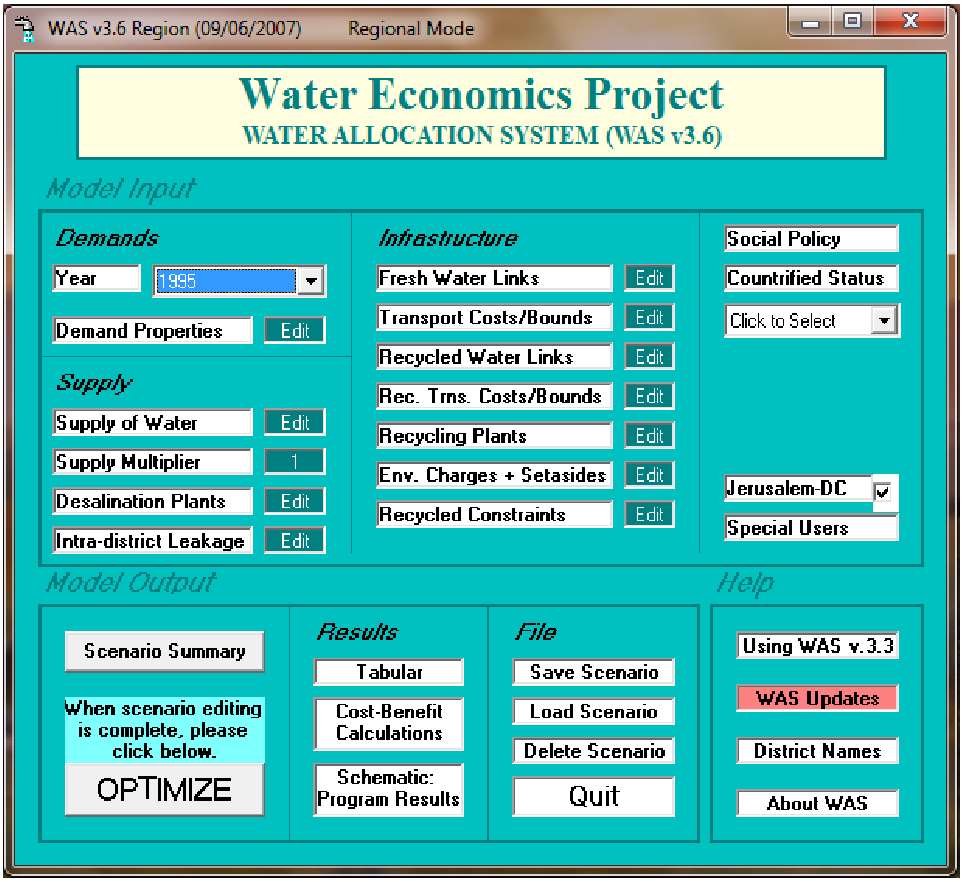

Figure 1.7: Main screen of WAS (Water Economics Project, 2007).

The preparation of input files and the inputting of needed data is demonstrated in section 3.2 Existing water conditions.

Chapter Two

Literature Review

2.1 Optimal Utilization of Potential Water Resources

There is enough freshwater in the world to meet the existing and future needs of the world's population. Water, however, is poorly distributed: there are regions that suffer severe drought, while others are heavily flooded; regions that have ample water in winter, but not enough in summer; and regions that abound in water during certain years, but are threatened by droughts in others. Thus, the management of freshwater is largely a question of redistribution of a natural resource, given certain physical, economic, environmental, and social constraints. Such management inevitably brings into play the competing priorities of different uses and users; and, since most water resources traverse political boundaries, these competing priorities often become regional conflicts between riparian states (Benvenisti, 1996).

2.2 Previous Studies

In 1998 Emch and Yeh developed a management model for managing water use within a coastal region. Two conflicting objectives were considered: cost-effective allocation of surface water and ground water supplies, and minimization of saltwater intrusion. Optimal control of the system was examined by studying the response of these objectives to changes in ground water pumping rates and transfer of surface water between sources and users. System constraints include economic, operational, and institutional requirements(Emch and Yeh, 1998). After that in 1999 Belaineh, Peralta and Hughes developed a model that integrates conjunctive use of surface and ground water, and delivery via branching canals to water users(Belaineh, 1999).

In 1999 (Amir and Fisher) developed model called Water Allocation System (WAS), based on the view that water is an economic good, to answer the questions that related to the distribution of water in the middle east, the provision of the water to meet the growing demand (Amir and Fisher, 1999). Moreover, in 2001 Jayyousi applied the WAS 3.3 model to explore the economic consequences of various water scenarios, Jayyousi answered the following questions; the distribution of water in the region, the production of additional water to cover the growing demand, the provisions for dry years, the allocation of costs and benefits and price charge to the consumers of water. The outcomes show that all parties in the region will gain if cooperation exists between these parties once the question of water rights is determined (Jayyousi, 2001).

The studied area (the West Bank and Gaza Strip) was divided into a number of governorates according to the Palestinian division. Within each governorate, water demand curves were defined for each household use, industrial use, and agricultural use. The annual renewable amount of water from each source was taken into account such as the pumping cost thereof. Allowance is made for recycling of wastewater, and the possibility of inter district conveyance is taken into account (Jayyousi, 2001).

It has been recognized that wastewater reuse or reclamation serves as an efficient and valuable way to cope with the scarcity of water resources and severity of water pollution. Based on the regional disparities in China, a linear programming optimization model was developed to explore the potential wastewater reuse quantities, under physical and economic constraints (Chu et al, 2004).

In 2010, Jaradat applied model called Water Evaluation and Planning Software (WEAP) to provide analysis towards an integrated water resource management (IWRM) for the Gaza Strip. Jaradat accomplished the model development through evaluating the existing water demand and supply conditions and expected future demand and supply scenarios taking into account the different operating policies and factors that affect demand (Jaradat, 2010).

In 2011, Siddiqi and Anadon, performed a country-level quantitative assessment of Water Energy Nexus in the Middle East region. The results showed a highly skewed coupling with a relatively weak dependence of energy systems on fresh water, but a strong dependence of water abstraction and production systems on energy. In case of Saudi Arabia it was estimated that up to 9% of the total annual electrical energy consumption may be attributed to ground water pumping and desalination. Other countries in the Arabian Gulf may be consuming 5–12% or more of total electricity consumption for desalination. The results suggested that policy makers should explicitly consider energy implications in water intensive food imports and future restructuring of water demand. This will help in making more integrated decisions on water and energy infrastructure systems (Siddiqi and Anadon, 2011).

2.3 Water Energy Nexus

Urban areas nowadays have population larger than the rural areas. So, resource distribution depends on population distribution. As the population is increasing in the urban centers the demand on water and energy exceeds supplies, which in turn leads to import from distant sources. Although urban areas manage the resources efficiently, and protects the undeveloped areas, new cities produce relatively large quantities of point source consumption. Therefore, urbanization connected with desertification in the remote areas and making use of resources in rural areas. This is especially true with water and energy. (Perrone et al, 2011).

Water and energy sources uses include percentage of losses, due to acquisition, processing, transportation, and end-use. These invisible quantities of water and energy are lost and often not counted in resource consumption. The water and energy nexus make the urban resource flows complicated. Water is consumed through the life cycle of energy. On the other hand, energy is consumed for extraction, distribution, and end-use of water resources (Perrone et al, 2011).

Urban areas cannot achieve sustainability in and of themselves, the urban communities can be responsible partner in achieving the overall sustainability. To achieve these sustainability analyzing of water and energy flows should be done. This step is difficult to achieve due to many reasons.

Wide range of stakeholders in the management of water and energy resources and, as a result, data often are not readily available. It is difficult to obtain water-energy nexus (WEN) data for a specific region not only because these data are presented for national scale, but also since these data be outdated, available in raw form, or unavailable for public use, which require more time and resources to make them useful. The organizational and jurisdictional boundaries make data collection and compatibility of the analyses very complicated. Supply chains are long and they are difficult to track, and the accurate allocation of demands along them is even more difficult, which leads to set major assumptions or truncated analysis boundaries (Perrone et al, 2011).

The water and energy use associated with trade-offs, which need to revealed by some work, resource use can be examined systemically using the calculation of the urban metabolism of cities, and life cycle assessments using material flow analyses. Such tools require a massive data assembly and analysis effort to treat a comprehensive portfolio of resource inputs and emission outputs. The national economic data do not capture the influence of a community's geographic location within the nation, in spite of, LCA using economic data within an input−output approach reduces the effort required for such studies. Moreover, many tools are only effective for a particular area. It also cannot neglect both energy for water and water for energy (Perrone et al, 2011).

Additional resources that are required by a community after the delivered water and energy consumption can be found from the frameworks within the tool (Perrone et al, 2011).

In ecology, enriched microenvironment is called resource island when it contains the features of; resources are slowly depleted from the hinterland , nutrients are concentrated in the soil beneath desert shrubs. Urban centers rely on the remote regions resources and water and energy infrastructure to save their local resource, just as ecological resource islands acquire resources from their surroundings. So, all cities are considered resource islands and this include their surroundings (Perrone et al, 2011).

2.4 Methods of Water Energy Nexus

2.4.1 Urban Centers versus Community

Multiple energy sources are available for large cities, so they have more than one energy provider. The boundaries of different providers do not align, and they rare to align with boundaries of urban center. The same thing applies to water boundaries and energy boundaries where they rarely fit into each other. Therefore, the definition of the community is the area within an urban center or surrounding it that aligns best with utility boundaries (Perrone et al, 2011).

2.4.2 Energy for Water Framework

This framework consists of four main stages: acquisition, treatment, local distribution, and end use. Water can also be divided into two categories, delivered water and transport water. Water that consumed directly by the end-user called delivered water. While transport water is water that lost during the first stage; acquisition of water from, local distribution such as leaky pipes or a distant source like evaporation. transport water can be considered an inefficiency value which cannot be considered valuable. The energy involved in the energy nexus is itself that consumed for delivered water and transport water, which includes the energy needed for acquisition, municipal treatment, local distribution, and end use (Perrone et al, 2011). Figure 2.1 shows the WEN tool concept diagram.

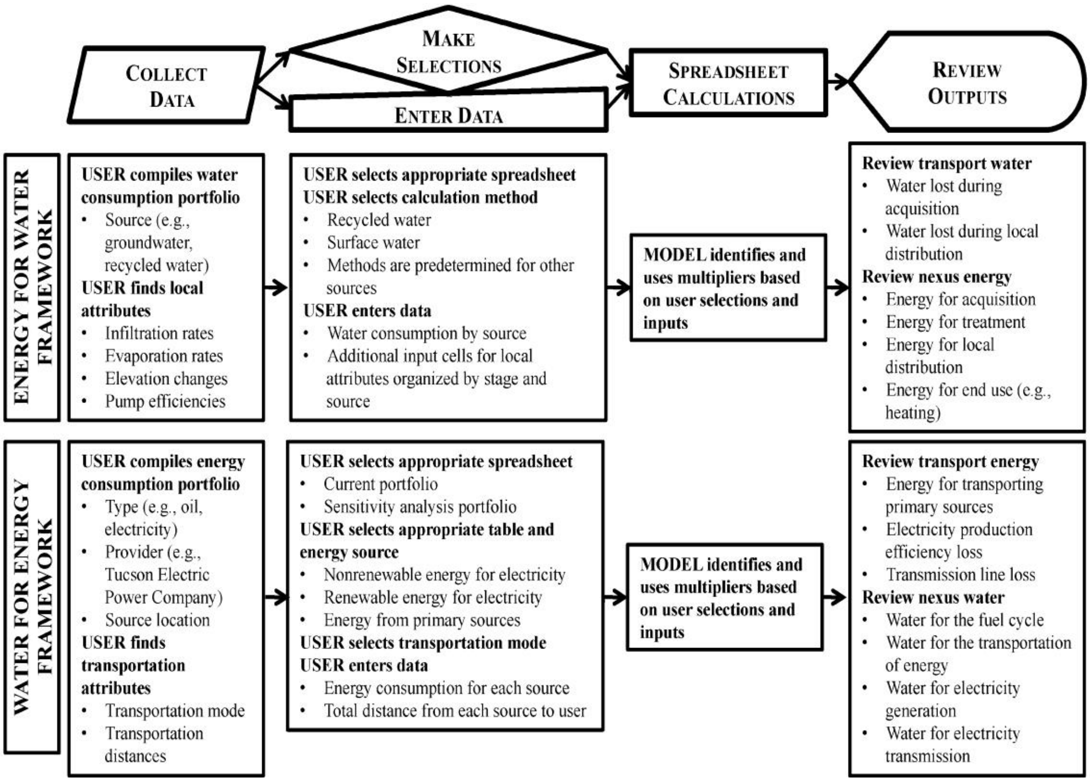

Figure 2.1: WEN tool concept diagram (Perrone et al, 2011).

2.4.2.1 Outputs

The energy for water framework deals with the energy consumed during using the water by a community. This framework calculates the transport water that lost due to transportation of water from the resource (Perrone et al, 2011).

2.4.2.2 Inputs

The community's water portfolio or the total delivered water are required as framework inputs to obtain the outputs of this framework, which including the sources of water, other information, such as the changes in elevation between the water source and the users and pump efficiency (Perrone et al, 2011).

2.4.2.3 Limitations

Review the data from water utility accurately is required, since it may include the transport water. Also, the water lost in the treatment process was not calculated and the water lost by the end-user was not calculated. The end use of water require energy that difficult to calculate as the users and the use of water itself varies from one to another, and so, has significant limitations(Perrone et al, 2011).

2.4.3 Water for Energy Framework

This framework consists of four main stages: energy fuel cycle like mining, extraction, and refining, energy transportation like fuel for trucks delivering coal, electricity generation, and electricity transmission. This framework including two categories of energy: delivered energy and transport energy. Energy that consumed by the end user defined as delivered energy. The electricity generation stage; are including the loss of primary energy during conversion to electricity, and the electricity transmission stage; are including the lost during the transmission of electricity, this stages are defines the transport energy. The water consumed for delivered energy and transport energy that calculated within the water for energy framework is called nexus water. Nexus water includes water for the fuel cycle, transportation, electricity generation, and electricity transmission stages(Perrone et al, 2011), see figure 2.1 above.

2.4.3.1 Outputs

The water for energy framework deals with the water that consumed for the energy consumed by a community. This framework also comprise the calculations of the energy that are required to move energy resources, the energy lost during the conversion from the primary source to secondary source, and the energy lost during transmission of electricity as described transport energy(Perrone et al, 2011).

2.4.3.2 Inputs

The community's energy portfolio as delivered energy, the mode of transportation, and distance need to travel from source location to community or power plant if transported via truck, rail, or water are essentially required as framework input to obtain the framework outputs. Government's website can be adopted to gathering the data of energy as energy portfolios. Geographic information system (GIS) can also be used to calculate transportation distances (Perrone et al, 2011).

2.4.3.3 Limitations

The energy calculations for transportation modes are based on efficiencies more than distances, since GIS data for energy infrastructure are limited publically available(Perrone et al, 2011).

2.5 Energy Prices and The Economics of Water

Water allocation and distribution are threatened by rising of energy prices, which in turn will increase the cost of extraction and conveyance of water. As a result, the cost of groundwater will increase. Efforts will drive to invest in land-and water-intensive biofuel technology, and produce energy from land and water supplies rather than food production. So, the negative impacts include the raise in the price of food and distributional effects (Zilberman et al, 2008).

Chapter Three

Model Development for Current Conditions

3.1 Introduction

The Water Allocation System (WAS 3.6) has been used to model the situation in Palestine. The data used in the model is the one presented in the Palestinian Water Authority (PWA) water tables in addition to other data and assumptions used for the model. Two base runs were prepared that reflects the existing conditions of the base year of 2015 and the future run that reflects the 2030 conditions under different energy sources including different energy prices.

This chapter describes two main components. Those are the data and the outcomes of the national model for Palestine for the year 2015 and the future assumptions used to reflect the conditions in the State of Palestine for the year 2030 described in the next chapter.

3.2 Existing Water Conditions

Data for the existing water conditions in Palestine has been collected and the model for the current conditions was prepared using the Palestinian Water Authority 2015 data. This section describes the data used for the current conditions scenario.

3.2.1 Population Data

The population for the year 2015 has been used as the base year population data. This data is shown in Table 1 below.

Table 3.1: Population Data at the end of the year 2015

Governorate	Population
Jenin	315,094
Nablus, Tubas and Salfit	522,435
Tulkarem and Qalqilia	295,871
Jericho	52,858
Ramallah	352,462
Jerusalem	160,768
Bethlehem	219,437
Hebron	717,372
North Gaza	369,949
Gaza	635,514
Dier Al-Balah	268,918
Khanyunis	346,664
Rafah	229,514

Source: PWA Water Tables, 2015

3.2.2 Demand Elasticity

Demand elasticity varies between sectors. For the current situation, demand elasticity is taken as follows:

Agricultural Demand Elasticity 0.5

Urban Demand Elasticity 0.6

Industrial Demand Elasticity 0.5

3.2.3 Demand Multipliers

All demand multipliers are set at 1.0 to represent an average year conditions.

3.2.4 Supply Steps

The available supply of water for the different governorate is taken from PWA data for the end of the year 2015. This data is summarized in Table 2 below.

Table 3.2 Supply Data for Palestine for 2015

<table>
<tr><th>Governorate</th><th>Wells Supply in Mcm/year</th><th>Springs Supply in Mcm/year</th><th>Mekorot Supply in Mcm/year</th><th>Desalination Supply in Mcm/year</th><th>Total In Mcm/year</th></tr>
<tr><td>Jenin</td><td>5.2</td><td>0.5</td><td>3.0</td><td>0.0</td><td>8.7</td></tr>
<tr><td>Tubas</td><td>2.7</td><td>0.9</td><td>5.4</td><td>0.0</td><td>9</td></tr>
<tr><td>Nablus</td><td>11.0</td><td>4.9</td><td>4.1</td><td>0.0</td><td>20</td></tr>
<tr><td>Qalqilia</td><td>12.8</td><td>0</td><td>1.5</td><td>0.0</td><td>14.3</td></tr>
<tr><td>Tulkarem</td><td>20.8</td><td>0</td><td>0.4</td><td>0.0</td><td>21.2</td></tr>
<tr><td>Salfit</td><td>0</td><td>0.2</td><td>3.0</td><td>0.0</td><td>3.2</td></tr>
<tr><td>Jericho</td><td>12.7</td><td>28.6</td><td>2.6</td><td>0.0</td><td>43.9</td></tr>
<tr><td>Ramallah</td><td>2.5</td><td>4.6</td><td rowspan="2">21.3</td><td>0.0</td><td rowspan="2">28.4</td></tr>
<tr><td>Jerusalem</td><td>0</td><td>0</td><td>0.0</td></tr>
<tr><td>Bethlehem</td><td>5</td><td>0.6</td><td rowspan="2">22.5</td><td>0.0</td><td rowspan="2">39.1</td></tr>
<tr><td>Hebron</td><td>10.6</td><td>0.4</td><td>0.0</td></tr>
<tr><td>North Gaza</td><td>49.5</td><td>0.0</td><td rowspan="5">6.4</td><td rowspan="5">3.9</td><td rowspan="5">208.6</td></tr>
<tr><td>Gaza</td><td>66.4</td><td>0.0</td></tr>
<tr><td>Khan Yunis</td><td>28.3</td><td>0.0</td></tr>
<tr><td>Dier Al-Balah</td><td>32.7</td><td>0.0</td></tr>
<tr><td>Rafah</td><td>21.4</td><td>0.0</td></tr>
</table>

Source: PWA Water Tables, 2015.

3.2.5 Supply Multipliers

All supply multipliers are set at 1.0.

3.2.6 Total Losses

The intra-district leakage for each governorate should be considered to input in the WAS model. The intra-district leakage rate must input as a fraction, the value of input must be greater than 0 and less than 1. Tables 3.3 and 3.4

below show the total losses for each governorate in the West Bank and Gaza Strip as quantity in million cubic meter of the difference between supplied water for domestic sector and the consumed water, and as percentage of the supplied water for domestic sector (in million cubic meter).

Table 3.3: Total Losses in the West Bank Governorates.

Governorate	Supplied Water for Domestic Sector (million m^3)	Consumed Water (million m^3)	Total Losses (million m^3)	Total Losses %	Population End of 2015	Daily Allocation per Capita from Consumed Water (liter/capita/day)
West Bank	**119.6**	**81.2**	**38.4**	**0.32**	**2,636,297**	**84.3**
Jenin	8.8	5.7	3.1	0.35	315,094	49.5
Tubas	2.3	1.4	0.9	0.39	65,787	58.3
Tulkarem	12.4	7.7	4.7	0.38	183,684	114.8
Nablus	16.7	11.3	5.4	0.32	385,145	80.3
Qalqilia	7.0	5.3	1.7	0.24	112,187	129.3
Salfit	2.8	2.3	0.5	0.18	71,503	88.1
Ramallah	16.3	12.3	4.1	0.25	352,462	95.5
Jerusalem	7.5	5.6	1.8	0.24	160,768	95.5
Jericho	6.6	4.4	2.2	0.33	52,858	227.9
Bethlehem	9.2	5.9	3.3	0.36	219,437	73.6
Hebron	30.0	19.3	10.7	0.36	717,372	73.6

Source: PWA, Water Tables, 2015

Table 3.4: Total Losses in Gaza Strip Governorates.

Governorate	Supplied Water for Domestic Sector (million m³)	Consumed Water (million m³)	Total Losses (million m³)	Total Losses %	Population End of 2015	Daily Allocation per Capita from Consumed Water (liter/capita/day)
Gaza Strip	**95.3**	**53.5**	**41.8**	**0.44**	**1,850,559**	**79.2**
North Gaza	24.5	12.5	12.0	0.49	369,949	92.5
Gaza	32.4	19.0	13.4	0.41	635,514	81.9
Deir Al-Balah	14.9	7.5	7.4	0.50	268,918	76.4
Khan Younis	13.8	8.7	5.1	0.37	346,664	68.7
Rafah	9.7	5.8	3.9	0.40	229,514	69.2

Source: PWA, Water Tables, 2015

3.2.7 Water Cost

The costs of producing water at the source is taken based on interviews with Palestinian Water Authority experts and they are shown in table 3.5 below.

Table 3.5: Water Costs in West Bank and Gaza Strip for 2015.

Region	Supply Source	Cost (US$/ m³)
West Bank	Mekorot	0.7
	Spring	0.2
	Groundwater wells	0.5
Gaza Strip	Mekorot	0.7
	Spring	0.2
	Groundwater wells	0.2

3.2.8 Description of Available Infrastructure

At present, both West Bank and Gaza Strip suffers heavily from the lack of proper infrastructure that can be summarized in the following:

- No Reuse of treated wastewater in 2015.
- No desalination plants are in place in 2015 except for the small scale desalination plants in Gaza.
- No infrastructure conveyance is available between Governorates are in place in 2015.
- No Governmental social policies are applied in 2015.

3.3 Discussion of Results

Based on the data used in this chapter, the model was developed and results were obtained, the shadow prices appear in schematic presentation in the program results. Figure 3.1 shows the shadow prices in $\$/m^3$ for each governorate in the West Bank and Gaza Strip.

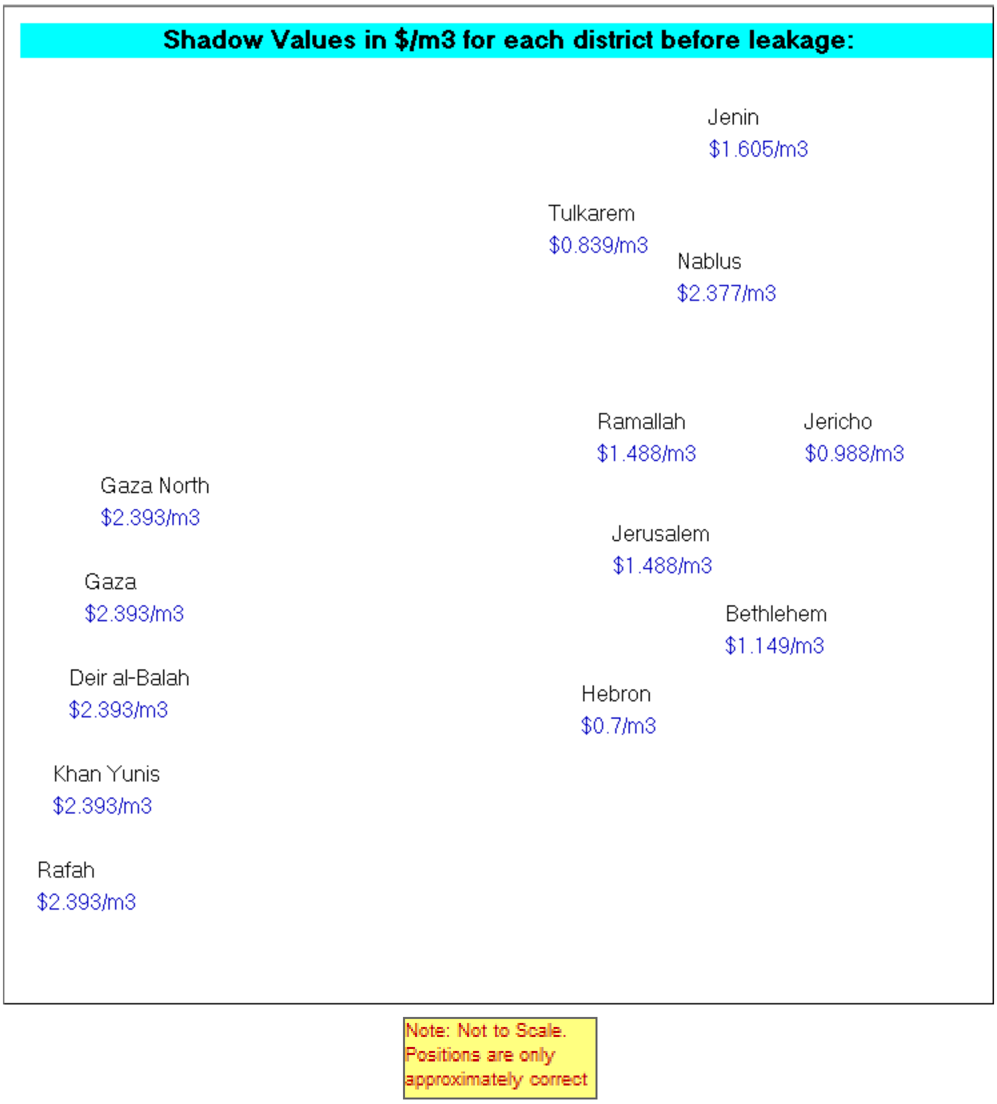

Figure 3.1: Shadow values before leakage for each governorate in West Bank and Gaza Strip for 2015.

Figure 3.2: Shadow values after leakage for each governorate in West Bank and Gaza Strip for 2015.

There is no quantities for export of freshwater in all governorates of the West Bank and Gaza Strip, since there is no infrastructure conveyance available between governorates according to the current conditions in 2015. Figure 3.3 shows the Net export of freshwater in million cubic meter (MCM) for each governorate in the West Bank and Gaza Strip.

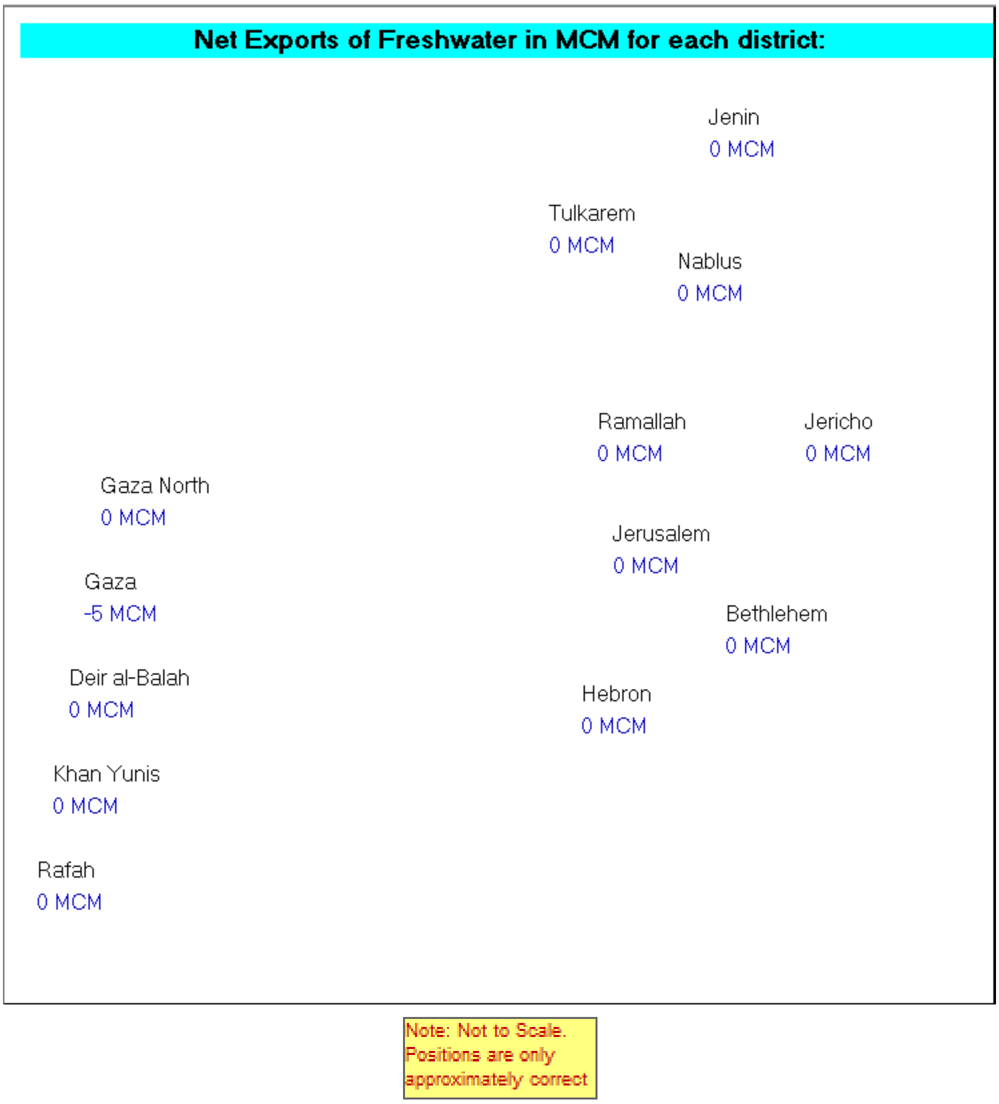

Figure 3.3: Quantities of Net exports of freshwater for each governorate in West Bank and Gaza Strip for 2015.

The urban freshwater demand quantities in million cubic meter results interpret that the governorates that have high shadow prices, their household have less willing to pay, which in turn make the urban freshwater demand quantity (Q*) that has shown in the demand curve in figure 1.5 above; less than the urban freshwater demand quantity (Q*) for the governorates that have low shadow prices. Figure 3.4 shows the urban freshwater demand quantities in million cubic meter (MCM) for each governorate in the West Bank and Gaza Strip.

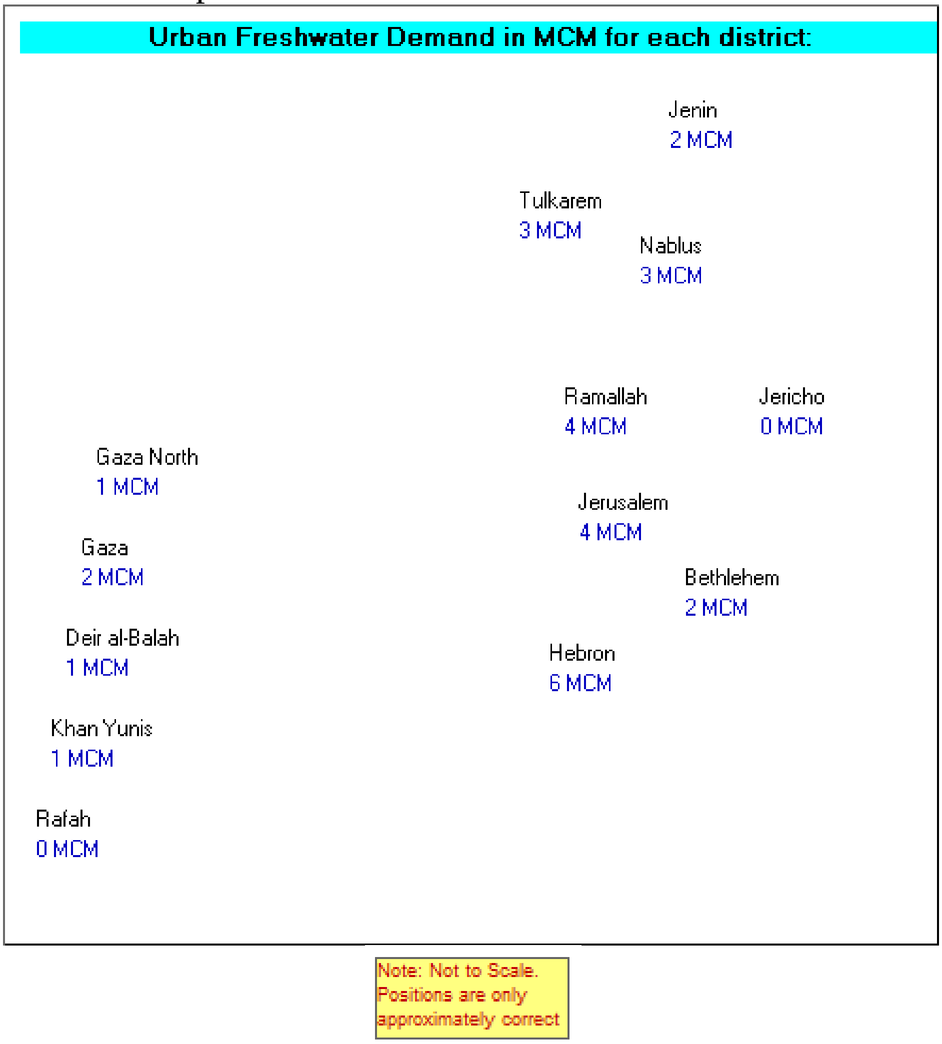

Figure 3.4: Urban freshwater demand quantities in million cubic meter for each governorate in West Bank and Gaza Strip.

To demonstrate the results of urban freshwater demand quantities, observe the results of shadow prices for each governorate in figure 3.2 above. For example, the shadow price for Jenin governorate is $2.470/m³, which meet urban freshwater demand quantity of 2 MCM as shown in figure 3.4. The shadow price for Nablus governorate is $3.496/m³, which meet urban freshwater demand quantity of 3 MCM as shown in figure 3.4. Conversely, the shadow price for Hebron governorate is $1.094/m³, which meet urban freshwater demand quantity of 6 MCM as shown in figure 3.4. The shadow price for Tulkarem governorate is $1.354/m³, which meet urban freshwater demand quantity of 3 MCM as shown in figure 3.4. This interpret that the household of Hebron and Tulkarem governorates willing to pay for more urban freshwater demand quantity than the household in Jenin and Jerusalem governorates.

Quantity supplied to agricultural use for each governorate in the West Bank and Gaza Strip are shown in figure 3.5 below.

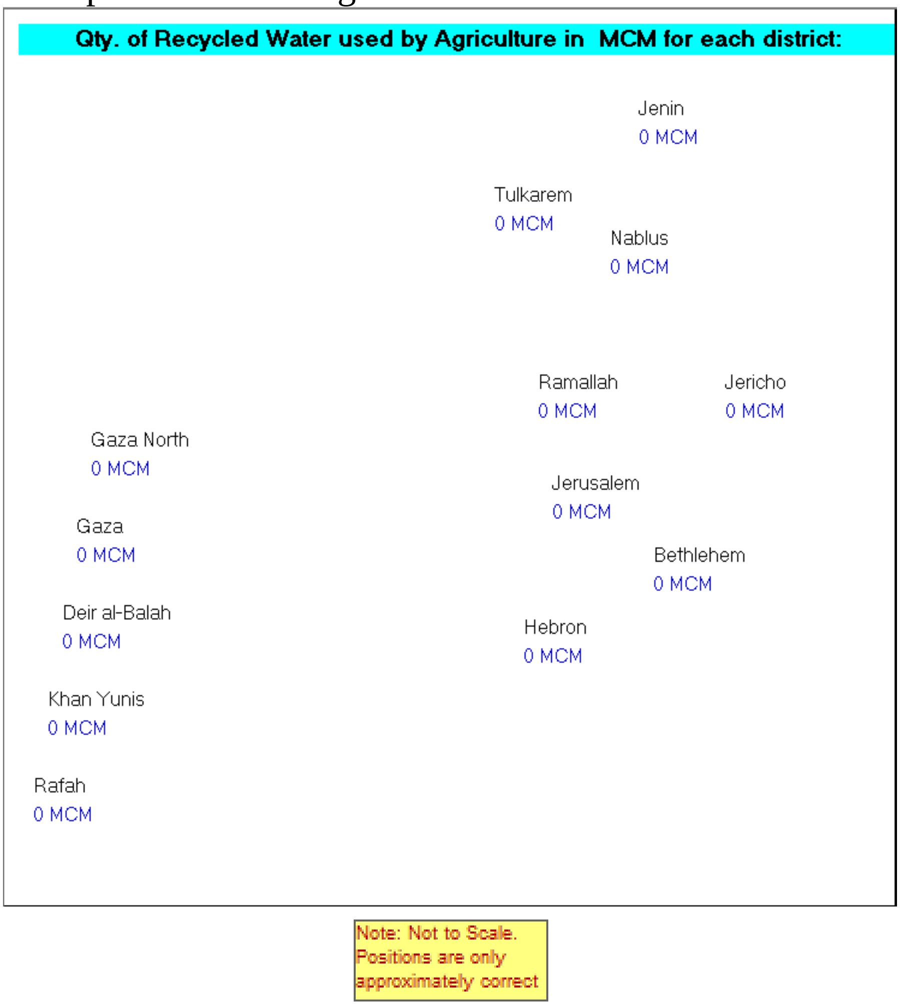

Figure 3.5: Quantity supplied to agricultural use for each governorate in the West Bank and Gaza Strip.

The results of run in the Water Allocation System (WAS) Model include the government costs for each governorate in the West Bank and Gaza Strip, which considered as a result of testing the implications of the social policies including, fixed price policy, subsidy/tax amount, and subsidy/tax percentage tools. However, in the run of base year 2015 current condition the government costs for each governorate in the West Bank and Gaza Strip are zeros.

The amount of government cost is zero for each governorate since there is no social policy applied in Palestine in 2015 current condition.

The two main messages that came out of the results are:

1. Shadow prices for all Governorates are relatively high and are extremely high in Jenin and Nablus in particular which reflects the facts on ground that Palestinians in West Bank in reality are living under water crisis especially in the Governorate of Nablus.
2. The model in general reflects the facts on ground and can be used to develop future water scenarios.

Chapter Four

Model Development for The Palestinian Water Sector Strategy Plan

4.1 Introduction

The Water Allocation System (WAS 3.6) has been used to assess the Palestinian water sector strategy plan. Model validation was calibrated using data that presented in the Palestinian Water Authority (PWA) water tables in addition to data from Palestinian Electricity Regulatory Council (PERC) and other data and assumptions used for the model. The run was prepared that reflects the future condition for the year 2030 using existing energy prices.

This chapter compare the results of the run for future condition for the year 2030 with the proposed quantities and prices in the Palestinian water sector strategy plan.

4.2 Future Scenario for the year 2030

This section describes the set of data and assumptions used to develop the regional run for the year 2030 for Palestine. These data and assumptions are summarized below:

4.2.1 Population Data

The 2030 population used in the Palestinian Water Sector Strategy was also used here.

The average growth rate for the population of Palestine for the last ten years has been increasing at a very high rate: 3.5%/year (PCBS, 2010).

So, in 2030 the West Bank will has a population of 5,692,267 and Gaza Strip has a population of 2,973,739 with a total of 8,666,007 million Capita.

Table 4.1: Population Data for the year 2030.

Governorate	**Population**
Jenin	619,958
Nablus, Tubas and Salfit	1,033,226
Tulkarem and Qalqilia	590,652
Jericho	103,231
Ramallah	686,372
Jerusalem	852,459
Bethlehem	428,610
Hebron	1,377,759
Gaza North	582,572
Gaza	1,030,342
Dier Al-Balah	431,888
Khanyunis	562,211
Rafah	366,727

4.2.2 Demand Elasticity

Demand elasticity varies between sectors. For the year of 2030, demand elasticity is taken as follows:

Agricultural Demand Elasticity 0.5

Urban Demand Elasticity 0.33

Industrial Demand Elasticity 0.33

4.2.3 Demand Multipliers

The demand multipliers used to reflect the 2030 demands using the present 2015 demands are

Agricultural Demand Multiplier 2.0

Urban Demand Multiplier 1.6

Industrial Demand Multiplier 1.33

4.2.4 Supply Steps

The available supply of water for the Different Governorate is based on the PWA water strategy in addition to the possibility of further desalination capacities if proven feasible. These supply quantities are shown below:

Table 4.2: The Available Supply of Water for the Different Governorates.

Governorate	Wells Supply in Mcm/year	Springs Supply in Mcm/year	Mekorot Supply in Mcm/year	Jordan River and Harvesting in Mcm/year	Desalination in Mcm/year	Reuse in Mcm/year
Jenin	5.2	0.5	3.0	76.5	0	10
Nablus, Tubas and Salfit	13.7	6.0	12.5	136.7	0.5	26
Tulkarem and Qalqilia	33.6	0.0	1.9	9	0	9
Jericho	12.7	28.6	2.6	108	0.8	6
Ramallah	2.5	4.6	21.3	2.5	0	8
Jerusalem	0.0	0.0		1	0	5
Bethlehem	5	0.6	22.5	2.5	0	6
Hebron	10.6	0.4		2.5	0	23
Gaza Strip	167.2	0.0	6.4	0	129	99

4.2.5 Supply Multipliers

All supply multipliers are set at 1.0.

4.2.6 Total Losses

The Palestinian Water Authority prepared strategy of reduce the loss of water that are non-accountant, which includes both of technical losses and administrative losses, and so to reduce water losses we need to expensive projects, such as change of networks and counters, and redistribution of water through municipal water departments (PWA, 2015).

The percentage of water loss is expected to diminish from 38% to 15%, so the value of 0.15 was used to input in the intra-district leakage in the WAS model.

4.2.7 Water Cost

The cost of producing water at the source for the year of 2030 is taken based on interviews with Palestinian Water Authority experts as follows:

Mekorot Water at 0.7 US$/$m^3$

Spring Water at 0.2 US$/$m^3$

Groundwater wells in West Bank at 0.5 US$/$m^3$

Groundwater wells in Gaza at 0.2 US$/$m^3$

Reuse treated wastewater at 0.1 US$/$m^3$

Desalination water at 0.509 US$/$m^3$ for the 129 Mcm/year plant and 0.7 US$/$m^3$ for smaller scale plants, table 4.3 below summarize the costs of different water sources in The West Bank and Gaza Strip.

Table 4.3: Water Costs in West Bank and Gaza Strip for 2030.

Region	Supply Source	Cost (US$/ m^3)
West Bank	Mekorot	0.7
	Spring	0.2
	Groundwater wells	0.5
	Reuse treated wastewater	0.1
Gaza Strip	Mekorot	0.7
	Spring	0.2
	Groundwater wells	0.2
	Reuse treated wastewater	0.1
	Desalination for the 129 MCM/year plant	0.509
	Desalination for smaller scale plant	0.7

4.2.8 Additional Infrastructure

For the year 2030, the following infrastructure was added to the existing conditions of 2015:

- Reuse schemes were added to all treated wastewater plants included in the PWA water strategy.
- Desalination plants were added in all Gaza Strip governorates in addition to the proposed 129 Mcm/year desalination Plant in Gaza.
- Conveyance systems are included between the different Governorates.

According to the Palestinian Water Sector Strategy (P.W.S.S), the strategic objectives for the year 2030 as a long term strategy states to treat 60% of wastewater for agriculture irrigation in the West Bank governorates, and 50% of wastewater for agriculture irrigation in the Gaza Strip governorates (Palestinian Water Sector Strategy, 2014).

These percentages was inputted in the WAS model as maximum percentage to be treated in the recycling plants for each governorate. On the other hand, the cost of treating one cubic meter is 0.1$, according to interviews with wastewater treatment plants experts.

The infrastructure including the fresh water links between the governorates of Palestine. The links input in WAS model through define the origin of the water link, the destination that the water will reach. Moreover, the cost of transport and conveyance capacity added to the WAS model. The cost of pumping water can be calculated as

$$C = [\ (\frac{\gamma\, Q\, h}{1000})/3600\ ] \times c \tag{4.1}$$

where

C = cost per cubic meter (USD)

Q = volume flow (1 m^3)

h = head (m)

c = cost rate per kWh (USD/kWh), which is equal 0.1367 USD according to the article 8 in the tariff of council of ministers decision in January, 2017.

The calculation of head requires the difference in elevation between the two governorates in meter; the origin and the destination, which called ΔZ. And therefore, the head loss (hL) in meter as:

$h = \Delta Z + hL$, and

$$hL = \frac{f\, L}{d}\, \frac{1}{2g\, A^2} \tag{4.2}$$

Where,

f = friction factor.

L = the length of the pipe in meter.

d = diameter of the pipe in meter.

A = cross section- area of the pipe in square meter. We can substitute the fraction of $\frac{f}{d\ 2g\ A^2}$ as a constant equal 0.01. Figure 4.1 below shows the distances between the Palestinian governorates in Kilo-meter.

	Jerusalem	Hebron	Jericho	Bethlehem	Beit Sahour	Beit Jala	Ramallah	Nablus	Jenin	Tulkarem	Qalqilia	Gaza	Rafah	Khan Yunis	Deir Al-Balah
Jerusalem															
Hebron	34														
Jericho	38	70													
Bethlehem	13	24	47												
Beit Sahour	14	26	49	1.5											
Beit Jala	14	25	38	2	3										
Ramallah	19	54	31	30	32	31									
Nablus	67	101	70	77	79	78	50								
Jenin	112	143	109	122	124	123	93	43							
Tulkarem	99	134	99	111	113	112	80	29	52						
Qalqilia	102	146	102	122	124	123	84	32	63	34					
Gaza	97	95	135	118	120	119	101	149	192	179	183				
Rafah	128	125	166	148	150	149	130	180	223	210	214	30			
Khan Yunis	120	116	158	139	141	140	122	172	215	202	206	21	7		
Deir Al-Balah	112	107	150	130	132	131	114	164	207	194	198	12	17	9	

Figure 4.1: Distances between Palestinian Governorates.

Table 4.4 below shows the details of fresh water links and cost of transport and conveyance capacity.

Table 4.4: Details of fresh water links and cost of transport and conveyance capacity.

Origin	Destination	Cost of Transport From Origin to Destination (USD/m^3)	Max. Transport From Origin to Destination	Leakage from Destination To Origin	Transport Cost from Destination To Origin (USD/m^3)	Max. of Transport from Destination To origin
Jenin	Tulkarem	0.129	999	0	0.259	999
Jenin	Nablus	0.253	999	0	0.067	999
Tulkarem	Jenin	0.259	999	0	0.129	999
Tulkarem	Nablus	0.266	999	0	0.050	999
Nablus	Jenin	0.067	999	0	0.253	999
Nablus	Tulkarem	0.050	999	0	0.266	999
Nablus	Ramallah	0.298	999	0	0.075	999
Nablus	Jericho	0.037	999	0	0.559	999
Ramallah	Nablus	0.075	999	0	0.298	999
Ramallah	Jerusalem	0.115	999	0	0.089	999
Jericho	Nablus	0.559	999	0	0.037	999
Jerusalem	Ramallah	0.089	999	0	0.115	999
Jerusalem	Bethlehem	0.035	999	0	0.061	999
Bethlehem	Jerusalem	0.061	999	0	0.035	999
Bethlehem	Hebron	0.168	999	0	0.011	999
Hebron	Bethlehem	0.011	999	0	0.168	999
Hebron	Gaza North	0.001	999	0	0.685	999
Gaza North	Hebron	0.685	999	0	0.001	999
Gaza North	Gaza	0.008	999	0	0.016	999
Gaza	Gaza North	0.016	999	0	0.008	999
Gaza	Deir Al-Balah	0.058	999	0	0.032	999
Deir Al-Balah	Gaza	0.032	999	0	0.058	999
Deir Al-Balah	Khan Yunis	0.032	999	0	0.035	999
Khan Yunis	Deir Al-Balah	0.035	999	0	0.032	999
Khan Yunis	Rafah	0.016	999	0	0.036	999
Rafah	Khan Yunis	0.036	999	0	0.016	999

Yellow	Connection exists from origin to destination.
Green	Connection exists from destination to origin.
Pink	Connection exists between origin and destination both ways.

4.3 Discussion of Results

Based on the above data that inputted to the model, the WAS model was run, the shadow values in $/m³ for each governorate resulted in schematic presentation, figure 4.1.a shows the shadow values in $/m³ for each governorate in the West Bank and Gaza Strip before leakage, figure 4.1.b shows the shadow values in $/m³ for each governorate in the West Bank and Gaza Strip after leakage.

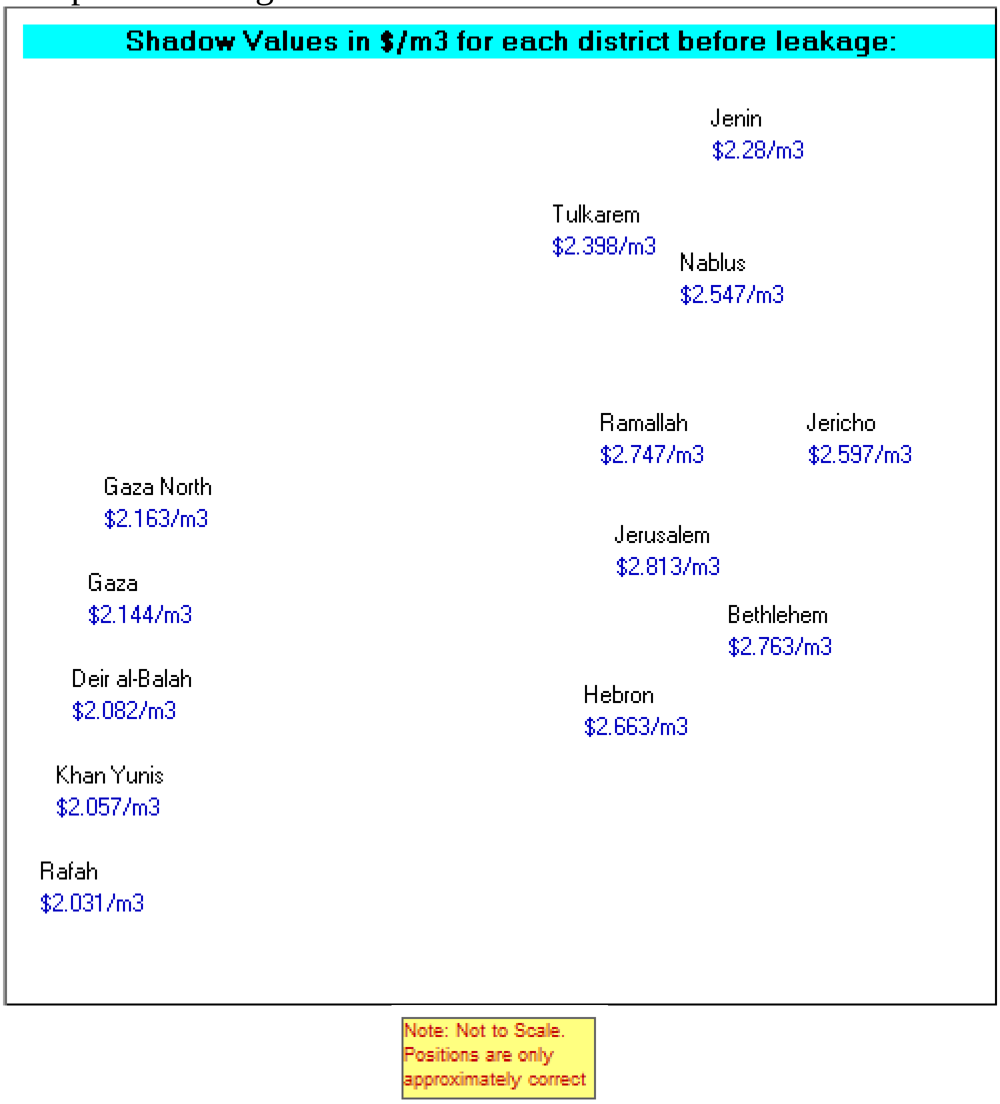

Figure 4.1.a: Shadow values for each governorate in West Bank and Gaza Strip for 2030 before leakage.

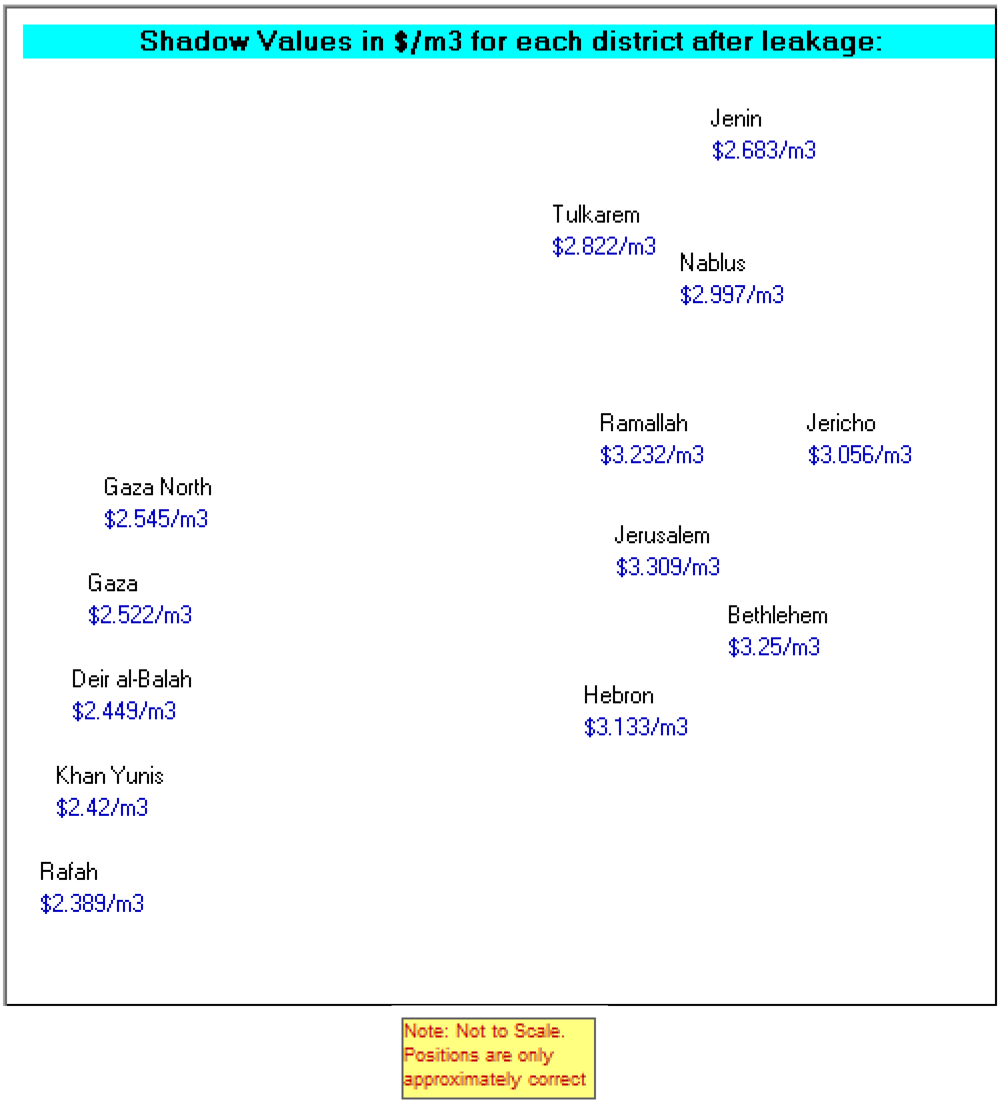

Figure 4.1.b: Shadow values for each governorate in West Bank and Gaza Strip for 2030 after leakage.

Freshwater links between the adjacent governorates of the West Bank and Gaza Strip was added in the current run, as additional infrastructure for the long term for the year 2030 to enable the Palestinian to achieve the optimal utilization of potential water resources. Trade of water between these governorates reduce the high shortages of water in some governorates as Jenin, and Jerusalem. Table 4.5 below shows the results of linkages used and quantities transported for optimal transport of fresh water in MCM and costs in $/m³ for the governorates in the West Bank and Gaza Strip.

Table 4.5: Linkages used and quantities transported for optimal transport of fresh water for the governorates in the West Bank and Gaza Strip for 2030.

From	To	Quantity (MCM)	Cost ($/m³)
Jenin	Tulkarem	175.72	0.1180
Tulkarem	Nablus	154.90	0.1490
Nablus	Ramallah	36.00	0.2000
Nablus	Jericho	46.35	0.0500
Bethlehem	Jerusalem	41.08	0.0500
Hebron	Bethlehem	58.89	0.1000
Gaza North	Hebron	71.73	0.5000
Gaza	Gaza North	38.91	0.0190
Deir Al-Balah	Gaza	4.49	0.0620
Khan Yunis	Deir Al-Balah	5.71	0.0250
Rafah	Khan Yunis	3.53	0.0260

According to the demand curve, as the price decreases the demand quantity increases, in this scenario the willing of household to pay for quantity of water (Q*) is higher than it in the previous scenario in chapter three. Figure 4.2 below shows the results of run the model as urban freshwater demand in MCM for each governorate in the West Bank and Gaza Strip.

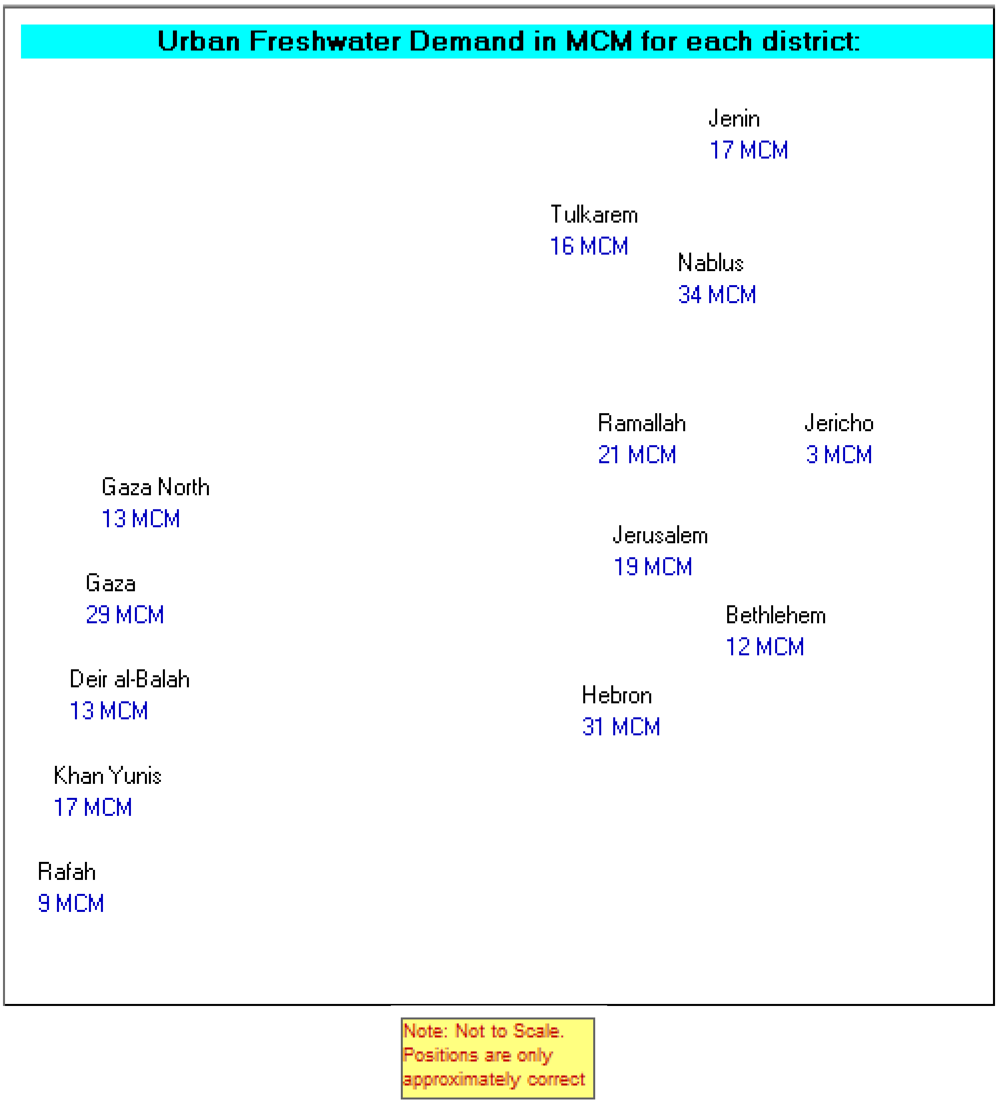

Figure 4.2: Urban freshwater demand quantities in million cubic meter for each governorate in West Bank and Gaza Strip for 2030.

The Palestinian water sector strategy plan aims to treat 60% of the wastewater of the West Bank governorates, and 50% of the wastewater of the Gaza Strip governorates by construct many of wastewater treatment plants in Palestine by the year 2032, the WAS model infrastructure includes the recycling plants and the cost of treated cubic meter in US$.

The results of the current scenario shows the quantity of recycled water used by agriculture in MCM for each governorates in the West Bank and Gaza Strip as shown in figure 4.3 below.

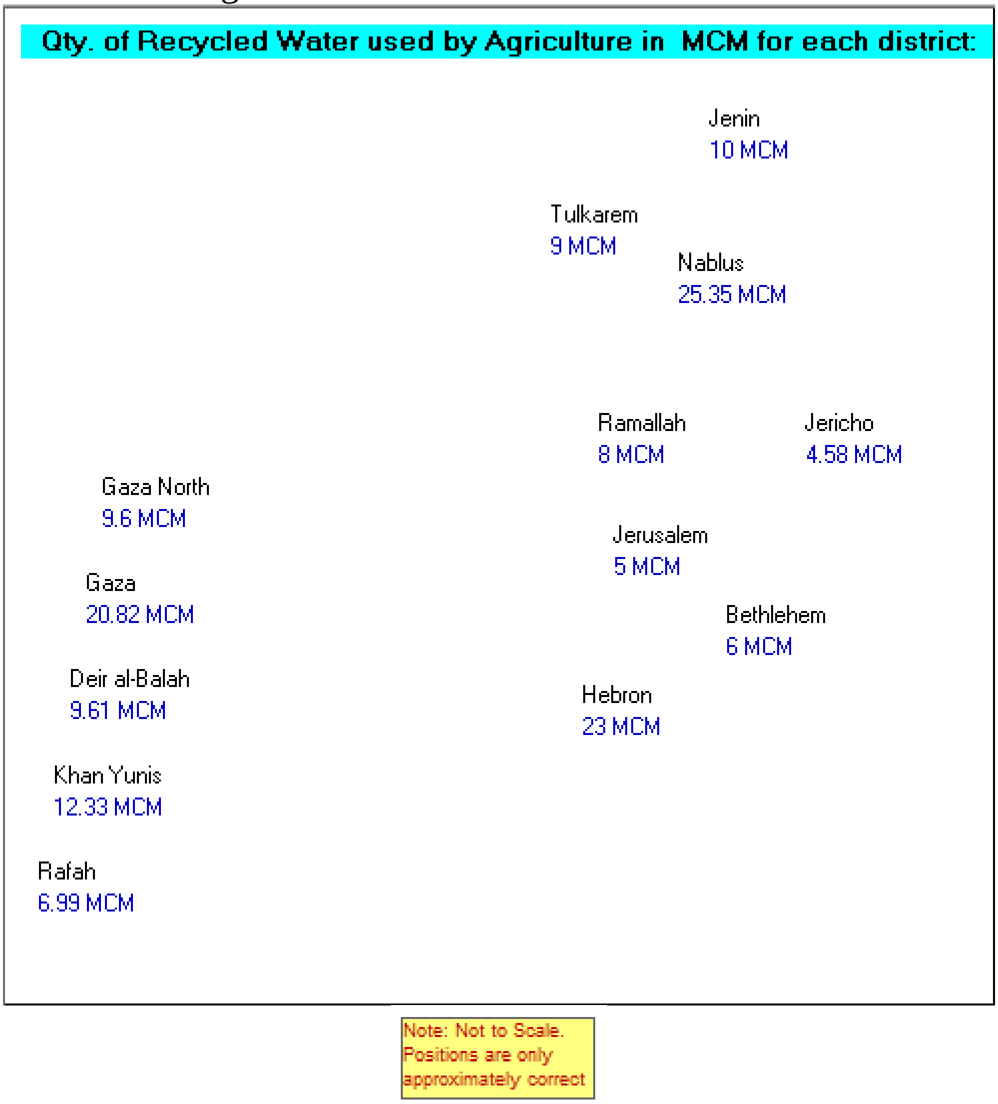

Figure 4.3: Quantity supplied to agricultural use for each governorate in the West Bank and Gaza Strip for 2030.

As obtained from the P.W.S.S the desalination quantities was entered in water supply in the WAS model, the quantities produced from the desalination plants are shown in table 4.6 below.

Table 4.6: Quantities produced from the desalination plants as obtained from the P.W.S.S for 2030.

Governorate	**Quantity Produced (MCM)**	**Cost ($/m³)**
Jericho	1	0.70
Gaza North	26	0.51
Gaza	44	0.51
Deir Al-Balah	19	0.51
Khan Yunis	24	0.51
Rafah	16	0.51

Social welfare from schematic results of WAS Program shows both the Profits in M$ and the government costs in M$ for each governorate of the West Bank and Gaza Strip. Figure 4.4.a and figure 4.4.b below shows the profits in M$ and government costs in M$ respectively, for each governorates in the West Bank and Gaza Strip.

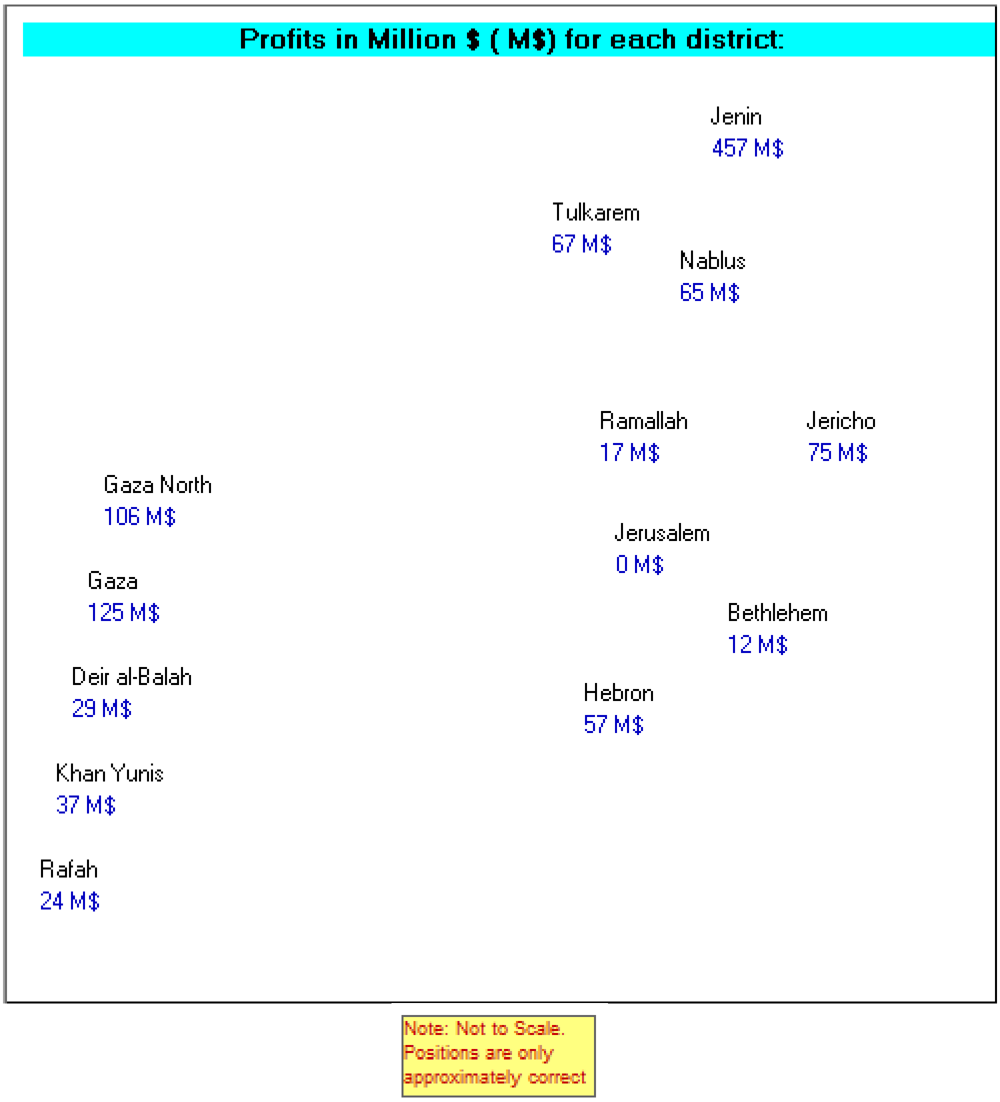

Figure 4.4.a : Profits for each governorate in the West Bank and Gaza Strip for 2030.

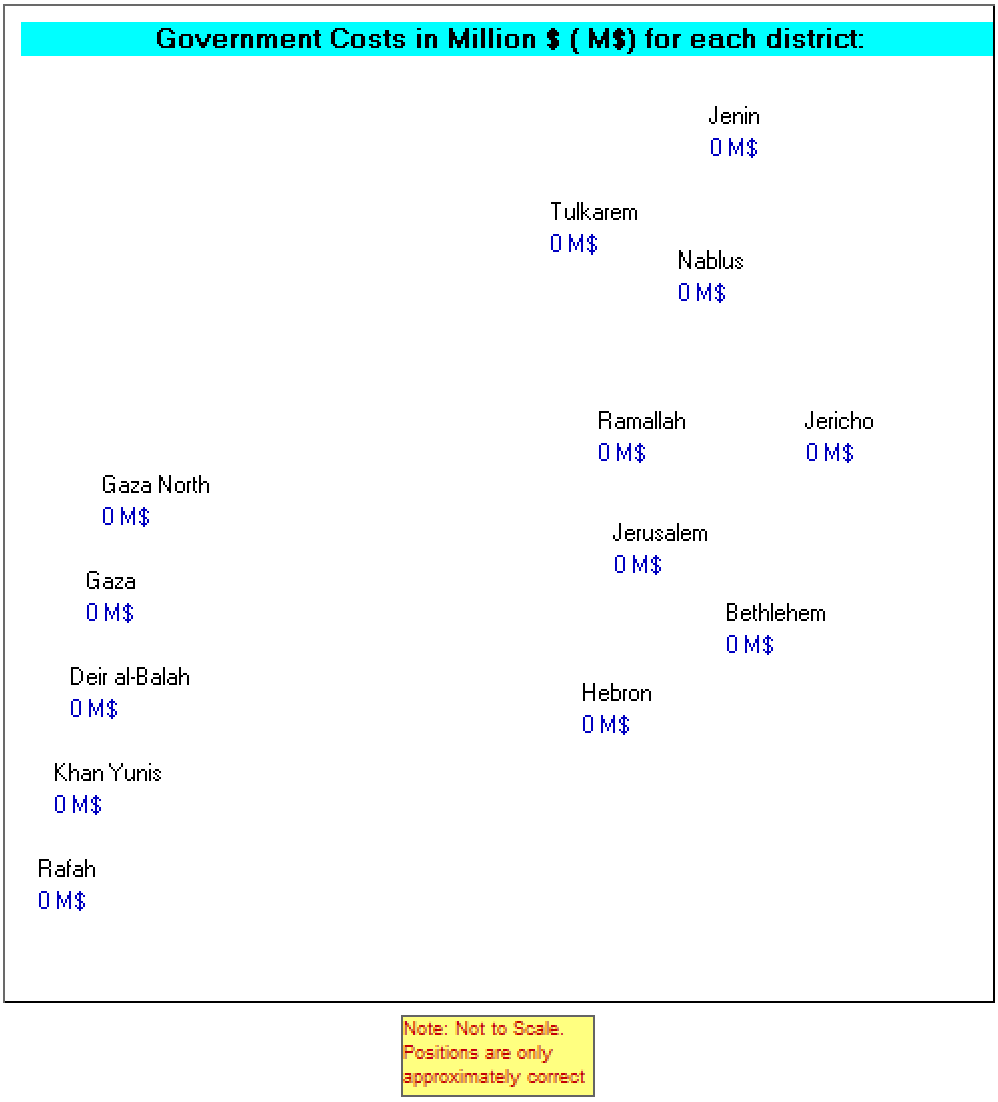

Figure 4.4.b : Government Costs for each governorate in the West Bank and Gaza Strip for 2030.

4.3.1. P.W.S.S and Quantities of Desalination for Supply Compare

As the model run and determine the quantities of desalination to be produced form desalination plants, the results are shown in table 4.7 below.

Table 4.7: Quantities produced from the desalination plants as the model run and determine the quantities of desalination for 2030.

Governorate	Quantity Produced (MCM)	Cost ($\$/m^3$)
Jericho	1	0.70
Gaza North	410	0.51
Gaza	35	0.51
Deir Al-Balah	36	0.51
Khan Yunis	36	0.51
Rafah	22	0.51

Table 4.8 below shows the results of linkages used and quantities transported for optimal transport of fresh water in MCM and costs in $\$/m^3$ for the governorates in the West Bank and Gaza Strip.

Table 4.8: Linkages used and quantities transported for optimal transport of fresh water for the governorates in the West Bank and Gaza Strip for 2030.

From	To	Quantity (MCM)	Cost ($\$/m^3$)
Nablus	Tulkarem	35.09	0.0530
Nablus	Jericho	69.33	0.0500
Ramallah	Nablus	210.93	0.2520
Jerusalem	Ramallah	268.64	0.0770
Bethlehem	Jerusalem	329.01	0.0500
Hebron	Bethlehem	360.57	0.1000
Gaza North	Hebron	394.36	0.5000

The following figures shows the comparing between the results of desalination quantities as obtained from the P.W.S.S in red and the desalination quantities that resulted from the run of WAS model in blue.

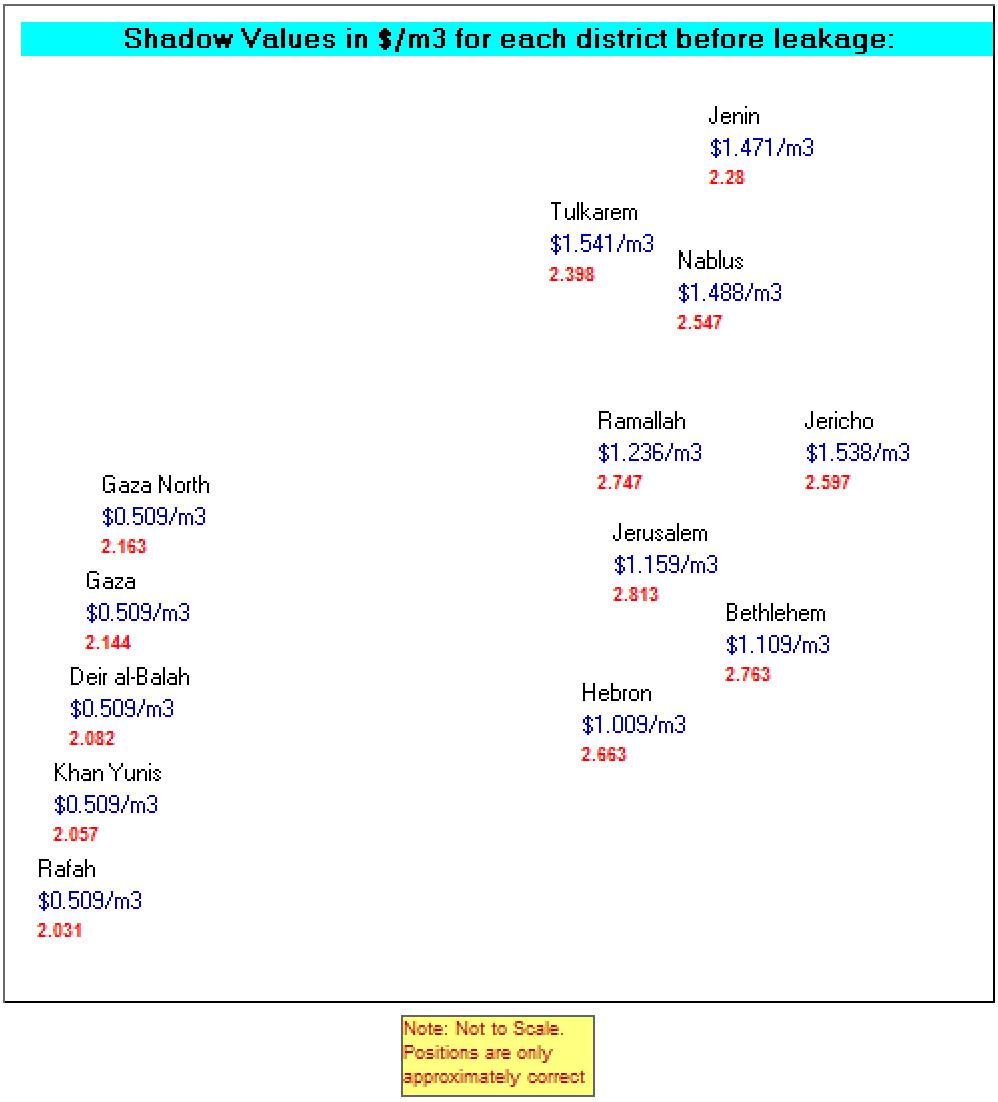

Figure 4.5: Shadow prices comparison for each governorate in West Bank and Gaza Strip for 2030 before leakage.

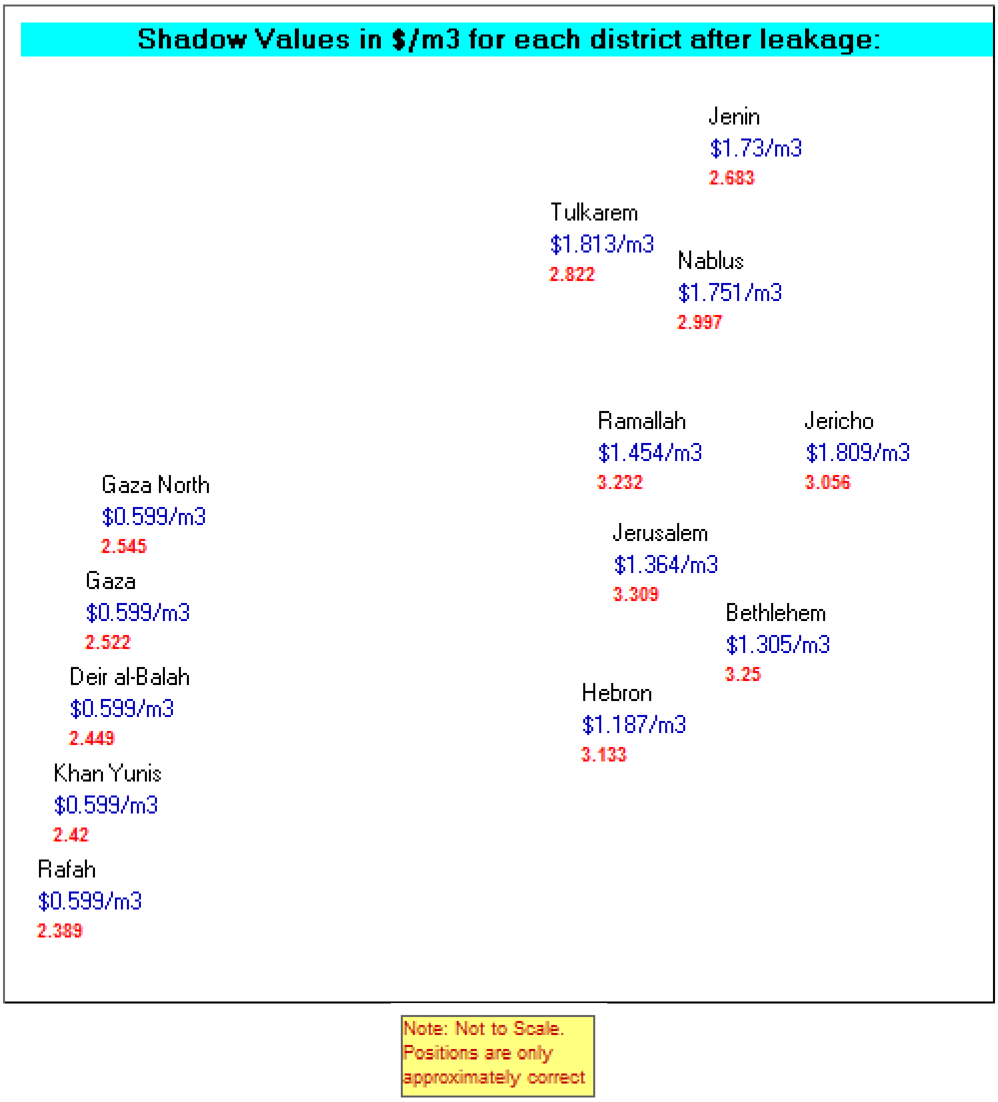

Figure 4.6: Shadow prices comparison for each governorate in West Bank and Gaza Strip for 2030 after leakage.

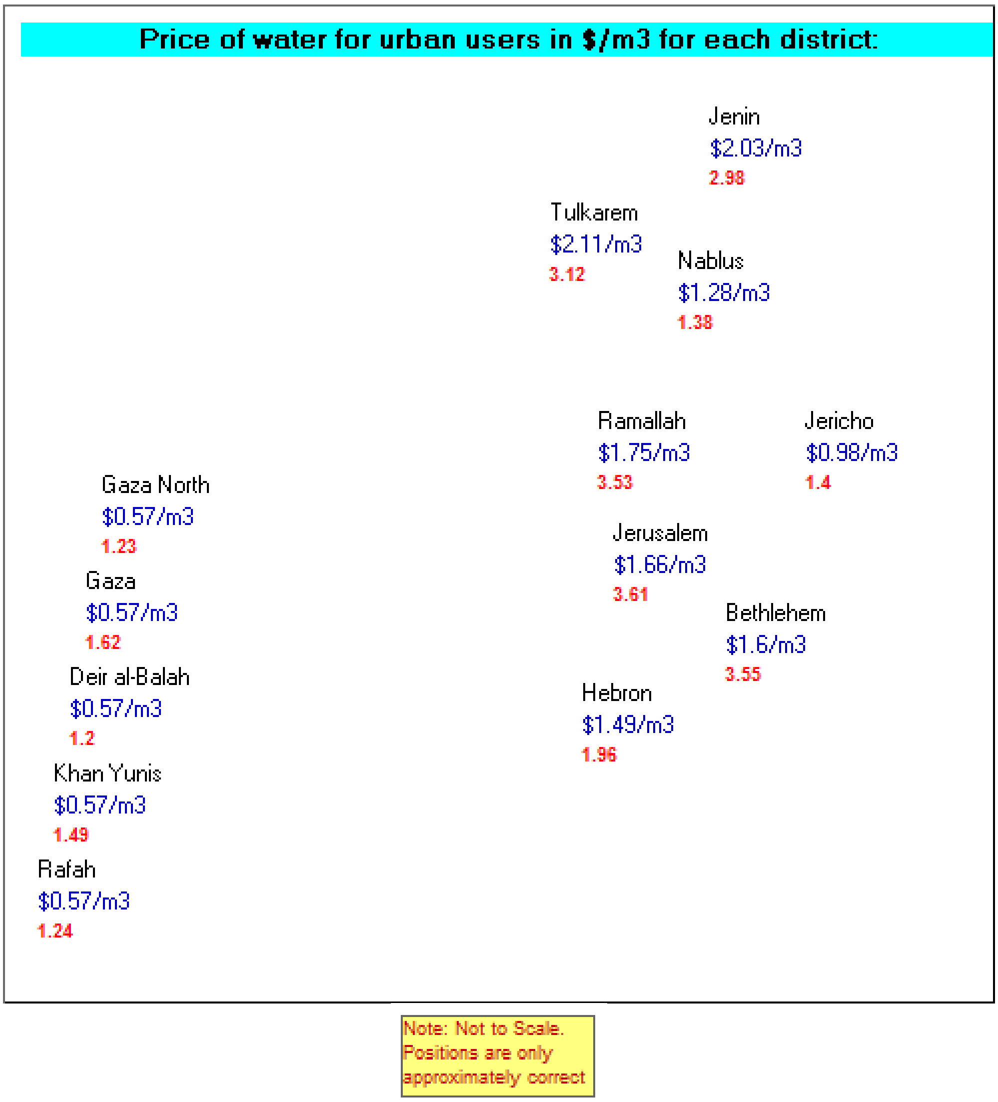

Figure 4.7: Price of water for urban users comparison for each governorate in West Bank and Gaza Strip for 2030 after leakage.

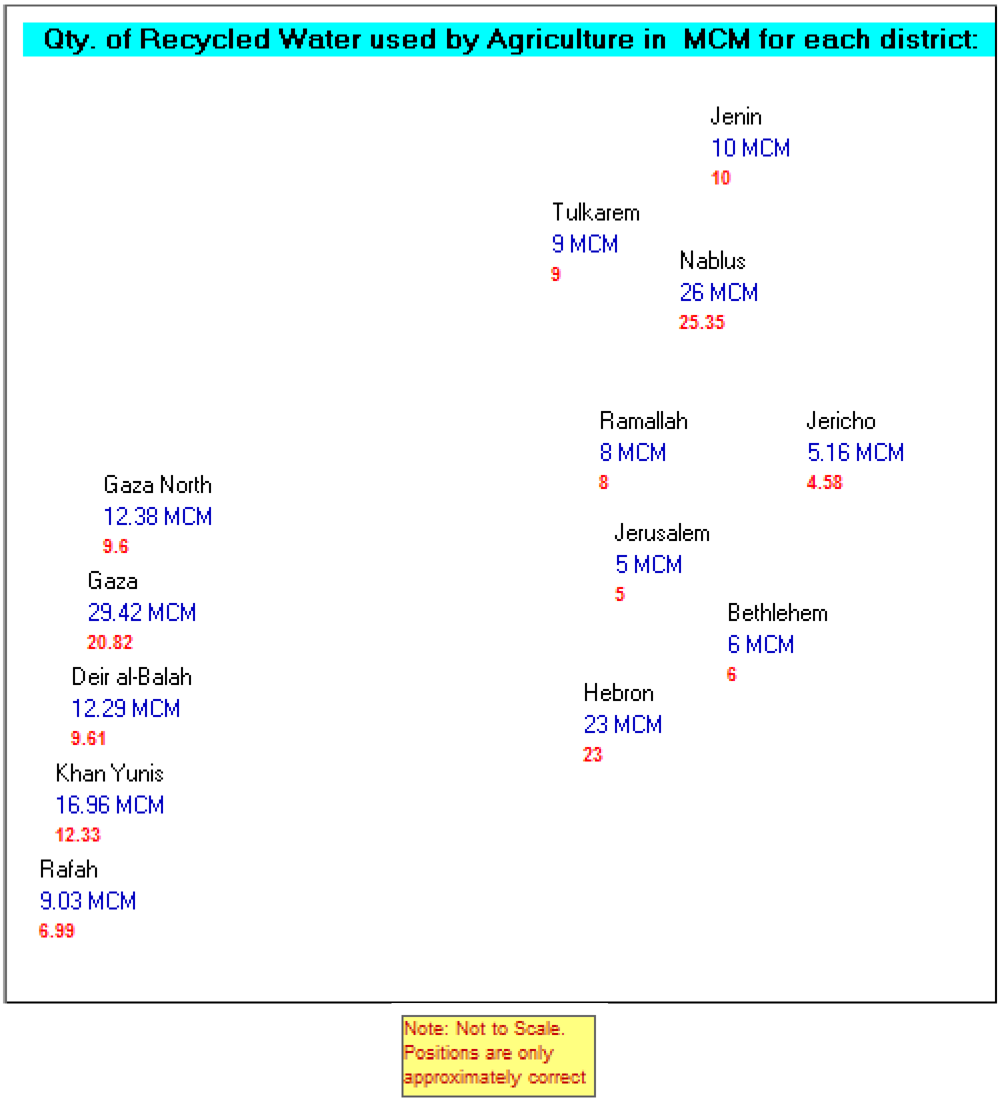

Figure 4.8: Quantity supplied to agricultural use comparison for each governorate in the West Bank and Gaza Strip for 2030**.**

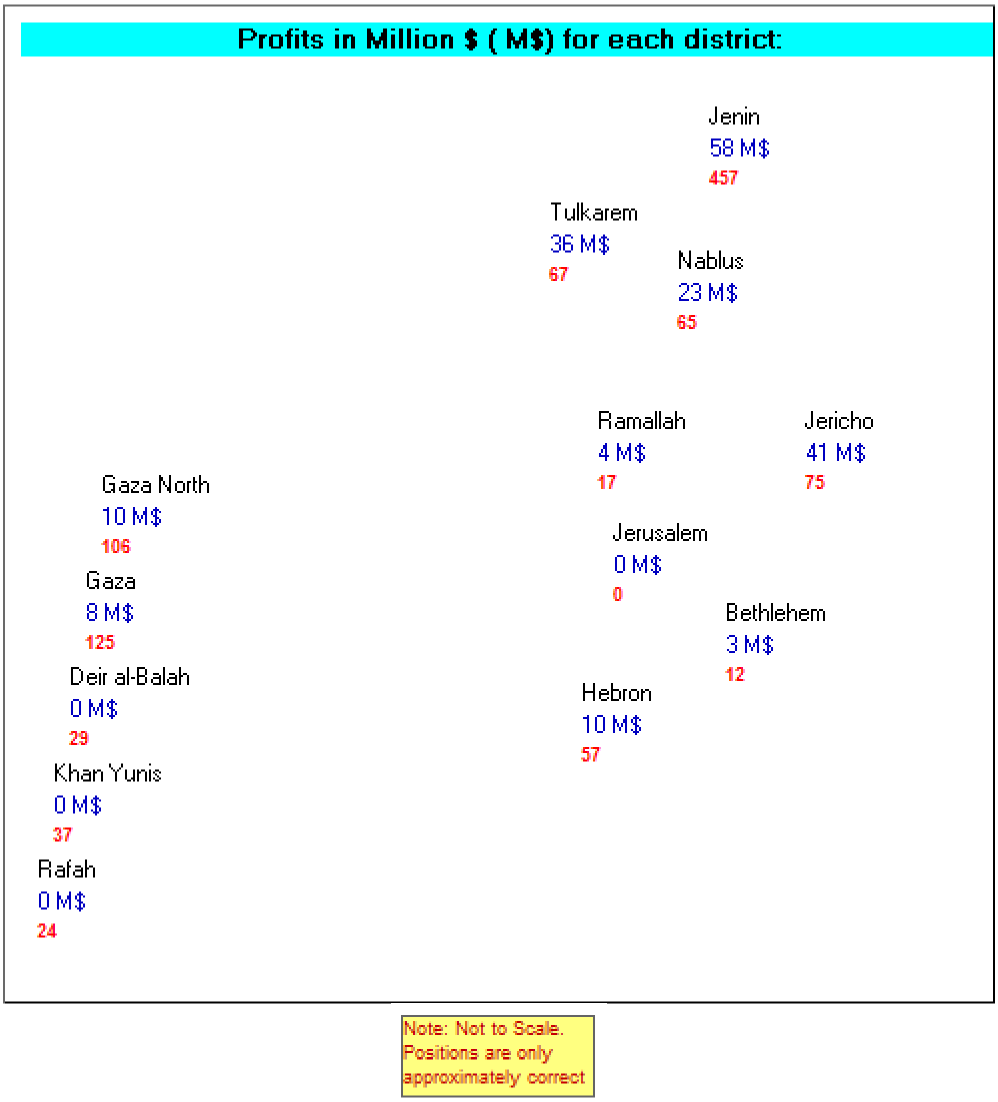

Figure 4.9 : Profits comparion for each governorate in the West Bank and Gaza Strip for 2030.

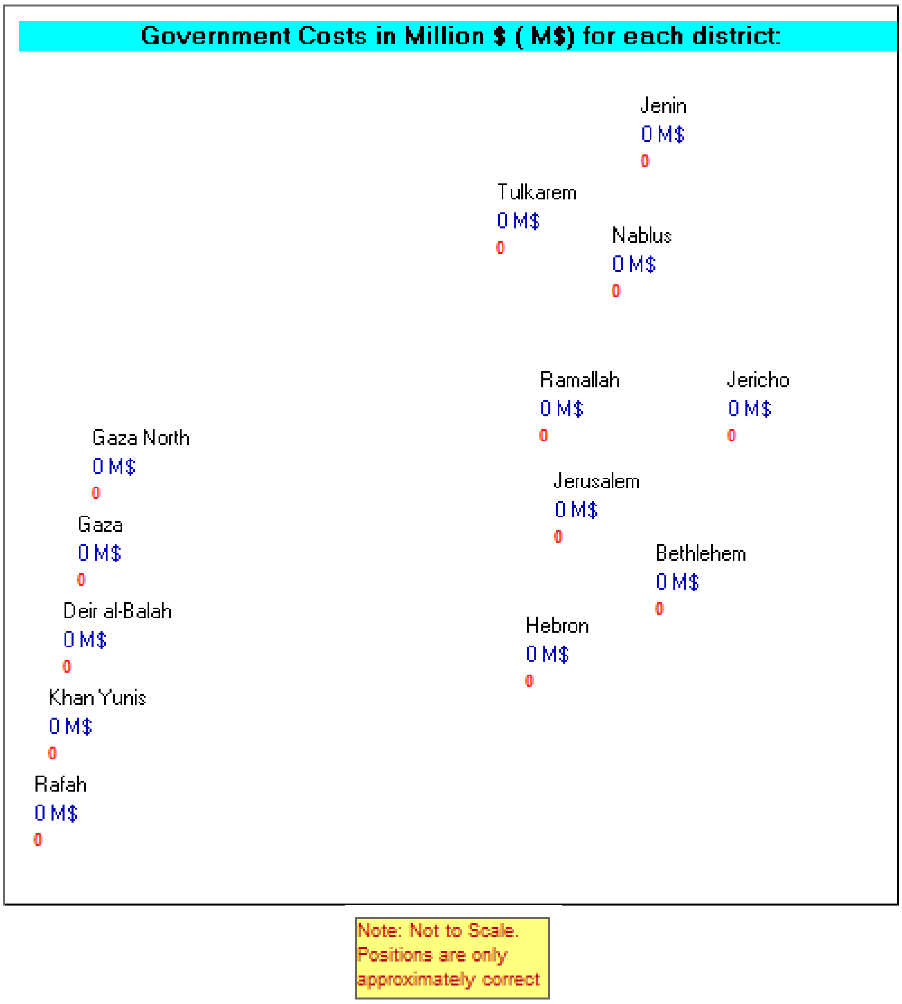

Figure 4.10 : Government costs comparison for each governorate in the West Bank and Gaza Strip for 2030.

Based on all the above, the model was developed and results were obtained. The two main messages that came out of the results regarding the Palestinian water sector are:

1. Shadow prices for all Governorates are reasonable and affordable under the new quantity of desalination.
2. The quantity of desalination in P.W.S.S is 130 MCM for the year 2030, while it was found to be 540 MCM for the year 2030 as resulted from the WAS model run.

Chapter Five

Model Development Under Different Energy Sources

5.1 Introduction

Water uses enormous amounts of energy; supply and conveyance, wastewater collection and treatment, water treatment, distribution, and wastewater discharge. On the other hand, energy uses enormous amounts of water; thermo electric cooling, hydropower, extraction and refining, and fuel production.

World energy consumption will increase with increasing population. Figure 5.1 shows world energy consumption between 1975 and 2025 with the increasing of the population.

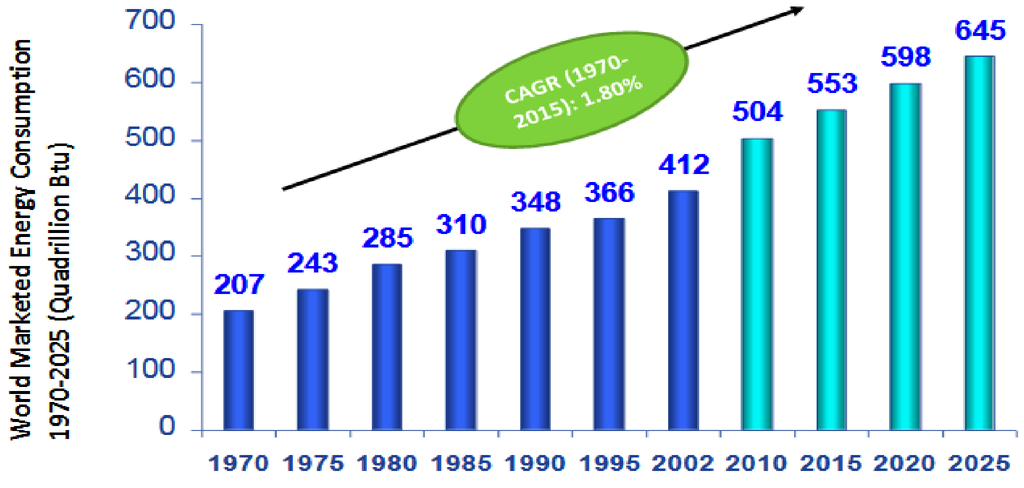

Figure 5.1: Energy consumption with the increasing of the population, 1975-2025.

CAGR= Compounded Annual Growth Rate

Source: EIA International Energy Outlook, 2005.

5.2 Water Energy Nexus

Water uses in energy production. Water uses in power generation, for cooling thermal power plants; it is used in the extraction, transport and processing of fuels, and in large amounts in irrigation to grow biomass feedstock crops. Freshwater providing depends on energy, it is needed to power systems, since the power systems collect, transport, distribute and treat freshwater.

Using water for energy production impact freshwater resources, affecting their availability and the quality, which represents the physical and chemical properties. Moreover, the water services depend on the on the availability of energy which is vital to provide clean drinking water and sanitation services, (Water energy outlook, 2017).

In this chapter we will apply renewable energy, and gas as energy sources in the West Bank and Gaza Strip to evaluate the feasibility of water-energy nexus.

5.3 Using Renewable Energy to Pump Water

Renewable energy serve to reduce air pollution and save money. Renewable energy sources are active in reducing the consumption of the conventional energy sources and the environmental impacts that may result from it for water pumping applications (Gopal et.al, 2013).

5.3.1 Wind

Connective currents that created by the sun’s rays develop the wind which form global air circulation across the surface of the Earth. The Earth surface heat when the solar radiation reach it, and reflection heats the surrounding air. Warm air differ than cool air that is less dense, it rises and cool air descends. While wind is calm in the morning, it is stronger in the afternoon. Spring is usually windy and summer is calm. Near the shores of lakes and along the coast, winds are stronger than any elsewhere because of unobstructed paths and sea-to-land breezes. As height increased above earth surface wind speed varies. Wind machine affects with turbulence. So, turbulence could shorten its life. The location of wind machine should be selected to be away from zone of distributed flow (Argaw et.al, 2003).

5.3.2 Solar

Solar energy is the cornerstone for all energy forms. Wind, ocean thermal energy, hydropower, biomass, and tidal energy are indirect forms of solar energy. Solar-thermal electric power generation, Crop drying, solar heat collection, and direct conversion of solar energy into electricity are direct forms. To convert solar energy directly into electricity we can use either PV cells or thermoelectricity (Argaw et.al, 2003).

Estimating Solar Energy Resources

Solar radiation data should be available and accurate to be used in the PV systems. Solar radiation depends on gross geographical features such as latitude, altitude, climate classification, prevailing vegetation, and geographical features. The availability of accurate solar radiation data are rare specially from remote locations where many PV systems are to be installed. So, many approaches have been developed for estimating solar radiation energy that based on commonly available satellite cloud cover data and sunshine hour or on direct measurements.

A pyrheliometer is an instrument usually used to measure the direct beam solar radiation. However, a pyranometer is usually used to measure the global solar radiation. These instruments depends on measuring the intensity of solar radiation directly when the electrical characteristics change in the presence of solar radiation, and they are categorized as photoelectric devices (Argaw et.al, 2003).

Based on personnel interviews, the cost of supply and installation of kilowatt hour reach 3,000 USD. In Palestine; one kilowatt produce 1750 kW/h annually, assume that the loss in electricity and maintenance per year in the first ten years of the age of the system limit from the productivity of the one kilowatt to become net production per year 1575 kW/h, and in the second ten years to become 1400 kW/h per year, and in the last five years as the working life of the system is at least 25 years is 1225 kW/h per year. The kilowatt of electricity produce sum of 35875 kW/h within 25 years of its work. This means that the cost per kWh (if the system price of 1 kW is 3000 USD) is 0.085 USD (Grid Parity, 2012).

5.4 Natural gas supply

Natural gas was formed over hundreds of millions of years from organic matter, such as plankton, plants and other life forms, which is why it's sometimes referred to as a 'fossil fuel'.

In Palestine, the Palestinian energy authority and natural resources develop a plan for Gaza electricity development, which aims at and not only to mitigate the Gazan People suffering of electricity shortages, but also to develop an enough, efficient, reliable and sustainable electricity system that has the ability to meet all sectors' electricity current and future needs.

Gas for Gaza project is the driving engine for the conversion of the existing 140MW plant, and expansion plant to reach 550MW cap.

The current electricity feeding sources provide 230MW for Gaza Strip. However, the base actual demand is 360MW and peak actual demand is 450MW, that means there is shortage in base 130MW and in peak 220MW. The development plan in its phase two for three years aims to expand the plant to reach 800MW by the 2022 with total cost of 144.5 MUSD.

5.5 Calculations

In this chapter it was depended according to the Palestinian water sector strategy the solar energy as renewable energy resource for the desalination and water pumping in the West Bank, and the natural gas for desalination and water pumping in Gaza Strip. Calculations of renewable energy and natural gas costs as described below.

5.5.1 Solar Energy

Cost of Solar Energy (C_{SE}) = $\frac{0.1367}{2}$ USD/kWh + 0.085 USD/kWh = 0.1534 USD/kWh.

For desalination in the West Bank,

Cost of Desalination (C_{DE}) = $\frac{0.7}{2}$ USD/m³+ $\frac{0.7}{2}$ USD/m³ $\left(\frac{0.1534\ USD/kWh}{0.1367\ USD/kWh}\right)$ = 0.743 USD/m³.

For pumping in the West Bank,

Cost of pumping (C_{pu}) USD/m³ =

$$\text{Cost of transport USD/m}^3 \times \left(\frac{0.1534\ USD/kWh}{0.1367\ USD/kWh}\right)$$

Cost of pumping (C_{pu}) for the West Bank is shown in table 5.1 below.

Table 5.1: Details of fresh water links and cost of transport and conveyance capacity using solar energy for water pumping the West Bank.

Origin	Destination	Cost of Transport From Origin to Destination (USD/m³)	Max. Transport From Origin to Destination	Leakage from Destination To Origin	Transport Cost from Destination To Origin (USD/m³)	Max. of Transport from Destination To origin
Jenin	Tulkarem	0.14	999	0	0.29	999
Jenin	Nablus	0.28	999	0	0.008	999
Tulkarem	Jenin	0.29	999	0	0.14	999
Tulkarem	Nablus	0.30	999	0	0.06	999
Nablus	Jenin	0.008	999	0	0.28	999
Nablus	Tulkarem	0.06	999	0	0.30	999
Nablus	Ramallah	0.33	999	0	0.08	999
Nablus	Jericho	0.04	999	0	0.63	999
Ramallah	Nablus	0.08	999	0	0.33	999
Ramallah	Jerusalem	0.13	999	0	0.10	999
Jericho	Nablus	0.63	999	0	0.04	999
Jerusalem	Ramallah	0.10	999	0	0.13	999
Jerusalem	Bethlehem	0.04	999	0	0.07	999
Bethlehem	Jerusalem	0.07	999	0	0.04	999
Bethlehem	Hebron	0.19	999	0	0.01	999
Hebron	Bethlehem	0.01	999	0	0.19	999
Hebron	Gaza North	0.001	999	0	0.44	999

Yellow	Connection exists from origin to destination.
Green	Connection exists from destination to origin
Pink	Connection exists between origin and destination both ways

5.5.2 Natural Gas

According to the development plan of the Palestinian energy authority and natural resources for Gaza electricity development the cost of 800 MW production is 144,500,000 USD, and

800 MW = 7,008,000,000 kWh. So,

Cost per rate = $\frac{144{,}500{,}000\ USD}{7{,}008{,}000{,}000\ kWh}$ = 0.02 USD/kWh.

Cost of Gas (C_{gas}) = $\frac{0.1367\ USD/kWh}{2}$ + 0.02 USD/kWh = 0.0884 USD/kWh.

For desalination in Gaza Strip,

Cost of Desalination (C_{DE}) = $\frac{0.509}{2}$ USD/m³+ $\frac{0.509}{2}$ USD/m³ $(\frac{0.0884\ USD/kWh}{0.1367\ USD/kWh})$

= 0.419 USD/m³.

For pumping in Gaza Strip,

Cost of pumping (C_{pu}) USD/m³ =

Cost of transport USD/m³ × $(\frac{0.0884\ USD/kWh}{0.1367\ USD/kWh})$

Cost of pumping (C_{pu}) for Gaza Strip is shown in table 5.2 below.

Table 5.2: Details of fresh water links and cost of transport and conveyance capacity using natural gas for water pumping in Gaza Strip.

Origin	Destination	Cost of Transport From Origin to	Max. Transport From Origin to Destination	Leakage from Destination To	Transport Cost from Destination To Origin (USD/m³)	Max. of Transport from Destination To origin
Gaza North	Hebron	0.44	999	0	0.001	999
Gaza North	Gaza	0.005	999	0	0.01	999
Gaza	Gaza North	0.01	999	0	0.005	999
Gaza	Deir Al-Balah	0.04	999	0	0.02	999
Deir Al-Balah	Gaza	0.02	999	0	0.04	999
Deir Al-Balah	Khan Yunis	0.02	999	0	0.02	999
Khan Yunis	Deir Al-Balah	0.02	999	0	0.02	999
Khan Yunis	Rafah	0.01	999	0	0.02	999
Rafah	Khan Yunis	0.02	999	0	0.01	999

Yellow	Connection exists from origin to destination.
Green	Connection exists from destination to origin.
Pink	Connection exists between origin and destination both ways.

5.6 Future Scenario for the year 2030

This section describes the set of data and assumptions used to develop the regional run for the year 2030 for Palestine. These data and assumptions are summarized below:

5.4.1 Population Data

The 2030 population used in the Palestinian Water Sector Strategy was also used here. The population of each governorate was gathered from table 4.1 in chapter four.

5.4.2 Demand Elasticity

Demand elasticity varies between sectors. For the year of 2030, demand elasticity is taken as follows:

Agricultural Demand Elasticity	0.5
Urban Demand Elasticity	0.33
Industrial Demand Elasticity	0.33

5.4.3 Demand Multipliers

The demand multipliers used to reflect the 2030 demands using the present 2015 demands are

Agricultural Demand Multiplier	2.0
Urban Demand Multiplier	1.6
Industrial Demand Multiplier	1.33

5.4.4 Supply Steps

The available supply of water for the Different Governorate is based on the PWA water strategy in addition to the possibility of further desalination capacities if proven feasible. These supply quantities are shown in table 4.2 in chapter four.

5.4.5 Supply Multipliers

All supply multipliers are set at 1.0.

5.4.6 Total Losses

The percentage of water loss is expected to diminish from 38% to 15%, so I will use the value of 0.15 to input in the intra-district leakage in the WAS model.

5.4.7 Water Cost

The cost of producing water at the source is taken based on interviews with Palestinian Water Authority experts as follows:

Mekorot Water at 0.7 US$/$m^3$

Spring Water at 0.2 US$/$m^3$

Groundwater wells in West Bank at 0.5 US$/$m^3$

Groundwater wells in Gaza at 0.2 US$/$m^3$

Reuse treated wastewater at 0.1 US$/$m^3$

Desalination water at 0.419 US$/$m^3$ for Gaza Strip plants and 0.743 US$/$m^3$ for West Bank plants.

5.4.8 Additional Infrastructure

For the year 2030, the following infrastructure was added to the existing conditions of 2015:

- Reuse schemes were added to all treated wastewater plants included in the PWA water strategy.

- Desalination plants were added in all Gaza Strip governorates in addition to the proposed 129 Mcm/year desalination Plant in Gaza.
- Conveyance systems are included between the different Governorates.

According to the Palestinian Water Sector Strategy (P.W.S.S), the strategic objectives for the year 2030 as a long term strategy states to treat 60% of wastewater for agriculture irrigation in the West Bank governorates, and 50% of wastewater for agriculture irrigation in the Gaza Strip governorates (Palestinian Water Sector Strategy, 2014).

5.5 Discussion of Results

The following figures shows the results of new energy sources and their prices, as entered in the WAS model.

Figure 5.2: Shadow values under different energy sources for each governorate in West Bank and Gaza Strip for 2030 before leakage.

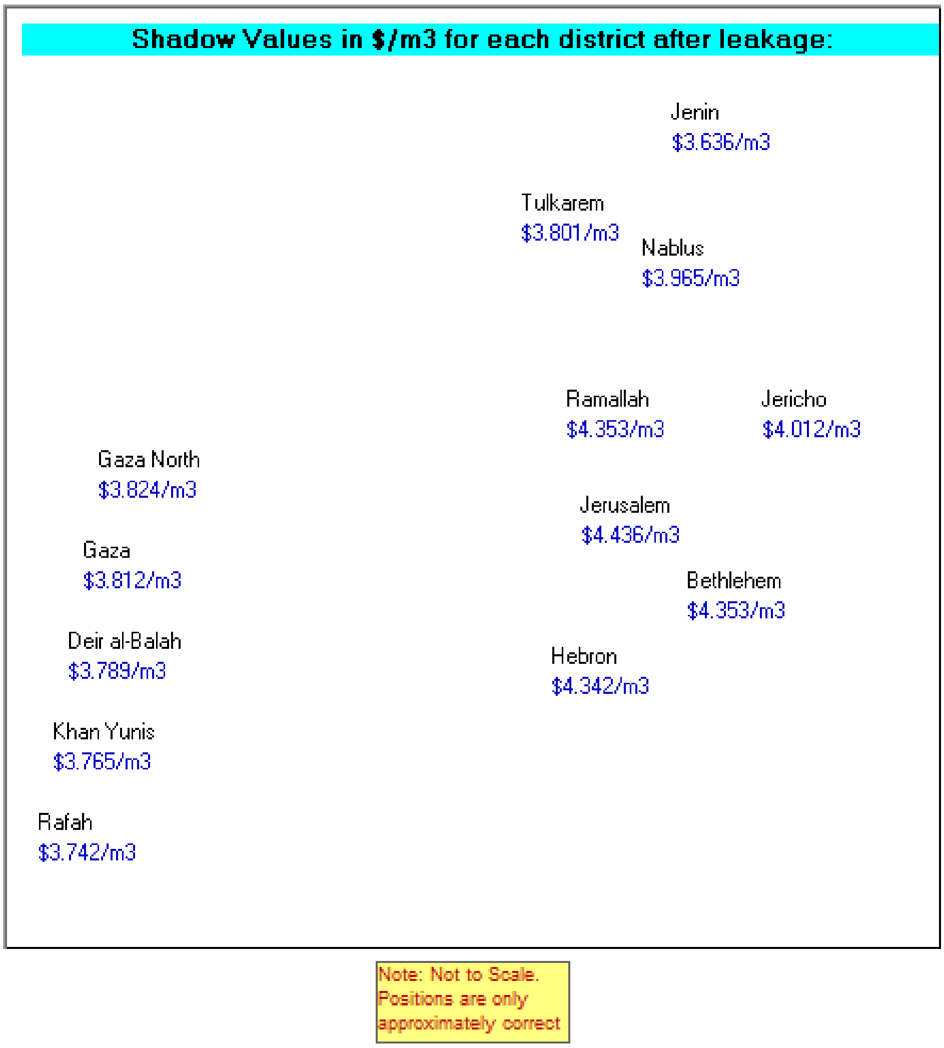

Figure 5.3: Shadow values under different energy sources for each governorate in West Bank and Gaza Strip for 2030 after leakage.

Table 5.3 below shows the results of linkages used and quantities transported for optimal transport of fresh water in MCM and costs in $/m³ for the governorates in the West Bank and Gaza Strip.

Table 5.3: Linkages used and quantities transported for optimal transport of fresh water under different energy sources for the governorates in the West Bank and Gaza Strip for 2030.

From	To	Quantity (MCM)	Cost ($/m³)
Jenin	Tulkarem	21.93	0.1400
Jenin	Nablus	130.70	0.2800
Nablus	Ramallah	33.45	0.3300
Nablus	Jericho	35.99	0.0400
Bethlehem	Jerusalem	35.49	0.0700
Hebron	Bethlehem	54.08	0.0100
Gaza North	Hebron	71.48	0.4400
Gaza	Gaza North	36.56	0.0100
Deir Al-Balah	Gaza	1.68	0.0200
Khan Yunis	Deir Al-Balah	2.52	0.0200
Rafah	Khan Yunis	2.64	0.0200

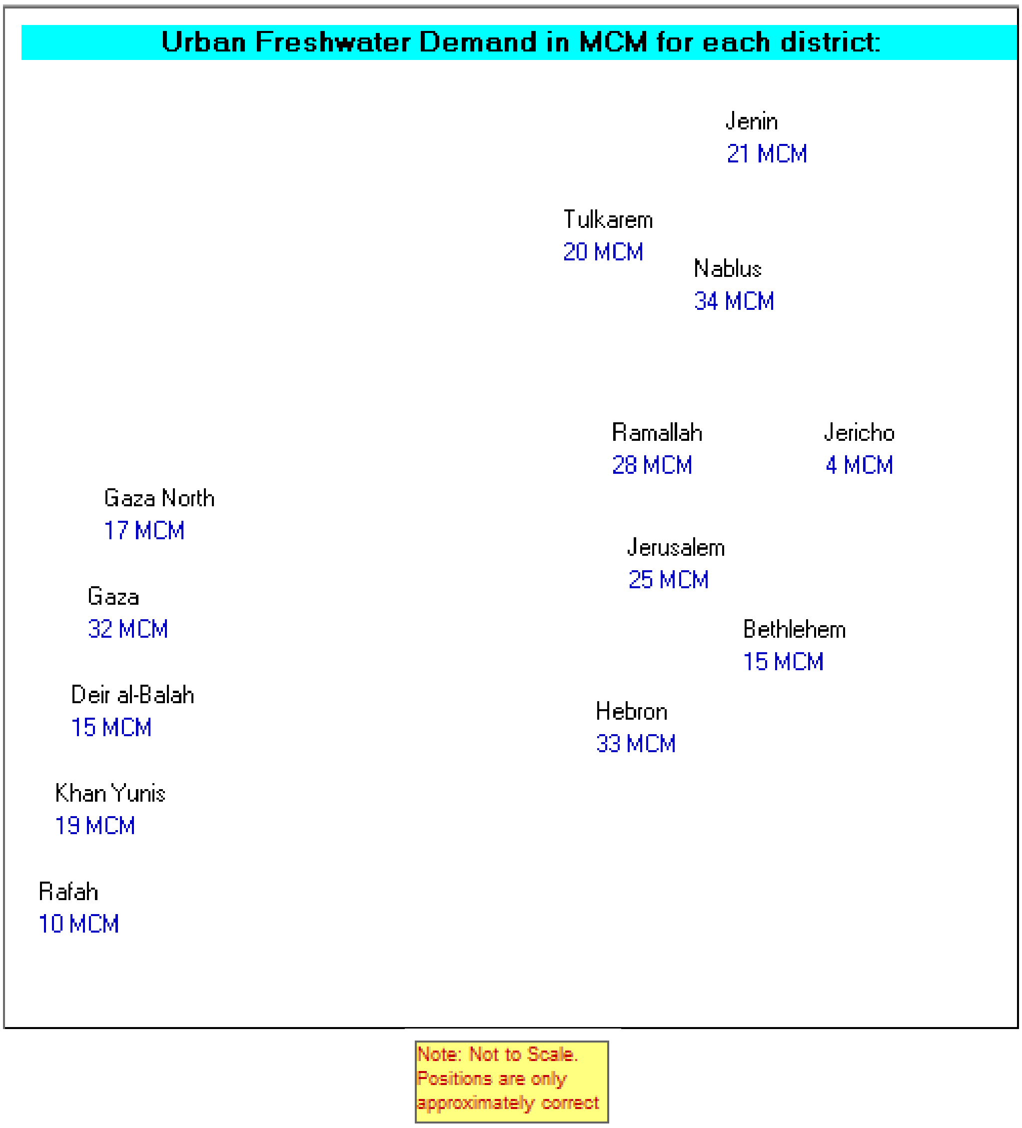

Figure 5.4: Urban freshwater demand quantities under different energy sources for each governorate in West Bank and Gaza Strip for 2030.

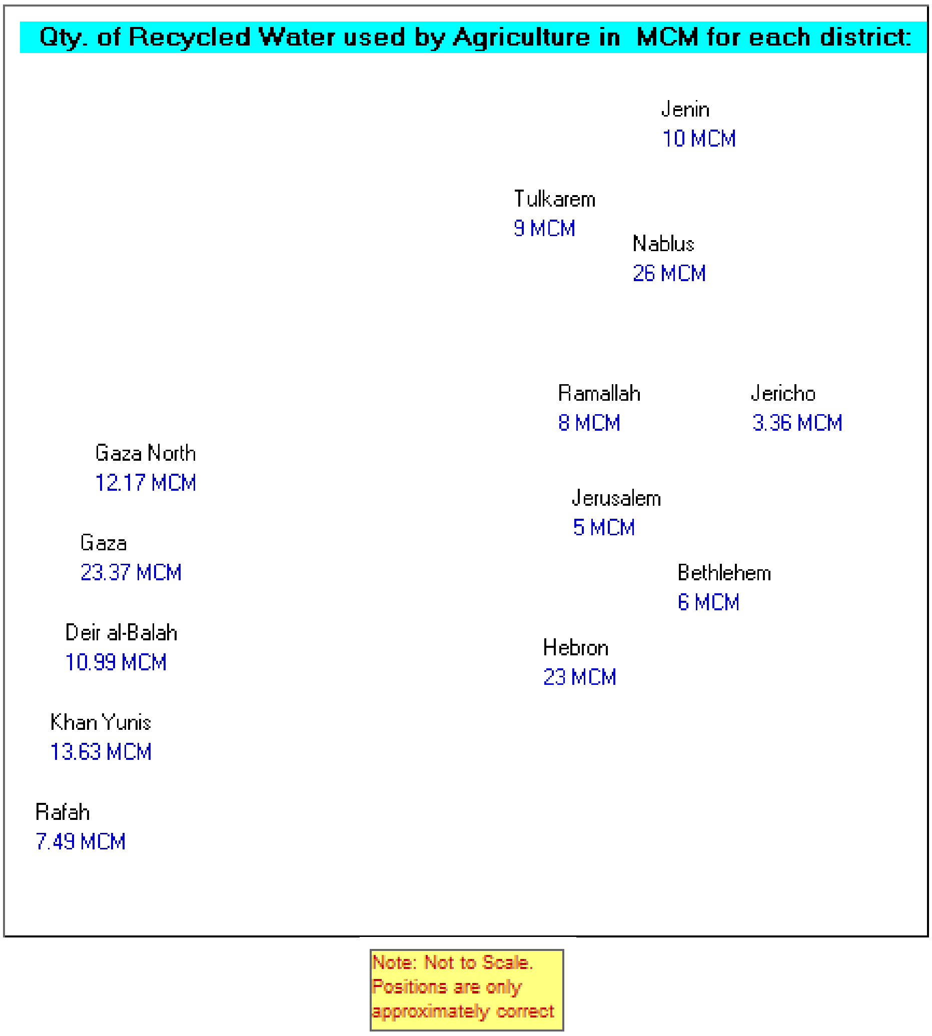

Figure 5.5: Quantity supplied to agricultural use under different energy sources for each governorate in the West Bank and Gaza Strip for 2030.

Table 5.4: Quantities produced from the desalination plants as obtained from the P.W.S.S for 2030.

Governorate	Quantity Produced (MCM)	Cost ($/m³)
Jericho	1	0.74
Gaza North	26	0.42
Gaza	44	0.42
Deir Al-Balah	19	0.42
Khan Yunis	24	0.42
Rafah	16	0.42

Social welfare from schematic results of WAS Program shows both the Profits in M$ and the government costs in M$ for each governorate of the West Bank and Gaza Strip. Figure 5.6.a and figure 5.6.b below shows the profits in M$ and government costs in M$ respectively, for each governorates in the West Bank and Gaza Strip.

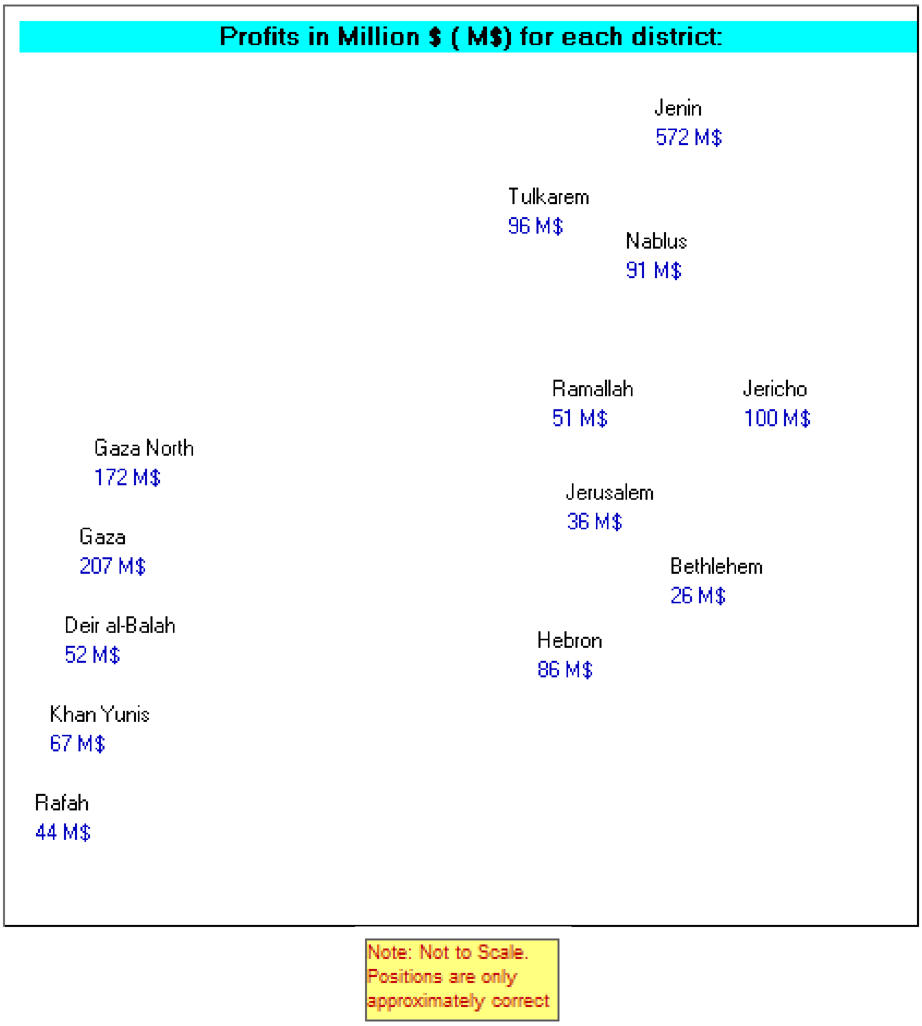

Figure 5.6.a : Profits under different energy sources for each governorate in the West Bank and Gaza Strip for 2030.

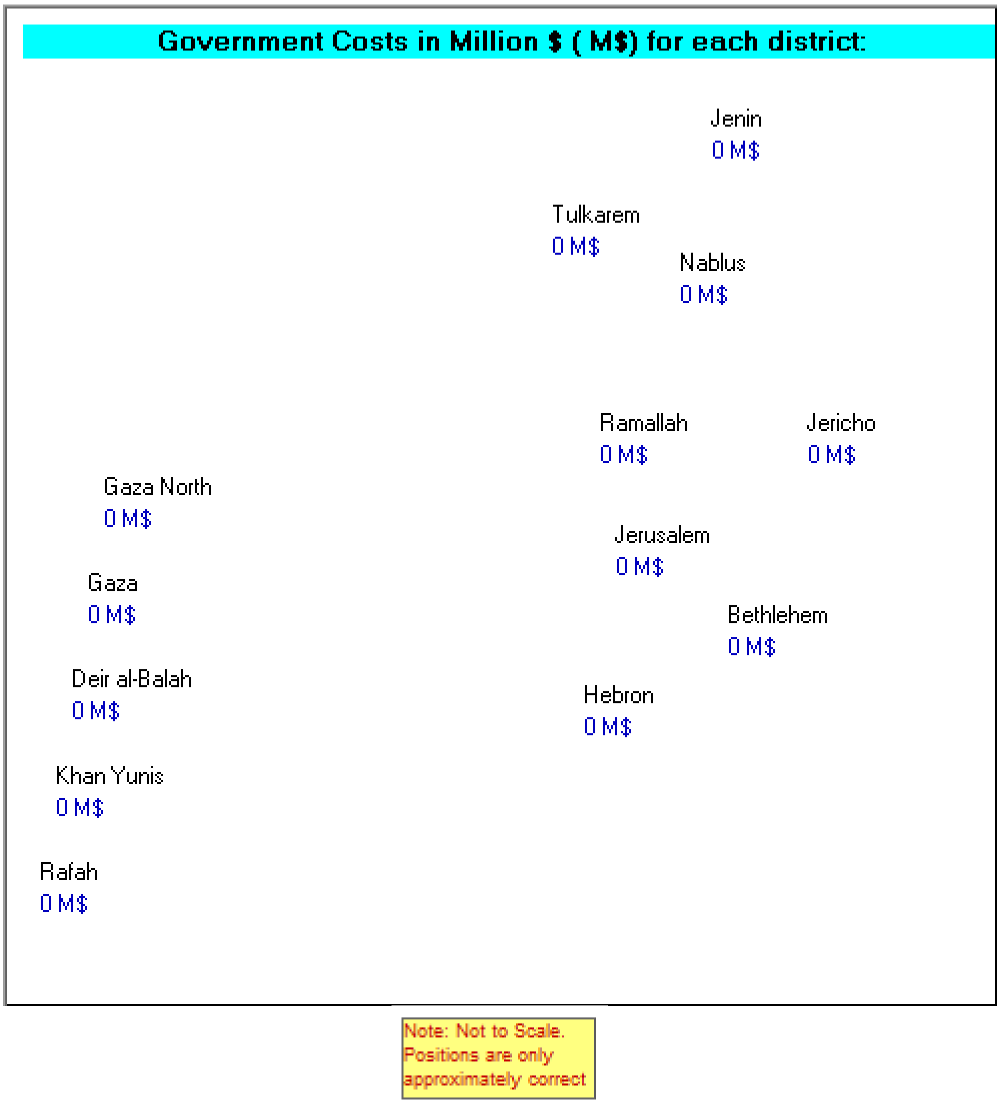

Figure 5.6.b : Government Costs under different energy sources for each governorate in the West Bank and Gaza Strip for 2030.

5.5.1. P.W.S.S and Quantities of Desalination for Supply Compare Under Different Energy Sources

As the model run and determine the quantities of desalination to be produced form desalination plants, the results are shown in table 5.5 below.

Table 5.5: Quantities produced from the desalination plants as the model run and determine the quantities of desalination under different energy sources for 2030.

Governorate	Quantity Produced (MCM)	Cost ($/m³)
Jericho	1	0.74
Gaza North	656	0.42
Gaza	48	0.42
Deir Al-Balah	42	0.42
Khan Yunis	45	0.42
Rafah	25	0.42

Table 5.6 below shows the results of linkages used and quantities transported for optimal transport of fresh water in MCM and costs in $/m³ for the governorates in the West Bank and Gaza Strip.

Table 4.8: Linkages used and quantities transported for optimal transport of fresh water for the governorates in the West Bank and Gaza Strip under different energy sources for 2030.

From	To	Quantity (MCM)	Cost ($/m³)
Nablus	Jenin	55.94	0.0080
Nablus	Tulkarem	57.57	0.0600
Nablus	Jericho	106.33	0.0400
Ramallah	Nablus	361.45	0.0800
Jerusalem	Ramallah	442.14	0.1000
Bethlehem	Jerusalem	524.97	0.0700
Hebron	Bethlehem	571.50	0.0100
Gaza North	Hebron	633.21	0.4400

The following figures shows the comparing between the results of desalination quantities as obtained from the P.W.S.S in red and the desalination quantities that resulted from the run of WAS model in blue.

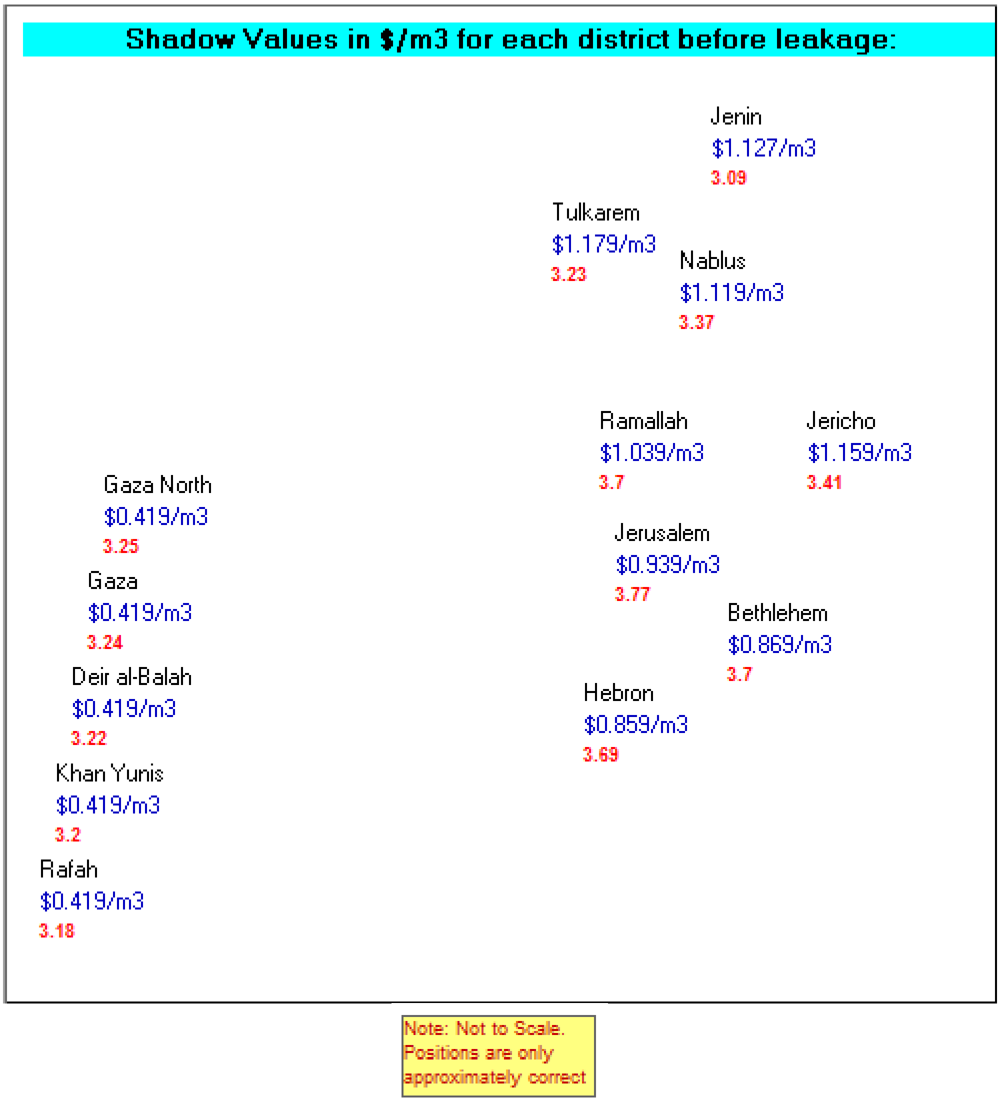

Figure 5.7: Shadow prices compare for each governorate in West Bank and Gaza Strip under different energy sources for 2030 before leakage.

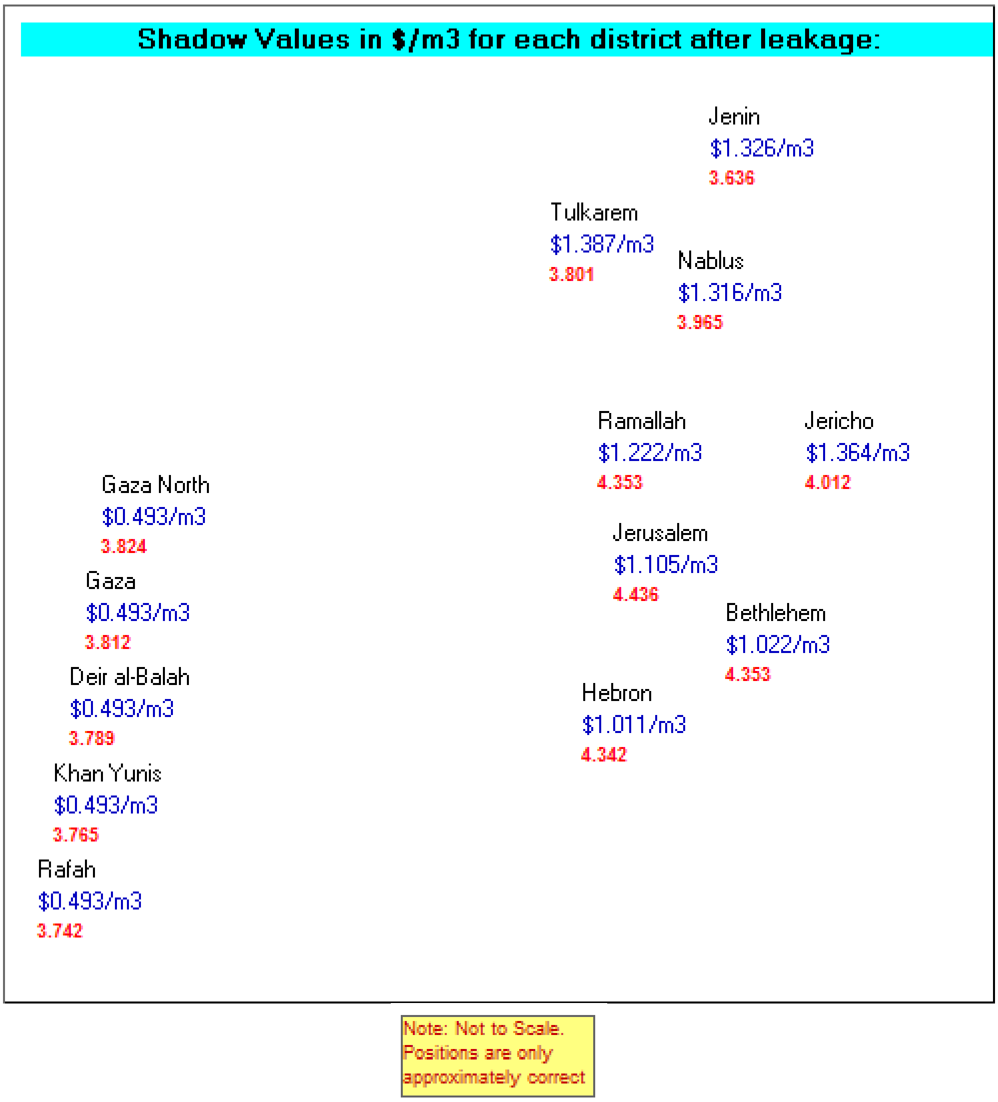

Figure 5.8: Shadow prices compare for each governorate in West Bank and Gaza Strip under different energy sources for 2030 after leakage.

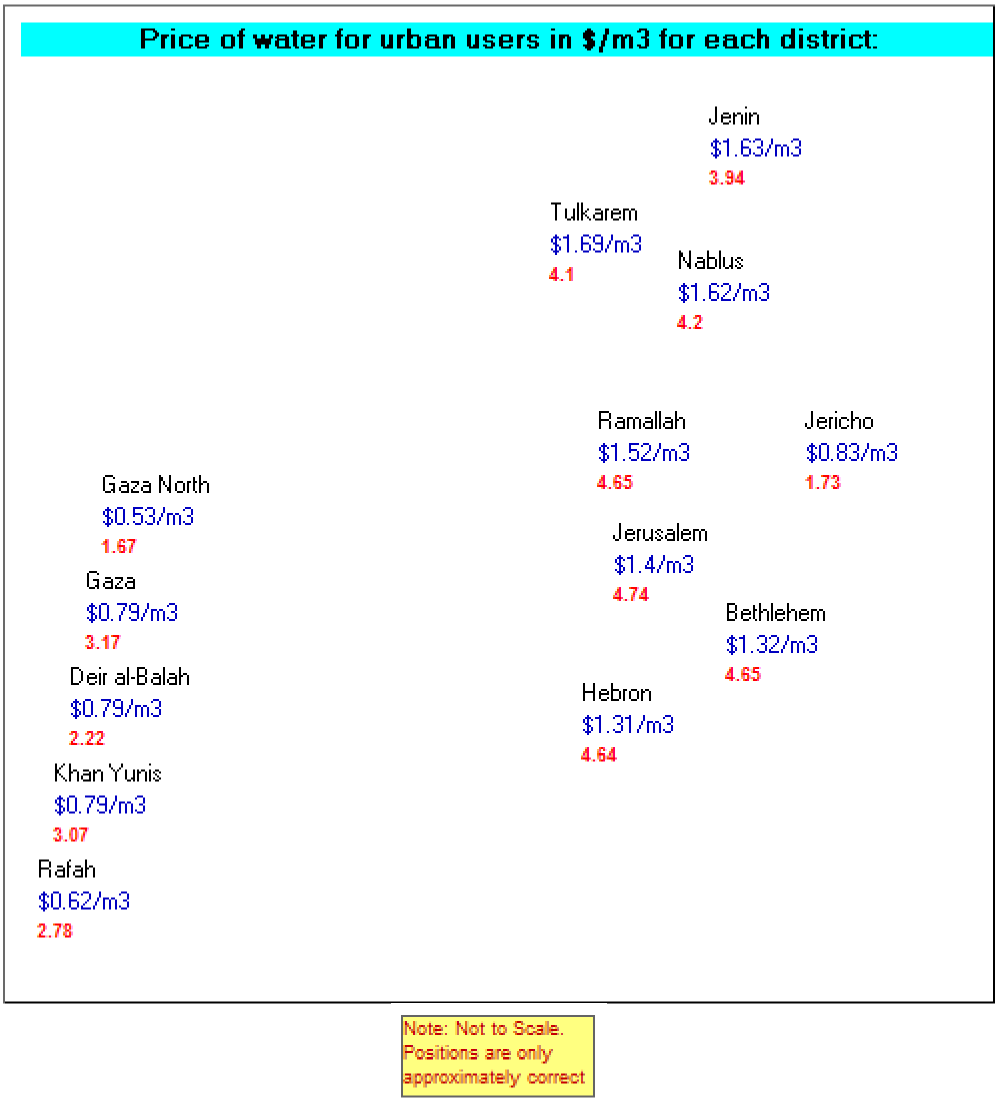

Figure 5.9: Price of water for urban users compare for each governorate in West Bank and Gaza Strip under different energy sources for 2030 after leakage.

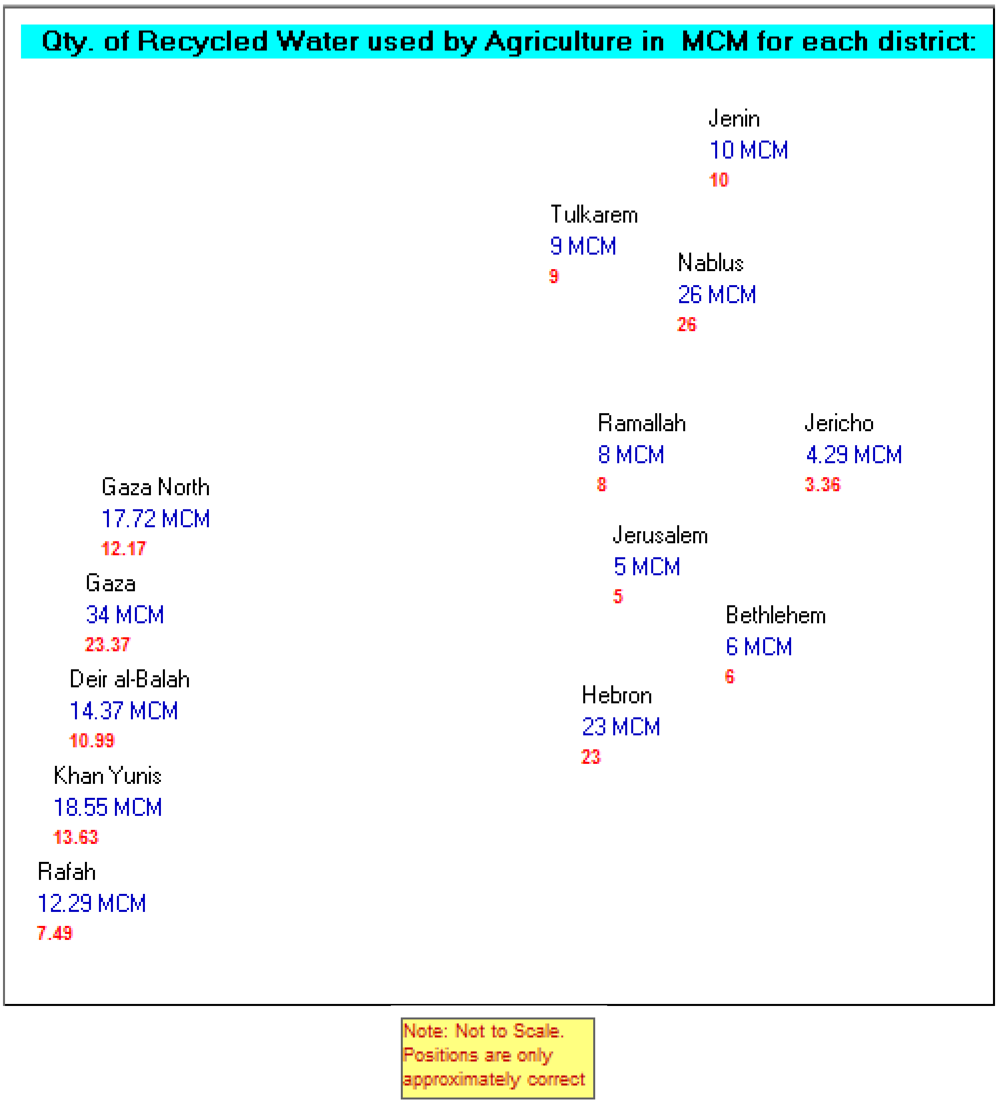

Figure 5.10: Quantity supplied to agricultural use compare for each governorate in the West Bank and Gaza Strip under different energy sources for 2030.

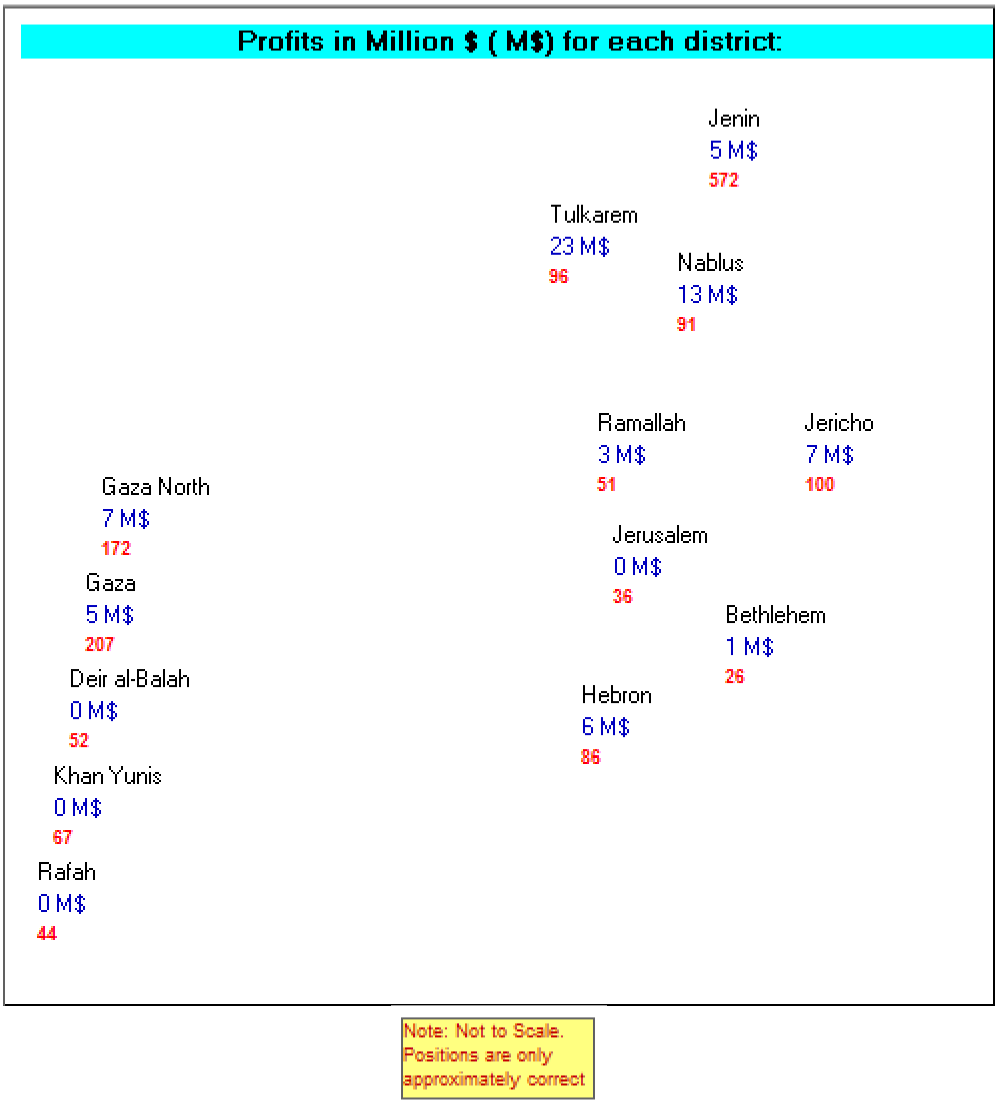

Figure 5.11 : Profits compare for each governorate in the West Bank and Gaza Strip under different energy sources for 2030.

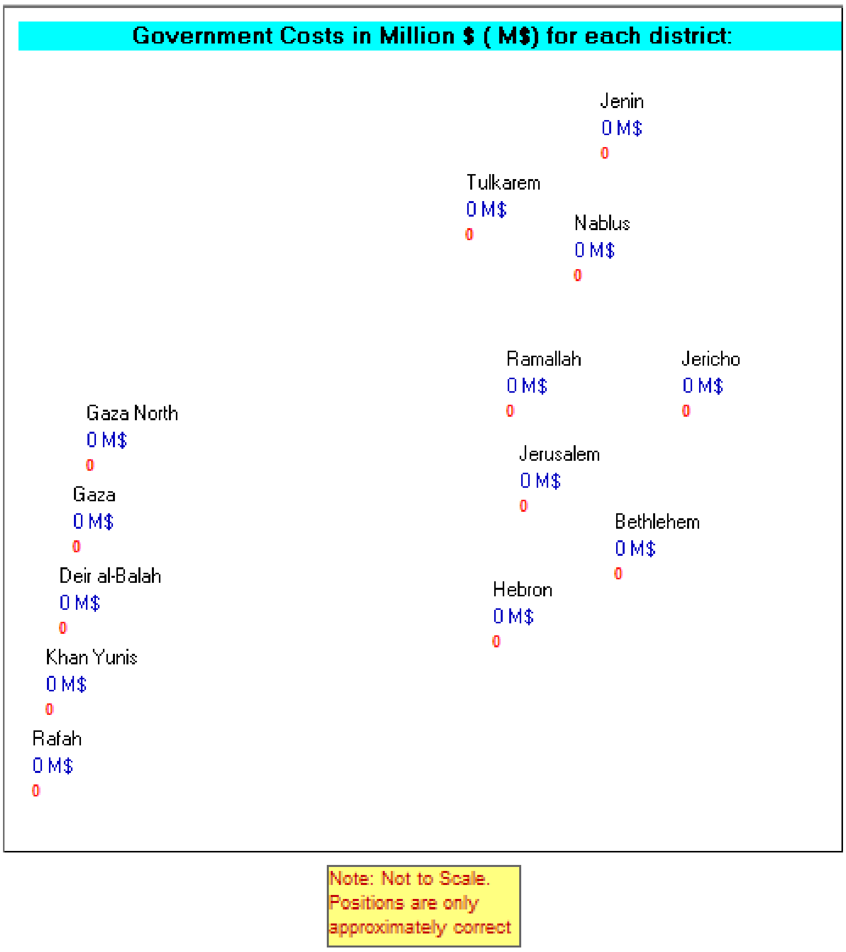

Figure 5.12 : Government costs compare for each governorate in the West Bank and Gaza Strip under different energy sources for 2030.

Based on all the above, the model was developed and results were obtained. The two main messages that came out of the results regarding the Palestinian water sector are:

3. Shadow prices for all Governorates are reasonable and affordable under the new quantity of desalination and the different energy sources and it is less than 1.5 USD in the governorates of the West Bank, and less than 0.5 USD in the governorates of Gaza Strip.
4. The quantity of desalination in P.W.S.S is 130 MCM for the year 2030, while it was found to be 817 MCM for the year 2030.

Chapter Six

Conclusions and Recommendations

7.1 Conclusions

Based on the results of the three previous chapters, the following are the main conclusions:

- Under the scenario of current conditions, as the data of the year 2015 was entered, the shadow prices are relatively high in two governorates of the West Bank; Jenin 2.470 $/m³, and Nablus 3.496 $/m³. In Gaza Strip the shadow prices are also high, in future and with the increasing in the population and water resources scarcity the shadow prices will be very high. Wastewater treatment and conveyance lines between governorates are good options to improve and decrease the prices of urban, agricultural, and industrial demand of water in Palestine.
- Under the scenario of the Palestinian Water Sector Strategy, as future scenario of the year 2030, and as both the wastewater reuse and conveyance lines between the governorates management options were applied, the shadow prices in Nablus governorate are decreased to 2.997$/m³ in addition to the shadow prices of Gaza Strip governorates to be almost 2.500$/m³.
- Under the scenario of different energy sources, as future scenario of the year 2030, and as both the solar energy and natural gas alternative energy sources were obtained, in addition to the waste water reuse and conveyance lines between the governorates management options, the

shadow prices are acceptable and convergent for all Palestinian governorates.

- The maximum profits for each governorates are achieved under the scenario of different energy sources.
- Palestinian Water Sector Strategy was obtained desalination quantity of 130 MCM, while the WAS model show desalination quantity of 540 MCM, and 817 MCM under different energy sources.

7.2 Recommendations

After the conclusions shown above, the following recommendations can be generated:

- The Palestinian Water Authority PWA should consider the conveyance lines between the Palestinian governorates to transport water in two way; from the origin to the destination, and from the destination to the origin when it necessary.
- The Palestinian Water Authority PWA should depend the wastewater reuse in all Palestinian governorates as potential future water resource.
- PWA should trend toward using the alternative energy sources, particularly solar energy for desalination and pumping in the West Bank, and natural gas for desalination and pumping in Gaza Strip.
- Data development must be done consistently over the years. Moreover, multiyear runs should be done for future scenarios.

References

- Aliewi, A. (2007). **Water Resources in Palestine, House of Water and Environment,** Ramallah, Palestine.
- Annual Water Resources Status Report, 2013**. *Status report of water resources in the occupied state of Palestine-2012, West Bank, Palestine, 2.*** Palestinian Water Authority, Palestine.
- Argaw, N., Foster, R., & Ellis, A. (2003). **Renewable Energy for Water Pumping Applications in Rural Villages,** (2003). New Mexico State University, Las Cruces, New Mexico.
- Belaineh, G, Peralta, R. C., & Hughes, T. C. (1999). ***Simulation/Optimization Modeling for Water Resources Management. Retrieved from ASCE. doi***: http://dx.doi.org/10.1061/(ASCE)0733-9496(1999)125:3(154)
- Benvenisti, E. (1996). ***Collective Action in the Utilization of Shared Freshwater: The Challenges of International Water Resources Law. American Society of International Law*** **The American Journal of International Law,** *90(3)*, 384-415. doi: 10.2307/2204064. URL: http://www.jstor.org/stable/2204064
- Chu, J., Chen, J., Wang, C., & Fu, P. (2004). ***Wastewater reuse potential analysis: implications for China's water resources management,*** 38(11), 2746-2756. http://dx.doi.org/10.1016/j.watres.2004.04.002
- Emch, P. G., & Yeh, W. W-G. (1998). ***Management Model for Conjunctive Use of Coastal Surface Water and Ground Water.***

Retrieved from ASCE. doi: http://dx.doi.org/10.1061/(ASCE)0733-9496(1998)124:3(129).

- **Fanack after UNEP**. (2002). ***Palestine maps and infographics, Fanack Water of the Middle East and North Africa***.
- Fisher, F. M., Huber-Lee, A., Amir, I., Arlosoroff, S., Echstein, Z., aaaaaa Haddadin, M. J., Hamati, S. G., Jarrar, A. M., Jayyousi, A. F., Shamir, U., & Wesseling, H. (2001). ***Liquid Assets: An Economic Approach for Water Management and Conflict Resolution in the Middle East and Beyond (Resources for the Future).*** **ISBN-13: 978-1933115092.** ISBN-10: 1933115092.
- Fisher, F. M., Huber-Lee, A., Amir, I., Arlosoroff, S., Echstein, Z., aaaaaa Haddadin, M. J., Hamati, S. G., Jarrar, A. M., Jayyousi, A. F., Shamir, U., & Wesseling, H. (2007). ***The Water Allocation System (WAS).*** **Water Economics Project**.
- **Food and Agriculture Organization**, (2008). ***Irrigation in the Middle East region in figures – AQUASTAT Survey***, 2008, Roma, Italy
- Gopal, C., Mohanraj, M., Chandramohan, P., & Chandrasekar, P. (2013). ***Renewable energy source water pumping systems***. https://doi.org/10.1016/j.rser.2013.04.012
- Jaradat, N. E. (2010). ***Evaluation of Water Resources Management Options in Gaza Strip using WEAP.*** An-Najah National University, Nablus, Palestine.

- Jayyousi, A. F. (2001). ***Application of Water Allocation System Model to the Palestinian-Israeli Water Conflict***. An-Najah Univ. J. Res., 15, **Water and Environmental Studies Institute,** An-Najah N. University, Nablus, Palestine.
- Mayyaleh, M. F. (2014). ***The Use of Water Allocation System "WAS" as a Decision Support System "DSS" Tool for Water Management in the West Bank.*** An-Najah National University, Nablus, Palestine.
- Meinzen-Dick, R. S., Rosegrant, M. W., & Dinar, A. (1997). ***Water Allocation Mechanisms: Principles and Examples,*** 1779, 1-17.
- Nazer, D. W., Siebel, M. A., Van der Zaag, P., Mimi, Z., & Gijzen, H. J. (2008). ***Water Footprint of the Palestinians in the West Bank,*** 44(2), 449-458, doi: 10.1111/j.1752-1688.2008.00174.x
- ***Palestinian Central Bureau of Statistics,*** (2015). **Palestine Statistical Yearbook,** 2015. 16, Ramallah, Palestine.
- Palestinian Water Authority, (2012). ***Annual Status Report on water resources, Water Supply, and Wastewater in the Occupied State of Palestine, 2011***. **Palestinian Water Authority**, Ramallah, Palestine.
- Palestinian Water Authority, (2015). ***Water & Sustainable Development. World Water Day,*** 2015. **Palestinian Water Authority,** Ramallah, Palestine.
- Palestinian Water Authority, (2013). ***National Water and Wastewater Strategy for Palestine, 2013.*** **Palestinian Water Authority,** Ramallah, Palestine

- Perrone, D., Murphy, J., & Hornberger, G. M. (2011). ***Gaining Perspective on the Water−Energy Nexus at the Community Scale Environmental, 2011.*** **Science & Technology,** 45(10), 4228-4234. DOI: 10.1021/es103230n.
- Siddiqi, A., & Anadon, L. D. (2011). ***The water–energy nexus in Middle East and North Africa,*** **39(8),** 4529-4540. doi.org/10.1016/j.enpol.2011.04.023
- Water Economics Project, (2007). ***WAS Concepts and Theory,*** 4-5. **The Water Allocation System (WAS),** 2007
- **Water energy outlook,** (2017). ***Water Energy Nexus. International Energy Agency,*** 2017.
- Wurbs, R. A. (2013). ***Water Allocation Systems, Texas A&M University.*** doi: 10.5772/54438. **ISBN: 978-953-51-1092-Yaseen**, B. T. (2007). Renewable Energy Applications in Palestine,
- ***Palestinian Energy and Environment Research Center (PEC)-Energy Authority,*** Palestine, 2007.
- Zilberman, D., Sproul, T., Rajagopal, D., Sexton, S., & Hellegers, P. (2007). ***Rising energy prices and the economics of water in agriculture.*** **Department of Agricultural and Resource Economics, University of California at Berkeley,** 207 Giannini Hall, Berkeley, CA 94720, USA. Energy and Resources Group, University of California at Berkeley, 310 Barrows Hall, Berkeley, CA 94720, USA. International Water Management Institute, P.O. Box 2075, Colombo, Sri Lanka.

Appendice

Table 1: Selected Indicators for Water Statistics in Palestine [(1)], 2009 – 2015

Unit : million m³ | الوحدة: مليون م³

Indicator	Year						السنة	المؤشر
	2015	2014	2013	2012	2011	2010	2009	
Annual Available Water Quantity[(2)]	365.3	342.7	365.7	349.2	323.9	331.1	315.2	كمية المياه المتاحة سنويا[(2)]
Annual Pumped Quantity from Groundwater Wells[(3)]	250.5	246.3	262.9	253.3	245.5	244.0	227.2	كمية الضخ السنوية من الآبار الجوفية[(3)]
Annual Discharge of Springs Water[(4)]	40.7	28.2	39.5	39.3	21.4	26.8	30.6	التدفق السنوي لمياه الينابيع[(4)]
Desliniated Drinking Water [(5)]	3.9	4.7	-	-	-	-	-	مياه شرب محلاة [(5)]
Annual Quantity of Water Purchased from Israeli Water Company (Mekorot)[(6)]	70.2	63.5	63.3	56.6	57.0	60.3	57.4	كمية المياه المشتراة من شركة المياه الاسرائيلية (ميكروت)[(6)]

[(1)] Data exclude that part of Jerusalem, which was annexed forcefully by Israel following its occupation of the West Bank in 1967.

[(2)] This includes the unsafe pumping from the coastal aquifer in the Gaza Strip (and does not include the abstraction of the unlicensed wells in Gaza), of which the safe pumping and the basin sustainable yield do not exceed 50-60 million m³ from the abstracted 198.6 million m³. About 100 million m³ is sea water from return flow (sea Water intrusion). More than 90% of the water pumped from the coastal aquifer does not satisfy the water quality standards of the World Health Organization.

[(3)] This does not include abstraction from unlicensed wells.

[(4)]This does not include Fashkha springs group for the years (2011-2015).

[(5)] Desalinated water plants owned by private sector, supplied people with bottled desalinated drinking water

[(6)] This includes 4.4 million m³ supplied for agricultural use in Tubas governorate in 2015.

(-) Nill

Source: Palestinian Water Authority, 2016. Water Information System.
Ramallah - Palestine.

Table 2: Annual Available Water Quantity in Palestine by Region and Source, 2015

Unit : million m^3 | الوحدة: مليون م^3

Region	المجموع Total	Source المصدر: المياه المشتراة من شركة المياه الإسرائيلية (ميكروت)[5] Water Purchased from Israeli Water Company (Mekorot)[5]	مياه شرب محلاة[4] Desalinated Drinking Water[4]	تصريف الينابيع[3] Springs Discharge[3]	المياه المضخوخة من الآبار الفلسطينية[2] Water Pumped from Palestinian Wells[2]	المنطقة
Palestine[1]	**365.3**	**70.2**	**3.9**	**40.7**	**250.5**	**فلسطين[1]**
West Bank	**187.8**	63.8	-	40.7	83.3	الضفة الغربية
Gaza Strip	**177.5**	6.4	3.9	-	167.2	قطاع غزة

(1) Data exclude that part of Jerusalem, which was annexed forcefully by Israel following its occupation of the West Bank in 1967.
(2) This does not include water abstracted from unlicensed wells.
(3) This does not include Fashkha springs.
(4) Desalinated water plants owned by private sector, supplied people with bottled desalinated drinking water
(5) Includes the pumped water from the wells which are located in the territories of the State of Palestine and controlled by Israeli Water Company (Mekorot) for domestic and agricultural uses, includes 4.4 million m^3 for agricultural use in Tubas.
(-) Nill
Source: Palestinian Water Authority, 2016. Water Information System. Ramallah - Palestine.

Table 3: Palestinian Water Wells and its Annual Pumping Quantity in Palestine by Governorate and Type of Use(1), 2015

Unit: million m^3 الوحدة: مليون م^3

Governorate(2)	Type of Use		نوع الاستخدام	المحافظة(2)
	المجموع(3) Total(3)	زراعي(4) Agriculture(4)	منزلي Domestic	
Palestine	**250.5**	**120.6**	**129.9**	**فلسطين**
West Bank	**83.3**	**35.6**	**47.7**	**الضفة الغربية**
Jenin	5.2	0.9	4.3	جنين
Tubas	2.7	1.3	1.4	طوباس
Tulkarem	20.8	11.4	9.4	طولكرم
Nablus	11.0	1.9	9.1	نابلس
Qalqiliya	12.8	7.4	5.4	قلقيلية
Ramallah & Al-Bireh And Jerusalem	2.5	-	2.5	رام الله والبيرة والقدس
Jericho & Al-Aghwar	12.7	12.7	-	أريحا والأغوار
Bethlehem & Hebron	15.6	-	15.6	بيت لحم والخليل
Gaza Strip(4)	**167.2**	**85.0**	**82.2**	**قطاع غزة(4)**

(1) Data exclude that part of Jerusalem, which was annexed forcefully by Israel following its occupation of the West Bank in 1967.
(2) The wells existence is restricted to the governorates mentioned.
(3) Quantities pumped from the wells were calculated according to use, not to the well's permit and does not include water abstracted from unlicensed wells.
(4) Data about annual quantities from agricultural wells in Gaza Strip is estimated.
(-) Nill
Source: Palestinian Water Authority, 2016. Water Information System. Ramallah - Palestine.

Table 4: Annual Discharge of Springs in the West Bank by Governorate and Year[1] 2012- 2015

Unit : million m^3 | الوحدة: مليون م3

Governorate[2]	2015	[3]2014	2013	2012	المحافظة[2]
West Bank	**40.7**	**28.2**	**39.5**	**39.3**	**الضفة الغربية**
Jenin	0.5	0.5	-	-	جنين
Tubas[4]	0.9	0.9	0.8	1.3	طوباس[4]
Nablus	4.9	5.1	8.4	6.9	نابلس
Salfit	0.2	0.2	0.3	0.4	سلفيت
Ramallah & Al-Bireh And Jerusalem	4.6	1.9	2.4	1.6	رام الله والبيرة والقدس
Jericho & Al-Aghwar[5]	28.6	18.9	27.1	28.2	أريحا والأغوار[5]
Bethlehem & Hebron	1.0	0.7	0.5	0.9	بيت لحم والخليل

[1]Data exclude that part of Jerusalem, which was annexed forcefully by Israel following it's occupation of the West Bank in 1967.

[2] Number of springs and quantity of discharged water are for the springs monitored by the Palestinian Water Authority and restricted to the governorates mentioned.

[3] The significant decrease of water quantities discharged from springs in 2014 compared with 2013 is a result of low rainfall season.

[4] Fara'a spring used to discharge an annual quantity of about 6 million m^3, has dried up since 2008.

[5] Data does not include water discharged from Fashkha springs

(-) Nill

Source: Palestinian Water Authority, 2016. Water Information System. Ramallah - Palestine.

Table 5: Quantity of Water Purchased From Israeli Water Company (Mekorot) in Palestine by Governorate and Year(1), 2009 - 2015

Unit: million m^3 — الوحدة: مليون م3

Governorate	Year 2015	2014	2013	2012	2011	2010	2009 السنة	المحافظة
Palestine(2)	**70.2**	**63.5**	**63.3**	**56.6**	**57.0**	**60.3**	**57.4**	**فلسطين(2)**
West Bank	**63.8**	**60.0**	**59.3**	**52.6**	**52.8**	**55.4**	**52.7**	**الضفة الغربية**
Jenin	3.0	3.0	2.9	2.3	2.2	2.0	2.1	جنين
Tubas(3)	5.4	4.2	4.4	4.1	4.2	4.3	4.0	طوباس(3)
Tulkarem	0.4	0.5	0.5	0.4	0.4	0.4	0.3	طولكرم
Nablus	4.1	3.9	3.7	3.2	3.5	3.6	3.8	نابلس
Qalqiliya	1.5	1.4	1.0	0.7	0.6	0.7	0.5	قلقيلية
Salfit	3.0	3.0	2.8	2.6	2.4	2.5	2.1	سلفيت
Ramallah & Al-Bireh and Jerusalem	21.3	20.0	20.4	19.3	19.7	20.3	18.5	رام الله والبيرة والقدس
Jericho & Al-Aghwar	2.6	2.4	2.2	2.0	1.9	1.8	1.9	أريحا والأغوار
Bethlehem and Hebron	22.5	21.6	21.4	18.0	17.9	19.8	19.5	بيت لحم والخليل
Gaza Strip	**6.4**	**3.5**	**4.0**	**4.0**	**4.2**	**4.9**	**4.7**	**قطاع غزة**

(1)Data exclude that part of Jerusalem, which was annexed forcefully by Israel following its occupation of the West Bank in 1967.

(2) Includes the pumped water from the wells which are located in the territories of the State of Palestine and controlled by Israeli Water Company (Mekorot).

(3) This amount is purchased for agricultural purposes in Bardala.

Source: Palestinian Water Authority, 2016. Water Information System. Ramallah - Palestine.

Unit: million m^3

الوحدة: مليون م3

Table 6: Quantity of Water Supply for Domestic Sector in the West Bank by Governorate and Year[1], 2010 - 2015

Governorate	Year					السنة	المحافظة
	2015	2014	2013	2012	2011	2010	
West Bank[2]	**119.6**	**102.8**	**100.9**	**93.9**	**88.3**	**85.0**	**الضفة الغربية[2]**
Jenin	8.8	6.4	8.8	5.9	5.7	6.0	جنين
Tubas	2.3	2.0	1.6	1.7	1.5	1.7	طوباس
Tulkarm	12.4	7.1	8.5	6.2	5.2	4.6	طولكرم
Nablus	16.7	12.0	15.0	15.0	15.0	11.2	نابلس
Qalqiliya	7.0	8.6	6.5	5.6	4.7	4.0	قلقيلية
Salfit	2.8	3.1	2.6	2.8	2.5	2.6	سلفيت
Ramallah & Al-Bireh, and Jerusalem	23.8	22.5	20.0	21.6	21.3	20.8	رام الله والبيرة والقدس
Jericho & Al-Aghwar[3]	6.6	5.9	5.1	5.6	3.8	3.6	أريحا والأغوار[3]
Bethlehem and Hebron[4]	39.2	35.2	32.8	29.5	28.6	30.5	بيت لحم والخليل[4]

(1) Data exclude that part of Jerusalem, which was annexed forcefully by Israel following its occupation of the West Bank in 1967.

(2) Some governorates use additional amounts from agricultural wells to cover their domestic needs.

(3) Jericho and Al -Aghwar used 3.5 million m^3 from Ein Sultan and Dyouk spring in additition to water purchased from Israeli Water Company "Mekarot"

(4) Due to water supply system in Bethlehem and Hebron, separation of data for each governorate is not applicable.

Table 7: Quantity of Water Supply for Domestic Sector, Water Consumed, Total Losses, Population and Daily Allocation per Capita in the West Bank by Governorate(1), 2015

Governorate	حصة الفرد اليومية من المياه المستهلكة (لتر/فرد/يوم) Daily Allocation per Capita from consumed water (liter/capita/day)	عدد السكان نهاية العام 2015 Population End of 2015	الفاقد الكلي (مليون م^3) Total Losses (million m^3)	المياه المستهلكة (مليون م^3) Consumed Water (million m^3)	المياه المزودة للقطاع المنزلي (مليون م^3) Supplied Water for Domestic Sector (million m^3)	المحافظة
West Bank (2)	**84.3**	**2,636,297**	**38.4**	**81.2**	**119.6**	**الضفة الغربية (2)**
Jenin	49.5	315,094	3.1	5.7	8.8	جنين
Tubas	58.3	65,787	0.9	1.4	2.3	طوباس
Tulkarm	114.8	183,684	4.7	7.7	12.4	طولكرم
Nablus	80.3	385,145	5.4	11.3	16.7	نابلس
Qalqiliya	129.3	112,187	1.7	5.3	7.0	قلقيلية
Salfit	88.1	71,503	0.5	2.3	2.8	سلفيت
Ramallah & Al-Bireh, and Jerusalem	95.5	513,230	5.9	17.9	23.8	رام الله والبيرة والقدس
Jericho & Al-Aghwar(3)	227.9	52,858	2.2	4.4	6.6	أريحا والأغوار (3)
Bethlehem & Hebron (4)	73.6	936,809	14.0	25.2	39.2	بيت لحم والخليل (4)

(1) Data exclude that part of Jerusalem, which was annexed forcefully by Israel following its occupation of the West Bank in 1967. Where this part inhabited by 262,630 Palestinian citizens whom holding Jerusalem identity card and no information is available about the water supplied to them. (2) This quantity is supplied for non-agricultural uses and includes water supplied for commercial and industrial uses; hence, the actual supply and consumption rates per capita are less than the indicated numbers.
(3) Includes recreational, touristic and economical activities in Jericho and Al-Aghwar governorate. (4) Due to water supply system in Bethlehem and Hebron, separation of data for each governorate is not applicable. Sources: Palestinian Water Authority, 2016. Water Information System. Ramallah – Palestine, Palestinian Central Bureau of Statistics, 2016. Revised estimated population based on the final result of Population, Housing, and Establishment Census 2007. Ramallah- Palestine.
Source: Palestinian Water Authority, 2016. Water Information System. Ramallah - Palestine.

Table 8: Quantity of Water Supply for Domestic Sector, Water Consumed, Total Losses, Population and Daily Allocation per Capita in Gaza Strip by Governorate, 2015

Governorate	حصة الفرد اليومية من المياه المستهلكة (لتر/فرد/يوم) Daily Consumption Rate per capita (liter/capita/day)	عدد السكان نهاية العام 2015 Population End of 2015	الفاقد الكلية (مليون م3) Total Losses (million m^3)	المياه المستهلكة (مليون م3) Consumed Water by Domestic Sector (million m^3)	المياه المزودة للقطاع المنزلي(مليون م3)(1)(2) Water Supply for Domestic Sector (million m^3)(1)(2)	المحافظة
Gaza Strip	**79.2**	**1,850,559**	**41.8**	**53.5**	**95.3**	**قطاع غزة**
North Gaza	92.5	369,949	12.0	12.5	24.5	شمال غزة
Gaza	81.9	635,514	13.4	19.0	32.4	غزة
Deir Al-Balah	76.4	268,918	7.4	7.5	14.9	دير البلح
Khan Younis	68.7	346,664	5.1	8.7	13.8	خان يونس
Rafah	69.2	229,514	3.9	5.8	9.7	رفح

(1) More than 90% of the water pumped from the coastal aquifer does not satisfy the water quality standards of the World Health Organization.

(2) Data include water purchased from Mekorot 6.4 million m^3.

Sources: Palestinian Water Authority, 2016. Water Information System. Ramallah - Palestine.

Palestinian Central Bureau of Statistics, 2016. Revised estimated population based on the final result of Population, Housing, and Establishment Census 2007. Ramallah- Palestine.

Table 9: Needed, Supply and Consumed Quantities, Population and Deficit in Domestic Supply in the West Bank by Governorate[1], 2015

Governorate	العجز الحقيقي في تغطية الإستخدام المنزلي (مليون م3) Actual Deficit for Domestic Need (million m^3)	العجز لتغطية الاستخدام المنزلي (مليون م3) Deficit Domestic Supply (million m^3)	عدد السكان نهاية العام 2015 Population End of 2015	المياه المستهلكة (مليون م3) Water Consumed for Domestic Sector (million m^3)	المياه المزودة للقطاع المنزلي (مليون م3) Water Supply for Domestic Sector (million m^3)	المياه المطلوبة (2) (مليون م3) Needed Quantities of Water[2] (million m^3)	المحافظة
West Bank	**63.2**	**24.8**	**2,636,297**	**81.2**	**119.6**	**144.4**	**الضفة الغربية**
Jenin	11.6	8.5	315,094	5.7	8.8	17.3	جنين
Tubas	2.2	1.3	65,787	1.4	2.3	3.6	طوباس
Tulkarm	2.4	-2.3	183,684	7.7	12.4	10.1	طولكرم
Nablus	9.8	4.4	385,145	11.3	16.7	21.1	نابلس
Qalqiliya	0.8	-0.9	112,187	5.3	7.0	6.1	قلقيلية
Salfit	1.6	1.1	71,503	2.3	2.8	3.9	سلفيت
Ramallah & Al-Bireh, and Jerusalem	10.2	4.3	513,230	17.9	23.8	28.1	رام الله والبيرة والقدس
Jericho & Al-Aghwar	-1.5	-3.7	52,858	4.4	6.6	2.9	أريحا والأغوار
Bethlehem & Hebron[3]	26.1	12.1	936,809	25.2	39.2	51.3	بيت لحم والخليل(3)

[1] Data exclude that part of Jerusalem, which was annexed forcefully by Israel following its occupation of the West Bank in 1967. Where this part inhabited by 262,630 Palestinian citizens whom holding Jerusalem identity card and no information is available about the water supplied to them.
[2] Needed quantity of water is calculated based on a water supply of 150 l/c.d, according to WHO standard.
[3] Due to water supply system in Bethlehem and Hebron, separation of data for each governorate is not applicable.

Sources: Palestinian Water Authority, 2016. Water Information System. Ramallah - Palestine.
Palestinian Central Bureau of Statistics, 2016. Revised estimated population based on the final result of Population, Housing, and Establishment Census 2007. Ramallah- Palestine.

Table 10: Water Produced per Basin in the West Bank(1), 2015

Unit: million m^3 | الوحدة: مليون م3

Governorate	المجموع Total	انتاج الحوض الشمالي الشرقي(4) North-Eastern Basin Production (4)	انتاج الحوض الغربي(3) Western Basin Production(3)	انتاج الحوض الشرقي(2) Eastern Basin Production (2)	المحافظة
West Bank	**124.1**	**21.7**	**37.6**	**64.8**	**الضفة الغربية**
Jenin	**5.8**	5.3	0.5	-	جنين
Tubas	**3.6**	2.3	-	1.3	طوباس
Tulkarm	**20.8**	-	20.8	-	طولكرم
Nablus	**15.9**	14.1	-	1.8	نابلس
Qalqiliya	**12.8**	-	12.8	-	قلقيلية
Salfit	**0.2**	-	0.2	-	سلفيت
Ramallah Al-Bireh & Jerusalem	**7.1**	-	2.9	4.2	رام الله والبيرة و القدس
Jericho & Al-Aghwar	**41.3**	-	-	41.3	أريحا والأغوار
Bethlehem & Hebron	**16.6**	-	0.4	16.2	بيت لحم والخليل

(1) Data exclude that part of Jerusalem, which was annexed forcefully by Israel following its occupation of the West Bank in 1967.
(2) OSLO ll (1995) agreement aquota is 54 million m3 in addition to 78 million m3 to be developed.
(3) OSLO ll (1995) agreement aquota is 22 million m3.
(4) This includes the unlicensed wells OSLO ll (1995) agreement quota is 42 million m3
(-) Nill
Source: Palestinian Water Authority, 2016. Water Information System. Ramallah - Palestine.

Table11: Water Produced for Domestic Use from the Coastal Aquifer in Gaza Strip by Governorate, 2015

Unit: million m^3 | الوحدة: مليون م^3

Region	انتاج الحوض الساحلي (1) Coastal Aquifer Production(1)	المحافظة
Gaza Strip(2)	**103.0**	**قطاع غزة (2)**
Gaza	25.7	شمال غزة
Middle	34.5	غزة
Deir Al-Balah	17.0	دير البلح
Khan-younis	14.7	خانيونس
Rafah	11.1	رفح

(1)The Gaza Strip suffers from a disastrous situation due to water quality degradation. Based on international reports, more than 90% of the coastal aquifer production is not suitable for human consumption due to the unsafe pumping of more than 100 million m3. Therefore, this number is considered misleading if used in calculating the per capita consumption.

(2) This quantity does not include the quantities pumped from the UNRWA wells and the desalinated water. But mostly includes the unsafe pumping, of which the safe pumping and the basin sustainable yield do not exceed 50-60 million m3. More than 90% of the water pumped from the coastal aquifer in the Gaza Strip does not satisfy the water quality standards of the World Health Organization.

Source: Palestinian Water Authority, 2016. Water Information System. Ramallah - Palestine.

Table12: Average Consumer Price for Water Tariffs by Region (1), 2015

Unit: NIS/m^3 | الوحدة: شيكل جديد/م^3

Description	Price السعر			الوصف
	قطاع غزة Gaza Strip	الضفة الغربية West Bank	**فلسطين Palestine**	
Water tariffs for (0-5) Cubic meters consumption groups - monthly Bill	1.50	4.21	**3.34**	تعرفة المياه لفئة الاستهلاك 0 - 5 متر مكعب دورة الفاتورة شهر
Water tariffs for (5.1 - 10) Cubic meters consumption groups - monthly Bill	1.66	4.58	**3.65**	تعرفة المياه لفئة الاستهلاك 5.1 - 10 متر مكعب دورة الفاتورة شهر
Water tariffs for (10.1 - 20) Cubic meters consumption groups - monthly Bill	2.50	6.0	**4.9**	تعرفة المياه لفئة الاستهلاك 10.1 - 20 متر مكعب دورة الفاتورة شهر

(1) Data exclude that part of Jerusalem, which was annexed forcefully by Israel following its occupation of the West Bank in 1967.

Source: Palestinian Central Bureau of Statistics, 2016. Consumer Price Index Survey, 2015. Ramallah– Palestine

دولـــة فلسطيـــن

مجلس الوزراء

قرار مجلس الوزراء رقم (17/68/24/م.و/ر.ح) لعام 2015م

المصادقة على التعرفة الكهربائية

بناءً على الصلاحيات المخولة لنا قانوناً

وتنسيب رئيس سلطة الطاقة والموارد الطبيعية

وبناءً على مقتضيات المصلحة العامة

وبعد الاطلاع على القانون الأساسي المعدل لسنة 2003 وتعديلاته؛

وعلى القرار بقانون الكهرباء العام رقم (13) لسنة 2009م؛

قرر مجلس الوزراء في جلسته المنعقدة بمدينة رام الله بتاريخ (2015/09/15م) ما يلي:

المادة الأولى

المصادقة على التعرفة الكهربائية، الواردة من سلطة الطاقة والموارد الطبيعية، والمرفقة مع هذا القرار.

المادة الثانية

يلغى كل ما يتعارض مع أحكام هذا القرار.

المادة الثالثة

على الجهات المختصة تنفيذ أحكام هذا القرار كل فيما يخصه، ويعمل بـه من تـاريخ صدوره، وينشر في الجريدة الرسمية.

صدر بمدينـة رام الله بتاريخ 2015/09/15م.

رامي حمد الله

رئيس الوزراء

دولة فلسطين

State of Palestine

قرار بخصوص التعرفة الكهربائية

المادة الأولى

التعريفات

يكون للكلمات والعبارات التالية حيثما وردت في هذا القرار المعاني المخصصة لها أدناه ما لم تدل القرينة على غير ذلك:

مجلس الوزراء: مجلس وزراء السلطة الوطنية الفلسطينية.

السلطة (سلطة الطاقة): سلطة الطاقة و الموارد الطبيعية الفلسطينية.

الرئيس: رئيس سلطة الطاقة والموارد الطبيعية الفلسطينية

المجلس: مجلس تنظيم قطاع الكهرباء

رئيس المجلس: رئيس مجلس تنظيم قطاع الكهرباء

التوزيع: توزيع الطاقة الكهربائية بواسطة نظام التوزيع

الموزع: أي شركة مرخص لها بتوزيع الطاقة الكهربائية على المستهلكين

القطاع الكهربائي: القطاع المكون من محطات التوليد ونظام النقل ونظام التوزيع ومراكز التحكم والمعدات اللازمة لتشغيله.

التعرفة: الكمية من النقود التي تحدد لغايات بيع وحدة الطاقة الكهربائية للمستهلك ورسوم الربط لايصال التيار الكهربائي للمنشآت.

وحدة الطاقة الكهربائية: كيلوواط ساعة.

عامل القدرة: هو النسبة بين القدرة الفعالة الى القدرة الظاهرة.

المادة الثانية

تطبق التعرفة الواردة في مواد هذا الفصل الاول على شركات توزيع الطاقة الكهربائية في جميع أنحاء فلسطين وفقا لما هو مبين في المواد التالية.

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Council of Ministers / Cabinet Secretariat
State of Palestine

المادة الثالثة

1. يتم احتساب التعرفة الواردة في هذا القرار على اساس اخر سعر شراء للطاقة الكهربائية من المصدر والتي تدخل حيز التنفيذ اعتبارا من تاريخ 13-09-2015.

2. في حال تغير سعر الشراء وفقا لما هو محدد في الفقرة السابقة يتم اعادة احتساب التعرفة بناء على السعر الجديد.

المادة الرابعة

1. يستمر العمل بالدعم الحكومي على أسعار الشراء لشركات التوزيع ابتداء من تاريخ تنفيذ هذا القرار أو لحين حصول تغيير أسعار الشراء من المصدر. ويبلغ مقدار هذا الدعم حوالي 0.0156 شيكل لكل وحدة كهربائية مشتراة من المصدر. ويتم العمل على رفع هذا الدعم تدريجيا كل ستة أشهر وإعادة احتساب التعرفة بناء على التغير في قيمة هذا الدعم.
2. يكون الدعم المذكور في بند 1 أعلاه مشروطا بتزويد شركات التوزيع نسخة عن فواتير الشراء من المصدر للمجلس ويطبق على المناطق المزودة من الشركة القطرية فقط.
3. تقوم الحكومة باستخدام 50% من مقدار التخفيض على أسعار الشراء (ما يعادل 0.0052 شيكل لكل وحدة كهربائية مشتراة من المصدر) لدعم مشاريع الطاقة المتجددة التي يتم تركيبها في المدارس و المستشفيات و التي تحدد بالتنسيق مع وزارة التربية والتعليم ووزارة الصحة.
4. يقوم المجلس بتحديد القيمة المالية للدعم المذكور في بند 2 بشكل شهري بناء على فواتير الشراء المزودة من قبل شركات التوزيع والتي تبلغ حوالي مليون شيكل شهرياء و تقوم الحكومة بتحويلها الى حساب المجلس.

المادة الخامسة

تعرفة المشتركين المنزليين

1. تطبق في جميع المناطق باستثناء مناطق أريحا و الأغوار على المشتركين المنزليين، والبيوت السكنية ضمن مشاريع اسكانية، واماكن العبادة، والمصاعد المستخدمة لدى المشتركين المذكورين في هذه المادة للطور الواحد والثلاثة اطوار والعدادات المسبقة الدفع على النحو الاتي:

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من 1 – ما لا يزيد عن 160 كيلو واط ساعة شهريا	0,4366 شيكل لكل كيلو واط ساعة
من 161 – ما لا يزيد عن 250 كيلو واط ساعة شهريا	0,4707 شيكل لكل كيلو واط ساعة
من 251 – ما لا يزيد عن 400 كيلو واط ساعة شهريا	0,5429 شيكل لكل كيلو واط ساعة
من 401 – ما لا يزيد عن 600 كيلو واط ساعة شهريا	0,5805 شيكل لكل كيلو واط ساعة
أكثر من 600 كيلو واط ساعة شهريا	0,6417 شيكل لكل كيلو واط ساعة

2. تطبق في مناطق أريحا والأغوار فقط على المشتركين المنزليين، والبيوت السكنية ضمن مشاريع اسكانية، واماكن العبادة، والمصاعد المستخدمة لدى المشتركين المذكورين في هذه المادة للطور الواحد والثلاثة اطوار والعدادات المسبقة الدفع على النحو الاتي:

من 1 – ما لا يزيد عن 500 كيلو واط ساعة شهريا	0,4275 شيكل لكل كيلو واط ساعة
أكثر من 500 كيلو واط ساعة شهريا	0,4655 شيكل لكل كيلو واط ساعة
مشتركي عدادات مسبق الدفع (تعرفة مستوية)	0,4513 شيكل لكل كيلو واط ساعة

3. لحين اعادة برمجة وتبديل عدادات الدفع المسبق لتكون قادرة على تنفيذ تعرفة الشرائح تطبق تعرفة مستوية قدرها 0.4750 شيكل لكل كيلو واط ساعة في جميع المناطق ما عدا مناطق أريحا والأغوار. وبعد ذلك يتم تطبيق التعرفة حسب الشرائح المذكورة اعلاه.

المادة السادسة

تعرفة المشتركين التجاريين

تطبق على الفنادق والمباني العامة والمستشفيات، والنوادي الرياضية والاجتماعية والثقافية والمحلات التجارية والشركات الخاصة والعامة والبنوك والمطاعم والملاهي ودور السينما والمخابز العادية ومحلات بيع الحلويات واستوديوهات التصوير وعيادات الاطباء والصيدليات والاشعة والمختبرات ومحلات الخياطة ومحلات بيع الاحذية والمصاعد الكهربائية في البنايات التجارية والمحلات التي تقوم بتنقية وتعقيم المياه وتعبئتها يدويا لاغراض المتاجرة بها ومضخات المياه الخاصة لغاية بيع المياه والمتاجرة بها

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والثلاجات الخاصة بحفظ المجمدات النباتية و الحيوانية للمتاجرة بها ومشاحم ومغاسل السيارات ومحلات البناشر ومحلات تنجيد وكهرباء وميكانيك السيارات ومحلات تصليح الثلاجات والمكاتب والشركات الهندسية والخدماتية والمنشآت التعليمية ومؤسسات المجتمع المدني والدولية ، للطور الواحد والثلاثة اطوار والعدادات المسبقة الدفع للمشتركين المذكورين اعلاه تعرفة مقدارها:

تعرفة مستوية مقدارها	0,5956 شيكل لكل كيلو واط ساعة

بينما تطبق على عدادات مسبقة الدفع للمشتركين التجاريين تعرفة مستوية مقدارها:

تعرفة مستوية مقدارها	0,5684 شيكل لكل كيلو واط ساعة

المادة السابعة

تعرفة المشتركين الصناعيين ومشتركي الضغط المتوسط

1. تطبق على المشتركين الصناعيين المزودين من شبكات الضغط المنخفض والذين يقل استهلاكهم السنوي عن 60,000 كيلو واط ساعة التعرفة التالية:

تعرفة مستوية مقدارها	0,4850 شيكل لكل كيلو واط ساعة

2. تطبق على المشتركين المزودين من شبكات الفولطية المتوسطة 33، 11، 6.6 كيلو فولط التعرفة الاتية فى حال عدم وجود امكانية فنية لتطبيق تعرفة حسب الوقت عليهم:

تعرفة مستوية مقدارها	0,4136 شيكل لكل كيلو واط ساعة

3. بالاضافة لما ورد في بند (1)، يتم تطبيق تعرفة مستوية (صناعي 2) على مشتركي مناشير الحجر والرخام المربوطين على الضغط المنخفض و اللذين يزيد استهلاكهم السنوي عن 60,000 كيلو واط ساعة و لا يرغبون في تطبيق تعرفة حسب الوقت رغم وجود امكانية فنية لذلك:

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تعرفة مستوية مقدارها	0,5238 شيكل لكل كيلو واط ساعة

4. بالاضافة لما ورد في البند (3)، و في حالة رغبة المشتركين اللذين يتم تطبيق تعرفة "صناعي 2" عليهم كما في بند 3 تطبيق تعرفة حسب الوقت عليهم، يلتزم الموزع بتطبيق تعرفة حسب الوقت عليهم شريطة أن تكون من بداية العام و لمدة سنة على الأقل و بشرط توفر الامكانية الفنية لذلك.
5. في حال تجاوز الاستهلاك السنوي للمشتركين الصناعيين المزودين من شبكات الضغط المنخفض عن 60,000 كيلو واط ساعة و لم تتوفر الامكانية الفنية لدى الموزع لتطبيق تعرفة حسب الوقت عليهم، يلتزم الموزع بالاستمرار بتطبيق التعرفة الواردة في بند 1 أعلاه عليهم.

المادة الثامنة

تعرفة ضخ المياه

تطبق على مضخات المياه لاغراض الشرب ومحطات التنقية التابعة لسلطة المياه والبلديات والمجالس المحلية تعرفة مستوية مقدارها:

تعرفة مستوية مقدارها	0,4600 شيكل لكل كيلو واط ساعة

المادة التاسعة

التعرفة الزراعية

1. تطبق على المزارع بكافة انواعها ومزارع تربية المواشي والدواجن والطيور وكذلك ثلاجات التخزين للمنتوج الزراعي الفلسطيني الطازج بين المواسم و ثلاجات تخزين التقاوى والبذور للطور الواحد والثلاثة اطوار، و كذلك تطبق على مضخات المياه الخاصة بالري و الحاصلة على ترخيص زراعي من وزارة الزراعة وسلطة المياه تعرفة مستوية مقدارها:

تعرفة مستوية مقدارها	0,4400 شيكل لكل كيلو واط ساعة

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2. يكون تطبيق التعرفة الزراعية على ابار الري مشروطا بتقديم صاحب البئر نسخة عن رخصة البئر الزراعية من سلطة المياه و شهادة من وزارة الزراعة الى الموزع تبين ان استخدامات البئر هي لأغراض الري.
3. تطبق التعرفة الزراعية المستوية الواردة في بند 1 على المنشات الأخرى التي تحصل على كتاب توصية من وزارة الزراعة بتطبيق التعرفة الزراعية عليها على ان يتم تعويض شركات التوزيع من قبل الحكومة عن فروقات التعرفة ضمن الية يقرها المجلس.

المادة العاشرة

تعرفة انارة الشوارع

تطبق على استهلاك انارة الشوارع والساحات والميادين العامة في المدن والقرى والتجمعات السكانية تعرفة مستوية مقدارها:

تعرفة مستوية مقدارها	0,4500 شيكل لكل كيلو واط ساعة

المادة الحادية عشر

التعرفة للخدمات المؤقتة

تطبق على استهلاك الطاقة الكهربائية للخدمات المؤقتة بما في ذللك الخدمات المؤقتة مسبقة الدفع تعرفة مستوية مقدارها:

تعرفة مستوية مقدارها	0,7540 شيكل لكل كيلو واط ساعة

المادة الثانية عشرة

تعرفة حسب وقت الاستهلاك

1. تطبق على المشتركين الصناعيين المزودين من شبكات الضغط المنخفض تعرفة حسب وقت الاستهلاك في حال تجاوز استهلاك المشترك 60 ألف كيلوواط ساعة سنويا في حال سمحت

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State of Palestine

الامكانية الفنية بذلك فقط. بينما تطبق تعرفة حسب وقت الاستهلاك اختياريا على باقي المشتركين غير الصناعيين المزودين من شبكات الضغط المنخفض في حال تجاوز استهلاك المشترك 60 ألف كيلوواط ساعة سنويا في حال سمحت الامكانية الفنية بذلك فقط. وفي حال رغبة المشترك غير الصناعي في تطبيق تعرفة حسب الوقت، فلا يجوز له طلب ارجاع تطبيق التعرفة المستوية عليه لمدة سنة واحدة على الأقل من تاريخ بدء تطبيق التعرفة حسب الوقت. وتكون التعرفة حسب الوقت المطبقة بناء على شروط هذه المادة للضغط المنخفض على النحو الاتي:

صيف	ضغط منخفض تعرفة A	6.183	0.3767
	ضغط منخفض تعرفة B		0.5408
	ضغط منخفض تعرفة C		1.1894
ربيع وخريف	ضغط منخفض تعرفة A	6.183	0.3602
	ضغط منخفض تعرفة B		0.4400
	ضغط منخفض تعرفة C		0.5303
شتاء	ضغط منخفض تعرفة A	6.183	0.4010
	ضغط منخفض تعرفة B		0.6263
	ضغط منخفض تعرفة C		1.0283

2. تفرض تعرفة حسب وقت الاستهلاك على المشتركين المزودين على شبكة الضغط المتوسط 33 و11 و 6.6 ك.ف في حال سمحت الامكانية الفنية بذلك. وتكون التعرفة حسب الوقت المطبقة بناء على شروط هذه المادة للضغط المتوسط على النحو الاتي:

صيف	ضغط عالي تعرفة A	10.068	0.2886
	ضغط عالي تعرفة B		0.4349
	ضغط عالي تعرفة C		1.0305

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0.2780	10.068	ضغط عالي تعرفة A	[illegible]
0.3491		ضغط عالي تعرفة B	
0.4336		ضغط عالي تعرفة C	
0.3149	10.068	ضغط عالي تعرفة A	شتاء
0.5285		ضغط عالي تعرفة B	
0.8939		ضغط عالي تعرفة C	

المادة الثالثة عشر

انخفاض عامل القدرة

1. في حالة انخفاض عامل القدرة عند المشترك عن 0.92 يترتب علية اتخاذ جميع الخطوات الضرورية وعلى حسابه الخاص لمنع الانخفاض. وفي حالة انخفاض عامل القدرة عن 0.92 يتحمل المشترك بالاضافة الى التعرفة الطاقة الكيربائية التكلفة الآتية:

التكلفة الاضافية المترتبة على الفاتورة الشهرية	عامل القدرة عند المشترك
لا شيء	0.92 او اكثر
0.77% من قيمة الفاتورة لكل 0.01 من عامل القدرة دون 0.92	اقل من 0.92 وحتى 0.70
0.95% من قيمة الفاتورة لكل 0.01 من عامل القدرة دون 0.92	اقل من 0.70 وحتى 0.60
1.20% من قيمة الفاتورة لكل 0.01 من عامل القدرة دون 0.92	اقل من 0.60 وحتى 0.50
1.50% من قيمة الفاتورة لكل 0.01 من عامل القدرة دون 0.92	ما دون 0.50

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2. للمرخص له بالتوزيع وقف تزويد المستهلك بالطاقة الكهربائية اذا تبين له ان انخفاض عامل القدرة لديه يضر بالنظام الكهربائي وانه لم يتخذ الاجراءات الضرورية لتحسين عامل القدرة على ان تقوم الجهة المزودة باعادة تزويده بالكهرباء عندما يصل عامل القدرة للمقدار الذي يحدده المرخص له بالاتفاق مع المجلس .

المادة الرابعة عشر

المقطوعية الدنيا للاستهلاك

تحدد ادنى مقطوعية يومية للمستهلكين على النحو الاتي:

التعرفة	سعر المبلغ المقطوع اليومي بالشيقل
تعرفة المشتركين المنزليين	0,34
تعرفة المشتركين المنزليين (عداد مسبق الدفع)	0
تعرفة المشتركين التجاريين	0,67
تعرفة المشتركين التجاريين (عداد مسبق الدفع)	0
تعرفة المشتركين الصناعيين ض.م	1
تعرفة المشتركين للضغط المتوسط	4
تعرفة ضخ المياة	1
تعرفة انارة شوارع	0,34
تعرفة مؤقتة	0,67
تعرفة مؤقتة (عداد مسبق الدفع)	0
تعرفة زراعية	0,34

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المادة الخامسة عشر

ضريبة القيمة المضافة

جميع التعرفات المحددة وفقا لهذا القرار غير شاملة لضريبة القيمة المضافة.

المادة السادسة عشر

الشرائح

تطبق تعرفة الشرائح على جميع المستهلكين المنزليين بغض النظر عن كمية الاستهلاك.

المادة السابعة عشر

تسديد أثمان الطاقة الكهربائية

تسدد اثمان الطاقة الكهربائية المزودة للمشتركين المنزليين خلال فترة اقصاها 20 يوما من تاريخ استلام الفاتورة بينما تسدد اثمان الطاقة الكهربائية لباقي المشتركين خلال فترة اقصاها 12 يوما من تاريخ استلام الفاتورة . حيث تفرض غرامة تأخيربعد تلك الفترة مساوية للغرامة التي تفرض من قبل مصادر الطاقة الكهربائية.

المادة الثامنة عشر

التحصيل وقراءة العدادات

يتم التحصيل من كافة فئات المشتركين شهريا وتحدد بتعليمات يصدرها مجلس تنظيم قطاع الكهرباء عن كيفية قراءة العدادات.

المادة التاسعة عشر

مراجعة التعرفة

دولة فلسطين
مجلس الوزراء/الأمانة العامة
Council of Ministers / Cabinet Secretariat
State of Palestine

تنفيذا للمادة 14 من قانون الكهرباء العام، يراجع المجلس و بشكل مستمر التعرفة المقرة من مجلس الوزراء ويوصي بتغييرها بناء على أخطاء غير مقصودة تمت لصالح الشركة أولصالح المشتركين أوبناء على التغير في التكلفة.

المادة العشرون

صلاحية التعرفة

يعمل بهذه التعرفة من تاريخ اقرارها من قبل مجلس الوزراء ويستمر العمل بها لحين اجراء المراجعة السنوية.

١٧/٩/١٠ م

دولة فلسطين

State of Palestine

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Distances between Governorates

	Jerusalem	Hebron	Jericho	Bethlehem	Beit Sahour	Beit Jala	Ramallah	Nablus	Jenin	Tulkarem	Qalqilia	Gaza	Rafah	Khan Yunis	Deir Al-Balah
Jerusalem															
Hebron	34														
Jericho	38	70													
Bethlehem	13	24	47												
Beit Sahour	14	26	49	1.5											
Beit Jala	14	25	38	2	3										
Ramallah	19	54	31	30	32	31									
Nablus	67	101	70	77	79	78	50								
Jenin	112	143	109	122	124	123	93	43							
Tulkarem	99	134	99	111	113	112	80	29	52						
Qalqilia	102	146	102	122	124	123	84	32	63	34					
Gaza	97	95	135	118	120	119	101	149	192	179	183				
Rafah	128	125	166	148	150	149	130	180	223	210	214	30			
Khan Yunis	120	116	158	139	141	140	122	172	215	202	206	21	7		
Deir Al-Balah	112	107	150	130	132	131	114	164	207	194	198	12	17	9	

Cost USD/m^3

Origin	Destination	L (m)	ΔZ (m)	h (m)	P (KWh)	C (USD/m^3)
Jenin	Tulkarem	52000	-175	345	0.940125	0.13
Jenin	Nablus	43000	250	680	1.853	0.25
Tulkarem	Jenin	52000	175	695	1.893875	0.26
Tulkarem	Nablus	29000	425	715	1.948375	0.27
Nablus	Jenin	43000	-250	180	0.4905	0.07
Nablus	Tulkarem	29000	-425	-135	-0.357875	-0.05
Nablus	Ramallah	50000	300	800	2.18	0.30
Nablus	Jericho	70000	-800	-100	-0.2725	-0.04
Ramallah	Nablus	50000	-300	200	0.545	0.07
Ramallah	Jerusalem	19000	-500	-310	-0.84475	-0.12
Jericho	Nablus	70000	800	1500	4.0875	0.56
Jerusalem	Ramallah	19000	50	240	0.654	0.09
Jerusalem	Bethlehem	13000	-35	95	0.258875	0.04
Bethlehem	Jerusalem	13000	35	165	0.449625	0.06
Bethlehem	Hebron	24000	210	450	1.22625	0.17
Hebron	Bethlehem	24000	-210	30	0.08175	0.01
Hebron	Gaza North	91757	-920	-2.43	-0.0066217	-0.001
Gaza North	Hebron	91757	920	1837.57	5.0073783	0.68
Gaza North	Gaza	3243	-10	22.43	0.0611218	0.01
Gaza	Gaza North	3243	10	42.43	0.1156218	0.016
Gaza	Deir Al-Balah	12000	35	155	0.422375	0.06
Deir Al-Balah	Gaza	12000	35	85	0.231625	0.03
Deir Al-Balah	Khan Yunis	9000	-5	85	0.231625	0.03
Khan Yunis	Deir Al-Balah	9000	5	95	0.258875	0.04
Khan Yunis	Rafah	7000	-27	43	0.117175	0.02
Rafah	Khan Yunis	7000	27	97	0.254325	0.036

Distances between Governorates

	Jerusalem	Hebron	Jericho	Bethlehem	Beit Sahour	Beit Jala	Ramallah	Nablus	Jenin	Tulkarem	Qalqilia	Gaza	Rafah	Khan Yunis	Deir Al-Balah
Jerusalem															
Hebron	34														
Jericho	38	70													
Bethlehem	13	24	47												
Beit Sahour	14	26	49	1.5											
Beit Jala	14	25	38	2	3										
Ramallah	19	54	31	30	32	31									
Nablus	67	101	70	77	79	78	50								
Jenin	112	143	109	122	124	123	93	43							
Tulkarem	99	134	99	111	113	112	80	29	52						
Qalqilia	102	146	102	122	124	123	84	32	63	34					
Gaza	97	95	135	118	120	119	101	149	192	179	183				
Rafah	128	125	166	148	150	149	130	180	223	210	214	30			
Khan Yunis	120	116	158	139	141	140	122	172	215	202	206	21	7		
Deir Al-Balah	112	107	150	130	132	131	114	164	207	194	198	12	17	9	

Cost USD/m^3

Origin	Destination	L (m)	ΔZ (m)	h (m)	P (KWh)	C (USD/m^3)	C_{pu}(USD/m^3) under energy sources
Jenin	Tulkarem	52000	-175	345	0.940125	0.13	0.14
Jenin	Nablus	43000	250	680	1.853	0.25	0.28
Tulkarem	Jenin	52000	175	695	1.893875	0.26	0.29
Tulkarem	Nablus	29000	425	715	1.948375	0.27	0.30
Nablus	Jenin	43000	-250	180	0.4905	0.07	0.08
Nablus	Tulkarem	29000	-425	-135	-0.367875	-0.05	-0.06
Nablus	Ramallah	50000	300	800	2.18	0.30	0.33
Nablus	Jericho	70000	-800	-100	-0.2725	-0.04	-0.04
Ramallah	Nablus	50000	-300	200	0.545	0.07	0.08
Ramallah	Jerusalem	19000	-500	-310	-0.84475	-0.12	-0.13
Jericho	Nablus	70000	800	1500	4.0875	0.56	0.63
Jerusalem	Ramallah	19000	50	240	0.654	0.09	0.10
Jerusalem	Bethlehem	13000	-35	95	0.258875	0.04	0.04
Bethlehem	Jerusalem	13000	35	165	0.449625	0.06	0.07
Bethlehem	Hebron	24000	210	450	1.22625	0.17	0.19
Hebron	Bethlehem	24000	-210	30	0.08175	0.01	0.01
Hebron	Gaza North	91757	-920	-2.43	-0.0066217	-0.001	-0.001
Gaza North	Hebron	91757	920	1837.57	5.0073783	0.68	0.44
Gaza North	Gaza	3243	-10	22.43	0.0611218	0.01	0.005
Gaza	Gaza North	3243	10	42.43	0.1156218	0.016	0.01
Gaza	Deir Al-Balah	12000	35	155	0.422375	0.06	0.04
Deir Al-Balah	Gaza	12000	-35	85	0.231625	0.03	0.02
Deir Al-Balah	Khan Yunis	9000	-5	85	0.231625	0.03	0.02
Khan Yunis	Deir Al-Balah	9000	5	95	0.258875	0.04	0.02
Khan Yunis	Rafah	7000	-27	43	0.117175	0.02	0.01
Rafah	Khan Yunis	7000	27	97	0.264325	0.036	0.02

Supply Steps for Gaza Strip

Governorate	Population	Ratio	Wells Supply	Springs Supply	Mekorot Supply	Jordan River and Harvesting	Desalination	Reuse
Gaza Strip	2973740	1	167.2	0	6.4	0	129	99
Norht Gaza	582572	0.196	32.76	0	1.25	0	25.27	19.39
Gaza	1030342	0.346	57.93	0	2.22	0	44.70	34.30
Deir Al-Balah	431888	0.145	24.28	0	0.93	0	18.74	14.38
Khan Yunis	562211	0.189	31.61	0	1.21	0	24.39	18.72
Rafah	366727	0.123	20.62	0	0.79	0	15.91	12.21

Total Losses

Governorate	Supplied Water for Domestic Sector (million m³)	Consumed Water (million m³)	Total Losses (million m³)	Total Losses %	Population End of 2015	Daily Allocation per Capita from consumed water (litre/capita/day)
West Bank	**119.6**	**81.2**	**38.4**	**0.32**	**2,636,297**	**84.3**
Jenin	8.8	5.7	3.1	0.35	315,094	49.5
Tubas	2.3	1.4	0.9	0.39	65,787	58.3
Tulkarem	12.4	7.7	4.7	0.38	183,684	114.8
Nablus	16.7	11.3	5.4	0.32	385,145	80.3
Qalqilia	7.0	5.3	1.7	0.24	112,187	129.3
Salfit	2.8	2.3	0.5	0.18	71,503	88.1
Ramallah	16.3	12.3	4.1	0.25	352,462	95.5
Jerusalem	7.5	5.6	1.8	0.24	160,768	95.5
Jericho	6.6	4.4	2.2	0.33	52,858	227.9
Bethlehem	9.2	5.9	3.3	0.36	219,437	73.6
Hebron	30.0	19.3	10.7	0.36	717,372	73.6

Governorate	Supplied Water for Domestic Sector (million m³)	Consumed Water (million m³)	Total Losses (million m³)	Total Losses %	Population End of 2015	Daily Allocation per Capita from consumed water (litre/capita/day)
Gaza Strip	**95.3**	**53.5**	**41.8**	**0.44**	**1,850,559**	**79.2**
North Gaza	24.5	12.5	12.0	0.49	369,949	92.5
Gaza	32.4	19.0	13.4	0.41	635,514	81.9
Deir Al-Balah	14.9	7.5	7.4	0.50	268,918	76.4
Khan Younis	13.8	8.7	5.1	0.37	346,664	68.7
Rafah	9.7	5.8	3.9	0.40	229,514	69.2

جامعة النجاح الوطنية
كلية الدراسات العليا

تقييم الخطة الاستراتيجية لقطاع المياه الفلسطيني مع اعتبار مصادر الطاقة المختلفة باستخدام نظام توزيع المياه (WAS)

إعداد
فادي محمد أحمد جلاد

إشراف
د. عنان فخري الجيوسي

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

2017

تقييم الخطة الاستراتيجية لقطاع المياه الفلسطيني مع اعتبار مصادر الطاقة المختلفة باستخدام نظام توزيع المياه

إعداد

فادي محمد أحمد جلاد

إشراف

د. عنان فخري الجيوسي

الملخص

مصادر المياه في فلسطين محدودة. تقع فلسطين في جنوب غرب قارة اسيا وتعتبر حلقة الوصل بين قارتي اسيا وأفريقيا وتضم 16 محافظة منها 11 محافظة في الضفة الغربية في الجزء الشرقي من فلسطين الى الغرب من نهر الاردن و5 محافظات في قطاع غزة والذي يعتبر المنطقة الجنوبية من السهل الساحلي الفلسطيني على البحر الأبيض المتوسط. تعاني فلسطين من الازدياد في كلا التعداد السكاني ومعدل استهلاك الفرد للمياه.

يهدف هذا البحث الى تقييم الخطة الاستراتيجية لقطاع المياه الفلسطيني التي تم وضعها في عام 2014 وحتى عام 2034 باستخدام برنامج نظام توزيع المياه (WAS)، وادخال مصادر الطاقة المختلفة وأسعارها، وتقدير مدى الجدوى من ربط المياه والطاقة. تقييم الخطة الاستراتيجية لقطاع المياه الفلسطيني يتم من خلال ادخال بيانات الطلب (Demand Data)، بيانات العرض (Supply Data)، والبنية التحتية المتوفرة كمحطات تحلية المياه، خطوط نقل المياه العذبة بين المحافظات، ومحطات تنقية المياه العادمة في برنامج نظام توزيع المياه (WAS) لتشغيله واخراج النتائج.

تقدير مدى جدوى ربط المياه والطاقة يتم من خلال حساب أسعار الطاقة مع اعتبار مصادر الطاقة المختلفة، حيث تم استخدام الطاقة الشمسية في الضفة الغربية لعملية التحلية وضخ المياه، بينما تم استخدام الغاز الطبيعي كمصدر للطاقة في قطاع غزة لعملية التحلية وضخ المياه.

تم تشغيل برنامج (WAS) في ثلاثة سيناريوهات، أولا سيناريو الوضع الحالي حيث تم استخدام بيانات سلطة المياه الفلسطينية للعام 2015، ثانيا سيناريو فلسطين عام 2030 وتضمن خطوط نقل

المياه بين محافظات فلسطين، وثالثا سيناريو فلسطين عام 2030 مع اعتبار مصادر الطاقة المختلفة، حيث أظهرت النتائج أن خطوط نقل المياه العذبة بين المحافظات الفلسطينية يجب انشاؤها وهي فعالة وتخفض أسعار المياه في المحافظات الفلسطينية. كميات المياه المحلاة في قطاع غزة يجب أن تكون 540 مليون متر مكعب مع اعتبار وجود خطوط نقل المياه العذبة بين المحافظات وتكلفة التحلية هي 0.509 دولار لكل متر مكعب، و817 مليون متر مكعب مع اعتبار خطوط نقل المياه العذبة بين المحافظات والغاز الطبيعي كمصدر للطاقة والذي يخفض تكلفة عملية التحلية الى 0.419 دولار لكل متر مكعب.

خطوط نقل المياه العذبة بين المحافظات الفلسطينية في كلا الاتجاهين من المصدر الى الوجهة، ومن الوجهة الى المصدر عند الضرورة هو خيار اداري يجب اعتماده، اعادة استخدام المياه العادمة المعالجة في جميع المحافظات الفلسطينية كمصدر مياه مستقبلي محتمل هو خيار اداري مفضل أيضا. وعلاوة على ذلك، مصادر الطاقة المتجددة خصوصا الطاقة الشمسية لعملية تحلية المياه وضخ المياه في الضفة الغربية، والغاز الطبيعي لعملية تحلية المياه وضخ المياه في قطاع غزة هو خيار مفضل أيضا لجعل عملية تحلية المياه فعالة.