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Palestine Economic Policy Research Institute (MAS)

Future Water Needs in Palestine

Anan Jayyousi
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Palestine Economic Policy Research Institute (MAS)
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FOREWORD

The aim of this study is to estimate water needs in The Palestinian Territories for various uses (municipal, industrial, and cultural) up to the year 2020. The study stresses the vital need of developing additional water resources for Palestine. By the end of the coming decade, an extra 550 million cubic meters a year will be required to meet water needs. This presents an enormous challenge as the current water supply covers just 40% of the estimated water needs in the West Bank and Gaza for the year 2020.

The study applies relatively simple projection methods to estimate water needs in the three main sectors (residential, industrial and agriculture). It is therefore important to stress that the aim of the study is not to make precise projections of future water needs, or to identify all possible water outlets and factors that might affect water consumption. Rather, the aim is to give a general idea of the extent and seriousness of future water shortages in the Palestinian Territories in the near future. Establishing the extent of the problem is meant to invoke the Palestinian policy-makers and decision-takers to take action and work on increasing supplies, on two fronts: First, to increase Palestine's share of the underground and surface water available in the area between the Jordan Valley and the Mediterranean. Second, to initiate serious planning to develop unconventional resources of water, such as water desalination and water treatment stations for brackish and sewage water that can be used for irrigation.

Finally, and on behalf of MAS, I would like to express our gratitude to AECID and ACPP for funding this study and for their support of the Food Security unit at MAS.

Numan Kanafani
General Director

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Abbreviations

Applied Research Institute	(ARIJ)
Central of Housing Rights and Evictions	(COHRE)
Cubic Meters	(CM)
Domestic Resource Cost	(DRC)
Food and Agriculture Organization	(FAO)
Gaza Strip	(GS)
Gross Domestic Product	(GDP)
Hydrological Service of Israel	(HIS)
Jerusalem Water Undertaking	(JWU)
Joint Water Committee	(JWC)
Kilogram	(kg)
Kilometer	(km)
Liters per Capita per Day	(L/c/d)
Milligram per Liter	(mg/L)
Millimeters	(mm)
Million Cubic Meters	(MCM)
Ministry of Agriculture	(MOA)
Ministry of Health	(MOH)
Ministry of Industry	(MOIn)
Ministry of Local Governments	(MOLG)
Ministry of Planning	(MOP)
Ministry of Planning and International Cooperation	(MOPIC)
Meter	(m)
New Israeli Shekel	(NIS)
Non-Governmental Organizations	(NGOs)
Palestinian Central Bureau of Statistics	(PCBS)
Palestinian Water Authority	(PWA)
Palestinian Environmental Quality Authority	(PEQA)
Palestinian Hydrology Group	(PHG)
Regional Water Utilities	(RWUs)
Unaccounted-for Water	(UFW)
United Nations Conference on Trade and Development	(UNCTAD)
United States Agency for International Development	(USAID)
Water Supply and Sewerage Authority	(WSSA)
Water Sector Strategic Planning Study	(WSSPS)
West Bank Water Department	(WBWD)
West Bank and Gaza Strip	(WBGS)
World Health Organization	(WHO)

Executive Summary

The water problem remains one of the most controversial issues needing resolution between Israel and Palestine. The current water crisis is not only a consequence of the water scarcity in the region, but also an inherent part of the general Palestinian-Israeli conflict. For example, the Palestinians have yet to be granted their legal entitlements from the water resources they formally share with Israel.

This paper aims at identifying the future water needs for the Palestinians. The estimate is based on a number of assumptions, combining current levels of water use along with other factors such as improved food security, socio-economic conditions and sustainable yield of the different water resources.

Palestinian per capita water consumption from all sources and for all purposes is very low compared with the average per resident in Israel or in the Israeli colonies (settlements) in the West Bank. In fact, per capita water consumption in the West Bank and Gaza Strip is only 190 liters per day, while per capita water consumption of an Israeli in Israel and in the colonies is 1,000 and 870 liter per day, respectively. Moreover, Palestinians are only allowed to use 15% of total water resources in historic Palestine, while the Israelis use the remaining 85%. The outcome of the study provides guidance to any strategic planning efforts in the future for the water sector in general, and for the food security in particular.

The domestic (municipal) water needs are estimated in this study by using population as the sole factor that determines this type of consumption. The study breaks down the total population between rural and urban both in the West Bank and in Gaza Strip. Results show that water need for municipal use is expected to increase from the current level of 130 million cubic meters (MCM) to 165 MCM in 2010. The number increases further to 218 MCM in 2015 and to 268 by 2020.

The study then incorporates other factors to project the growth in water demand for municipal use other than population growth. These are growth rate of GDP and income elasticity of demand. The analysis shows that water demand will continue increasing even with a stagnant or declining

GDP. The results show that annual growth rate of water for municipal use will be in the range of 1.9 to 5.4%, depending on the growth rate of GDP.

Assuming that the plans for establishing new industrial zones in in different governorates of Palestine will go ahead, water needs for industrial purposes are estimated. Results show that future industrial water needs will increase from the current consumption of 9 MCM to 24 MCM in 2010. The figure increases to 39 MCM by 2020.

Water need for agricultural purposes is estimated on basis of assuming that all irrigable land in West Bank and Gaza will be brought under irrigation. Annual average water requirement per dunum is estimated to be 741 cubic meters. Based on this figure, future agricultural water needs are estimated. Results show that future needs in this category will be 552 MCM for all crops. Translating this figure to per capita base water use for irrigation, the figure turns out to be 145 cm per capita. This is quite similar to the rate in Jordan, but is still below the figures in the Israel.

Total farmers' income that will be generated when full irrigation is achieved is estimated to be $ 423 million. Income to additional hired labour that will be needed when full irrigation is achieved is estimated at about $ 197 million. In total, extra income that could be generated is about $620million, or some 13% of the 2007 GDP. The estimation also shows that about 32,500 agricultural jobs can be generated on full time basis.

In sum, total water needs in Palestine for the three major types of use (municipal, industrial and agricultural) will be around 860 MCM by the year 2020. Current water supply is merely about one-third of that figure.

The study finally stresses the following conclusions:

Based on the research estimates, Palestine should develop some 550 MCM /year in addition to water quantities available at present. To develop this quantity, it is necessary to design policies and strategies to, 1) increase the share of the Palestinians from surface and underground water sources available in the area between Jordan Valley and the Mediterranean, and 2) to develop unconventional sources of water, such as desalination of sea water and treatment of sewage water for irrigation purposes.

1. Introduction

The unique historical water situation in the West Bank and Gaza Strip (WBGS) Governorates has resulted in a low per capita water demand. Water supplies are generally constrained due to technical, institutional and political limitations. In addition, approximately 30% of Palestinian communities are not served, while 66% of the served communities suffer from water shortage especially in summer time (PWA, 2007). Since they do not accurately reflect real demands, current water demands cannot be used to predict future water needs. Future water needs projections should take into account the aforementioned facts in addition to normal assumptions used in predicting demands, like population growth, income growth, modernization and other socio-economic development requirements.

Water has been a major issue in the Palestinian-Israeli negotiations since the early 1990's, but up to this day, little progress has been made. In the Oslo II Agreement of September 1995, Israel recognized Palestinian water rights. This agreement provided some central guidelines for future negotiations about water rights, an essential matter which was deferred to the so-called "final status negotiations" – along with other thorny issues such as Jerusalem, the final borders, the refugees' right of return, the fate of the Israeli settlements, and security.

Many studies conducted recently, such as the comprehensive planning framework and the water sector strategic planning study have indicated that the gap between supply and demand for water will increase dramatically in the coming few years; it is therefore a necessity to seek feasible alternatives to the Palestinian water right issue. All these studies have made different assumptions and few of them have looked at water needs from food security point of view or considered in a comprehensive manner the socio-economic factors that might shape the demand patterns and thus affect the future Palestinian water needs.

The water problem remains one of the most debatable issues needing to be resolved between Israel and Palestine. The current water crisis is not only a consequence of the water scarcity in the region, but also an inherent part of the general Palestinian-Israeli conflict. For example, the Palestinians have yet to be granted their legal entitlements from the water resources they formally share with Israel.

Based on the above discussion, it can be concluded that there is a need to carry out a multidisciplinary research on future water needs for Palestine. The research will be part of future studies to asses the general shape of food security in Palestine under different political and socio-economic scenarios. The outcome of the study will provide guidance to any strategic planning efforts in the future for the water sector in general and for the food security in particular.

This paper tries to identify the future water needs for the Palestinians not only by depending on present consumption, but by also considering issues such as food security, socio-economic conditions and sustainable yield of the different water resources. The sectors covered in this study include municipal, industrial and agricultural sector.

2. BACKGROUND

This section contains background information related to the Palestinian water sector. The aim of this section is to describe the existing conditions that will form the starting point for any projections of future water needs. The section gives background information regarding the following issues:

- Strategic stakeholders in the water sector
- Existing studies and Article 40
- Water resources in historic Palestine
- Present water demands

2.1 Strategic Stakeholders

The Palestinian water sector consists of strategic stakeholder institutions or groups of institutions. The list of these stakeholders and their functions that are related to water are described below.

Palestinian Water Authority (PWA) – Since its establishment in 1995, the PWA has maintained the role of water sector regulator. By its own definition, its roles and responsibilities include (PWA, 2000):

- Secure Palestinian water rights
- Strengthen national policies and regulations
- Build institutional capacity and develop human resources
- Improve information services and assessment of water resources
- Regulate and coordinate integrated water and wastewater investments and operations
- Enforce water pollution control and protection of water resources
- Build public awareness and participation
- Promote regional and international cooperation

The PWA has effectively taken on the role of primary planning agency and the leading regulator for the water sector. Continued efforts to coordinate planning activities with other agencies which have historically planned, operated and maintained water infrastructure (Ministry of Planning [MOP], West Bank Water Department [WBWD], Jerusalem Water Undertaking [JWU]) will improve the efficiency of PWA management and strengthen PWA authority as the sector regulator.

Ministry of Agriculture (MOA) – The (MOA) is responsible for guiding and overseeing the agricultural sub-sector, which represents a major Palestinian water user. The intervention of the MOA in the sector does not involve the direct management of water resources; however, the MOA provides planning for agricultural development and extension services influencing irrigation water use and protection of water quality. These activities have direct impact on water demand from this sub-sector. The MOA is also responsible for reviewing and issuing permits (pending PWA approval) for new irrigation water wells.

Ministry of Planning (MOP) – The MOP is the key planner for Palestinian development in all sectors. In this role, MOP has created development plans covering all sectors of the Palestinian economy. Water and wastewater considerations have always figured prominently in these plans and have been the subject of specific planning studies (MOPIC, 1998). Since the establishment of the PWA, some of the planning responsibilities for the water sector have been transferred to the PWA; however, MOP continues to be a strategic stakeholder in the water sector due to its overall planning responsibility for Palestinian development, and its planning experience.

Ministry of Health (MOH) – The MOH is the regulator of the health sub-sector. In this role, the Ministry of Health is responsible for establishing and regulating health standards and guidelines in the West Bank (WB). These include drinking water standards and guidelines for other uses of water in the WB. Experience and guidance from the MOH directly impacts upon the design and implementation of water development projects and resource management actions.

Palestinian Environmental Quality Authority (PEQA) - The PEQA (formerly the Ministry of Environmental Affairs [MOEA]) is the regulator of the Palestinian environmental sub-sector. This authority does not have direct responsibility for water resources planning and management. However, environmental regulation in the form of policy, standards or law drafted and implemented by PEQA places limits, constraints and requirements on water resources management actions. The influence of PEQA on the water sector concerns both water quality and water quantity.

Ministry of Industry (MOIn) – The Ministry of Industry MOIn serves as the planning agency for the industrial sub-sector. At present, this sub-sector is relatively small; however, a strong potential for its development exists. Planning efforts for industrial development guided by the MOIn will impact water demand in the WB. In addition to planning, the MOIn is responsible for issuing permits (pending review by PEQA) to new industries for industrial development and effluent discharge.

Ministry of Local Governments (MOLG) – The MOLG is the key link between the national government and municipalities. The MOLG represents the municipalities in national decision making and is aware of the specific development requirements of Palestinian municipalities. In the water sector, the MOLG is involved in the coordination of local water sector operations and in processing license applications. The role of the MOLG as local government coordinator and its experience with municipal planning makes the MOLG a strategic stakeholder in the development of Integrated Water Resources Management Plans.

West Bank Water Department (WBWD) – The WBWD is responsible for developing and maintaining bulk water supply in the WB. Its activities include development of new resources and operation and maintenance of wells, pumps, and conveyance systems. Before the establishment of the PWA, the WBWD had primary responsibility for planning development, expansion, and maintenance of the WB water supply system. Since PWA's establishment, some of the planning responsibility has been transferred to the PWA; nevertheless, the WBWD has maintained planning capacity and the department's institutional and operational experience will be important to overall development of the water sector.

The future plan for the WBWD is to transform the agency into a bulk water utility providing wholesale water to the regional utilities. It is expected that the bulk utility will maintain many of the current functions of the WBWD; however, added responsibilities will include WB water resources management and hydrologic and financial accounting.

Regional Water Utilities (RWUs) – The Palestinian water sector has strategically committed to the development of three (RWUs), the Southern, Central and Northern Utilities, for the management of water and wastewater service, operation and maintenance (O&M) of water infrastructure, and fee collection in the WB. An additional regional utility will be formed to support the Gaza Strip (GS). At present, none of these utilities are in operation.

Utility functions in the WB are currently performed directly by municipalities, by the Jerusalem Water Undertaking (JWU) for Ramallah and surrounding areas, or by the Water Supply and Sewerage Authority

(WSSA) for Bethlehem and surrounding areas. These utility service organizations are responsible for distributing domestic water supply and providing sanitary service within the municipality or designated service area. Planning and management activities performed by these utilities are limited to the municipality boundary or service area; however, RWUs are considered a strategic stakeholder because of their institutional experience as a service utility and their close contact with WB water users.

Other constituent stakeholder institutions include:

- Ministry of Justice: influences approval of water law.
- Municipalities and Village Councils: provide support and guidance to the design and implementation of water-related activities.
- Ministry of Finance: provide final approval of water tariff schemes and will aid in identifying financing sources and methods of cost recovery.
- Water Users Association: provides direct feedback to decision makers regarding water-user requirements and concerns.
- Universities: support water sector research activities and train and develop experience of Palestinians working in the water sector.
- Non-Governmental Organizations (NGOs): provide financial and technological support to water sector projects. These NGO's include Palestinian Hydrology Group (PHG), Center on Housing Rights and Eviction (COHRE) through the right to water program, Applied Research Institute of Jerusalem (ARIJ) and many others.

Finally, it should be mentioned that management of the water sector suffers many obstacles including the lack of full control over the Palestinian water resources.

2.2 Existing Studies and Article 40

Numerous studies have been conducted in order to assess and evaluate the availability and sustainability of water resources in the West Bank. Estimates of future water needs have varied. The primary studies on this subject are listed in Table 1.

Table 1: Key Planning and Evaluation Documents

Study Title	Author	Date	Major Topics
Article 40 of the Oslo Accords	Oslo II[1]	1995	Water rights and evaluation of renewable groundwater resources
Comprehensive Planning Framework for Palestinian Water Resources Development	CDM/ Morganti[2]	1997	Local and regional water resources evaluation, planning, management, cost estimation
Regional Plan for the West Bank	MOPIC[3]	1998	Regional evaluation and planning of water resources for the WB governorates
Water Sector Strategic Planning Study	Carl Bro[4]	2000	Strategic planning, water resources evaluation, management, implementation programs, and cost estimates
National Water Plan	PWA[5]	2000	Strategic national planning, water rights, guidance Outlines the Palestinian water sector, management, policy and institutional organization
Master Planning Framework for Palestinian Water Resources Development	CH2M HILL[6]	2001	Local and regional water resources evaluation, planning, management, and cost estimates
Groundwater Resource Modeling and Water Quality Studies (various)	CH2M HILL[7]	1999-present	Water resources assessments, groundwater modeling, water quality analysis
Assessment of Restrictions on Palestinian Water Sector Development	World Bank	2009	It studies effects of restrictions on Palestinian water sector. Effects on water pricing, health status and the agricultural sector are also discussed

1 Oslo II participants and signatories.
2 USAID funded West Bank Water Resources Program Phase I, Consulting Team: CDM/Morganti
3 Ministry of Planning and International Cooperation
4 Carl Bro International and associated firms
5 Palestinian Water Authority
6 USAID funded West Bank Water Resources Program Phase II, Consulting Team: CH2MHILL and associated firms
7 USAID funded West Bank WRP Phase II and III, Consulting Team: CH2MHILL and associated firms

A brief description of these studies is presented below:

Comprehensive Planning Framework of the Water Sector (1997): This study was implemented within the Water Resources Program I funded by USAID and implemented by a group of consulting firms lead by CDM-Morganit in 1996. The study includes a planning framework for the water sector in Palestine for 40 years. The study proposes three scenarios for future water resources and based on these scenarios, alternatives are developed that try to bridge the growing gap between water supply and demand.

Regional Plan for The West Bank (MOPIC) (1998): This study was implemented by MOPIC in 1998. It includes an evaluation, planning management and cost estimations for the water resources in the West Bank Governorates. The study also developed a 20-year investment program for water and wastewater sectors. Mapping efforts and GIS databases were developed during the study.

Water Sector Strategic Planning Study (WSSPS) (2000): This study was funded by the World Bank through the TAFT program. In addition to a strategic plan for the Palestinian water sector, the study developed a 20 year investment program for water and wastewater sectors. The plan and investment program were based on the PWA strategy and policy principles.

The National Water Plan (2003): This plan was based on the WSSPS mentioned above. The plan describes the vision, mission, goals and the role and action of the PWA considered from a strategic planning point of view.

Master Planning Framework for Palestinian Water Resources Development (2001): This study came within the Water Resources Program II funded by USAID and implemented by a group of consulting firms lead by CH2MHill in 2001. It includes a planning framework for the water sector in Palestine with a 40 year horizon and was based on the 1997 comprehensive planning framework. The study developed a DSS tool to be used by decision makers in the water sector.

Groundwater Resources Modeling and Water Quality Studies (2005): This project is funded through USAID and executed by CH2MHill between 1999 and 2005. The project produced a sustainable management plan for some of the West Bank aquifers. Based on groundwater modeling results from these aquifers, recharge rates and management options for sustainable utilization were established. The project also included some water quality studies and data collection.

Assessment of Restrictions on Palestinian Water Sector Development (2009): This report is the Bank's first on the issue of water in the WBGS. The report examines access to water in the WBGS and provides comprehensive insight into a critical, but largely unaddressed component of the economic restrictions impeding Palestinian economic development, limited access to natural resources. The report studies effects of water restriction on water pricing, health status, and agricultural development.

Article 40 (Water Resources) of the Oslo Accords

The Declaration of Principles signed on September 13, 1993 (Oslo I) is the first bilateral agreement between the Palestinians and Israelis. According to this agreement, the Permanent Palestinian-Israeli Committee would discuss water resource issues for Economic Cooperation. The parties agreed to prepare plans for water rights and equitable use of water resources. However, the agreement did not identify or establish any explicit water rights for the parties.

Article 40 of the Oslo II Agreement, signed on September 18, 1995, is the basis for water sector planning and project implementation. This binding agreement regarding water and wastewater became the basis for water sector planning during the "interim period" and until the final agreement was reached. The agreement states that the interim period should not exceed 5 years from the date of the signing of Oslo II, or September 2000.

'Principle One' of the water section of Oslo II is the most significant element of the agreement. It states, "Israel recognizes the Palestinian water rights in the WB." These rights will be settled in the permanent status agreement after the final negotiations. This was the first time the Israeli government explicitly acknowledged the Palestinians' sovereign right to water on the WB.

The overall implications of Article 40 on the water sector are however negative. The approval process within the Joint Water Committee (JWC) established after Oslo II has prohibited the implementation of many crucial Palestinian water projects.

2.3 Water Resources in Historic Palestine

2.3.1 Groundwater Basins

Since the partition of Palestine in 1948 (which was instigated by the League of Nations to accommodate the creation of the State of Israel), water resources of pre-1948 Palestine have been studied and presented according to political boundaries since the political interest of Israel has dominated many water issues. Subsequently, and following several wars (e.g., 1967, 1973 and 1982 wars and invasions) between the Arabs and the Israelis, the latter put under their control the water resources of the entire region which includes the water resources of the WB, GS, and some territories from Syria and Lebanon. This situation continued for several decades during which the Israelis imposed strict measures to prevent the Palestinians from developing their water resources. After the creation of Israel and each war and invasion against Arab lands, the Israelis launched major well drilling programs in support of Israeli settlements and communities. The Israeli policy in respect of water has proved highly discriminatory and inequitable and weakened the Palestinian and Arab water rights. Israeli settlements in the WBGS have water on tap almost twenty four hours a day. Before the Oslo accords, many Palestinian areas had their water supply rationed to a few hours per week. Even after Oslo II and the establishment JWC, the Israeli policy to improve the water situation for the Palestinians proved largely ineffectual.

The Israeli practices outlined above put them in a position to study in detail the water resources of the entire region and consequently Israel has produced many reports and studies, most of which were released with the indirect aim of protecting a political interest to control the region's water resources. Caution should be given when considering the Israeli data and figures about the water resources of the region. This is applicable to Table 2, which summarizes the groundwater system in the region (Palestine and Israel). The data in Table 2 is taken from the Hydrological Service of Israel, (HSI, 2006). This reference is in Hebrew and is the only official reference that is made available to the Palestinians.

Table 2 shows that the Israelis and Palestinians jointly use the following aquifer basins; the Coastal Aquifer Basin, the Western Aquifer Basin and the Northeastern Aquifer Basin. Table 2 reflects the Israeli claim that the overall balance of the basins is negative [-212 million cubic meters per year (MCM/year)] such that the total annual net recharge to the groundwater basins is around 1833 MCM/year while the annual productivity of the aquifer basins is estimated at 2,045 MCM/year. At the same time, Israelis in the same report, (HSI, 2006) claim it is possible to develop huge volumes of water (through many well-fields) in the Tabariya Aquifer Basin. It is important to note that this Basin is on the boundaries between Israel, Jordan and Syria and this Israeli report does not acknowledge this fact.

Table 2: Water Balance for the Groundwater Basins in the Region* (MCM/year)

Basin	Natural Recharge	Return Flow	Abstraction	Spring Discharge	Yield
(1) Coastal	299	136	420	-	420
(2) Western	366	16	399	52	451
(3) Western Galali	194	-	82	51	133
(4) Karmel	39	-	36	6	42
(5) Tabariya	550	-	58	466	524
(6) Eastern and Northeastern	330	-	148	238	386
(7) Nagab and Arabah	55	67	89	-	89
Total	1833	152	1232	813	2045

Source: Hydrological Service of Israel, HSI, Annual Report (2006).
*Data may be inaccurate and released by the Israelis for political reasons

2.3.2 Groundwater Resources in the West Bank and Gaza

The West Bank Groundwater Resources

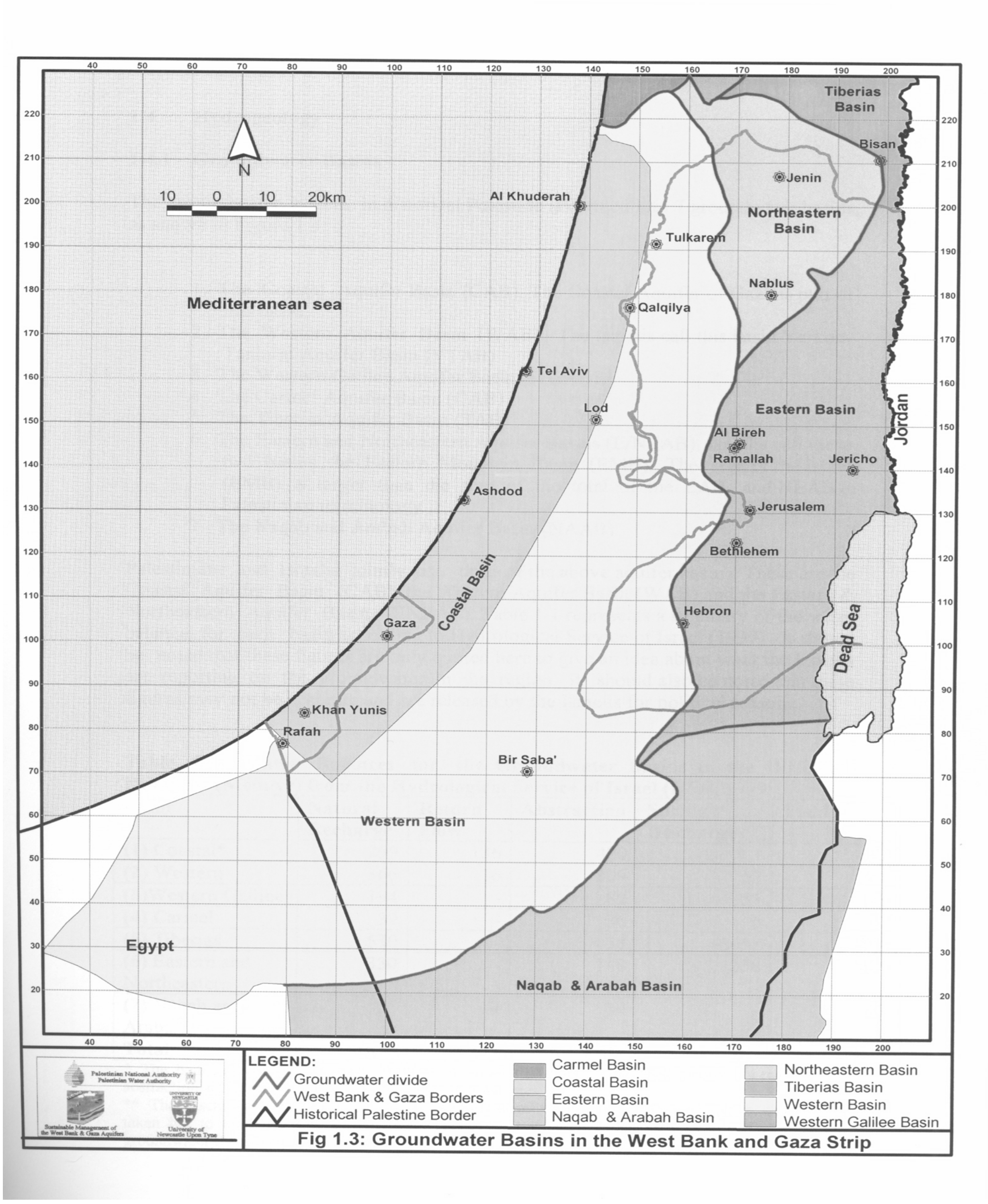
The WB is a hilly area, the hills being used for pasture, with elevations varying from 400 m below sea level in the Jordan Valley to 1000 m above sea level in the hills. These mountains have terraced valley flanks and valley floors and used to support subsistence arable cropping and commercial olive cultivation. The rainfall of the WB (Husary et. al., 1995) is strongly seasonal (October to May) and orographic [700 millimeters (mm) in the mountains and 100 mm in the Jordan Valley]. The surface geology of the WB is comprised of well-fractured and karstified carbonate rocks, both limestone and dolomite. Various geological formations are generally non-covered and show outcrops at the surface. This is true even for the very deep formations. Outcrops appear at the top of hills as a result of strong folding and faulting. Therefore, it is likely that these hills are major recharge zones for the WB aquifer systems, especially in the non-developed and non-covered areas. The existing water resources of the WB are derived from three groundwater aquifer basins (Eastern Aquifer Basin, Western Aquifer Basin, and North-eastern Aquifer Basin), a series of springs that emanate from the groundwater. At the present time, the groundwater and springs provide essentially all of the consumed water in the WB. The yields of the WB Aquifer Basins are not certain because of the lack of understanding of the water balance of these basins. The uncertainty of the yields of the three aquifer basins appear in the wide ranges provided for each basin as shown in Table 3. Figure 1 shows these aquifer basins.

Table 3: Reported Recharge from Aquifer Basins

Aquifer Basin	Recharge Rates (MCM/year)	Oslo II Rates MCM/year
Eastern	100-172	172
Northeastern	130-200	145
Western	335-380	362
Total	565-752	679

Source:
Article 40, Oslo II Agreement, September 18, 1995.
A Report Under Water Resources Program, 1997, comprehensive Planning Framework for Palestinian Water Resources Development, USAID and PWA.

Figure 1: Groundwater Basins in the West Bank and Gaza Strip



Source: Water and Environmental Studies Center (WESC), 1995, Middle-East Regional Study on Water Supply and Demand Development, Revised Draft Report Phase I. Nablus

In the WB there are four aquifers:

(1) *The Shallow Aquifer.* The Pleistocene, Ploicene-Miocene (Neogene) and Eocene ages represent this aquifer. The Pleistocene Aquifer is important to agriculture in the Jordan Valley. The aquifer consists mainly of unconsolidated beds of sands, gravel, cobbles and boulders separated by impermeable layers of saline marl deposits. The aquifer is of low to fair potential. The water quality is variable [Chloride level from 100 milligram per liter (mg/L) to more than 2000 mg/L]. The Palestinian and Israeli abstractions from the Pleistocene Aquifer in the WB are 10.3 and 1.25 MCM/year respectively. The Ploicene-Miocene (Neogene) Aquifer is of local importance at the northeastern boundary of the WB. The aquifer consists of well-cemented conglomerates of high permeability. Its water quality is good (about 70 mg/L of chloride concentration). The aquifer is of limited extent and thickness (around 100 m). The Palestinian and Israeli abstractions from the Neogene Aquifer in the WB are 0.72 and 6.14 MCM/year respectively. The Eocene Aquifer is extensively used for irrigation in the Faria and Jenin areas. The aquifer comprises of nummulitic limestones with chalks, chert bands and marl. The limestones are of limited thickness and they contain chalk, chert and marl intercalations which reduces the aquifer's potentiality. The yield of this aquifer is highly dependent on rainfall. The Palestinian and Israeli abstractions from the Eocene in the WB are 12.12 and 0.0 MCM/year respectively.

(2) The Upper Aquifer. This aquifer is represented by the formations of the age Turonian and Upper Cenomanian. The Turonian Aquifer consists of massive and thick limestone (sometimes thinly bedded limestone), and dolomitic limestone with well-developed karst features. The Turonian aquifer is part of the Upper Aquifer but can represent a local aquifer by its own if the formation beneath it acts as an aquitard. The aquifer is considered fairly good aquifer especially where the saturation thickness is in tens of meters. The water quality of this aquifer is generally good but in some area there is an evidence of deterioration because of sewage and agro-chemical pollution. The Upper Cenomanian Aquifer consists mainly of interbedded dolomites and chalky limestones. The aquifer is an important regional source of water supply for domestic uses. The well depths are less than 400 m with some exceptions. The depth to water is rarely more than 200 m below ground surface. The Aquifer has high recharge values. Its water quality is generally good (30-150 mg/L of chloride). The Palestinian and Israeli abstractions from the Turonian-Upper Cenomanian Aquifer in the WB are 27.09 and 8.91 MCM/year respectively.

(3) *The Lower Aquifer.* The high water bearing capacity and productivity of this excellent regional aquifer of Lower Cenomanian age is owed to the great thickness of dolomitic limestones and limestones. Water quality is generally good with chloride values in the 20-50 mg/L range, though slightly higher salinities have been encountered towards the Jordan Valley. The Palestinian and Israeli abstractions from the Lower Cenomanian Aquifer in the WB are 12.13 and 25.46 MCM/year respectively.

(4) *The Deep Aquifer.* The lower Albian and Neocomian ages form the Deep Aquifer. The aquifer is not yet fully explored and it seems there is a great change in the characteristics of aquifer from the middle to the north of the WB. In general, the aquifer seems to be of low potential.

Gaza Strip Groundwater Resources

Groundwater in GS, which accounts for almost 98 percent of the current use, is the only significant source of water for the people of GS; the remaining supplies are purchased from the Israeli Company Mekorot. Surface water that might be available from Wadi Gaza is diverted outside of the area.

The Gaza coastal aquifer consists of sand, sandstone, poorly consolidated shelly sandstone and pebbles of Pleistocene age. Semi-impervious silty-clayey layers are scattered in the aquifer. Gaza coastal aquifer is shallow with depths to water table range from 70 m in high topographic areas to less than 5 m in the low topographic lands near the coast. The aquifer is highly permeable and porous. The aquifer thickness can reach up to 160 m near the shoreline.

Rainfall is the major source of groundwater replenishment in GS. Rainfall either recharges the groundwater or is collected in cisterns and used immediately. It is estimated that almost 40 percent of the total annual rainfall infiltrates into the ground and recharges the groundwater system. The Ministry of Planning and International Cooperation (MOPIC, 1996) reported that the recharge percentage might approach 60 percent in sandy areas whereas it varies from 15 percent to 40 percent in clay areas.

Other sources of groundwater replenishment include groundwater flow from the eastern side, infiltration from surface water runoff, pipe leakage, infiltration of untreated wastewater, and return flow irrigation. Estimates of the quantity recharged into the GS Aquifer from the various sources are summarized in Table 4 below.

Table 4: Groundwater Replenishment for the Coastal Aquifer of Gaza Strip

Sources of Return Flow	Estimated Quantity (MCM/year)	(%) of Total
Rainfall	46	41
Groundwater Flow from the East	7	6.3
Surface Water Infiltration	2	1.6
Pipe Leakage	13	11.6
Untreated Wastewater	14	12.5
Irrigation	30	26.8
Total	112	100

Source: Coastal Aquifer Management Plan (2000), A study funded by USAID for PWA.

The water resources of GS face severe water pollution and salinisation problems. The high levels of chlorides, nitrates, faecal coliforms and heavy metals have rendered the GS water un-potable in a number of regions. The problem of water quality is getting worse in GS because the Israelis have diverted Wadi Gaza before it reaches GS borders and they also intercepted most of the groundwater moving towards Gaza Aquifer by sinking hundreds of wells just outside GS borders.

2.3.3 Surface Water Resources

Surface water in the WB consists mainly of Jordan River along with its tributaries and Wadi floods in high rainfall years.

Wadis

Surface water flow in wadis is referred to as surface runoff, and depends mainly on the quantities and duration of rainfall during the wet season. It was found that surface runoff occurs when rainfall exceeds 50 mm in one day or 70 mm in two consecutive days. The total runoff in the WB is estimated at 64 MCM/year. Different studies on water and wastewater shows that some 20 MCM/year could be utilised from surface flood water in major wadis by the construction of storage dams in these wadis (MOPIC, 1998).

Wadis in the WB are divided into two major groups: eastern wadis and western wadis. Eastern wadis flow from the central mountain towards the

Jordan Valley, and contribute to the recharge of shallow aquifers, and the Jordan River. Western wadis flow from the central mountains in a westerly direction towards the Mediterranean Basin. These wadis are of importance for surface water streams, where floods from different wadis coincide together to form major streams which discharge into the Mediterranean Sea.

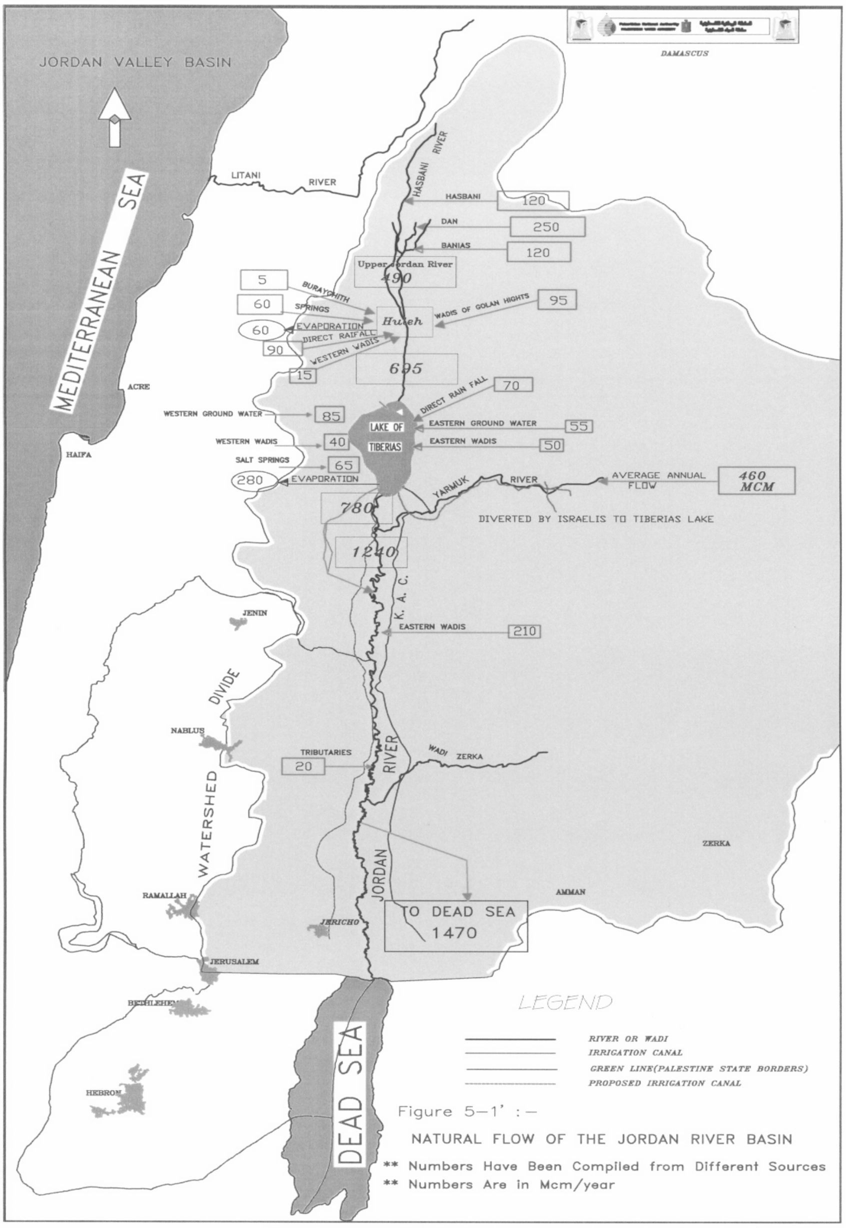
The Jordan River System

The Jordan River flows from north to south from an elevation of 2,200 m above mean sea level at mount Hermon to about 395 m below mean sea level at the Dead Sea. The Jordan River passes a straight distance of about 140 km with a river length of about 350 km due to its tortuous path.

In the northern part (from Al-Huleh to the north), the Jordan River is surrounded with high hills. Form Al-Huleh to Lake Tiberias; the Jordan River divides the lands. The slope of the land and accordingly the riverbed is slight and directed toward the south. Much steeper gradients than the Jordan River itself are found in all of its tributaries. Figure 2 shows the water balance of the Jordan River basin and its tributaries. As shown in the Figure, the natural flow of the river in the absence of extraction is estimated at 1300 -1800 MCM/year at the entrance to the Dead Sea. Table 5 shows the water flow rates for the Jordan River and Dead Sea Basin compiled from various sources (GTZ, 1996).

The catchments area of the Jordan River and Dead Sea basins is about 40,650 km^2. Table 6 shows the areas and rainfall supply of the catchments within the basin. From this Table, it can be seen that although the WB has 7% of the total catchments area of the basin, it has 11% of the catchments area with more than 300 mm of annual rainfall. In comparison, the area of Israeli catchments is 19% of the total catchments area of the basin, but Israel has only 12% of the catchments with rainfall more than 300 mm/year. This is because 4,780 km^2 of the Israeli catchments are located in Wadi Araba where rainfall is about 50 mm/year (GTZ, 1996).

Figure 2: Natural Flow of the Jordan River Basin



Source: Water and Environmental Studies Center (WESC), 1995, Middle-East Regional Study on Water Supply and Demand Development, Revised Draft Report Phase I. Nablus

Table 5: Water Flow Rates for the Jordan River and Dead Sea Basin Compiled From Various Sources

Description	Ali1 MCM/ Year	Naff & Matson3 MCM/Year	Gwyn & Rawly4 MCM/Year	Dabagh2 MCM/ Year	Jor. 3 MCM/ Year	Isr. MCM/ Year	Average MCM/ Year
Ash-Shareea’							
Hasbani	157	138	125	157		120	147
Banias	157	121	125	157		120	143
Dan	258	245	250	258		270	259
Springs & Wadis	328	340	---	300		360	292
Total	**900**	**844**	**---**	**872**		**870**	**841**
Lake Tiberias							
Ash-Shareea’	900	844				870	841
Evaporation	-300	-270				-280	-274
Tributaries	---	---				70	---
Total	**600**	**574**				**660**	**567**
Jordan River							
L. Tiberias	600	590				660	567
Yarmouk	475	500	500	467	260	460	478
Zarqa	---		80	92	87	---	75
Wadi	232				161 (east)	---	191
Total (Dead Sea)	**1307**					**---**	**1311**

Jor. Jordanian World Bank Study (1978).
Isr. Israeli World Bank Study in 1986).
Ali Mohammad, Jordan River and the Zionist Conspiracy (in Arabic). National Publishing and Printing House, Cairo, 1964, p 25.
Mustafa Al-Dabagh, Biladuna Falastin (in Arabic), Dar Al-Talia’a, Beirut, 1965, pp 15-23.
Thomas Naff and Ruth Matson, “Water in the Middle East - Conflict or Cooperation”. A Westview of Pennsylvania, 1984 pp 1-14.
Gwyn, R., Israel into Palestine, Mansel Publishing Limited, London, 1984.

Different measures (such as draining of Al-Huleh Lake and transferring saline/brackish water of salty springs to Lower Jordan discharging of industrial wastewater) have been implemented on the Jordan River by Israel, which affected its natural flow, deteriorated the environment and adversely impacted the regional ecology.

Israel has for a long time been transferring huge quantities of surface water through the National Water Carrier from Upper Jordan to Negev primarily for irrigation purposes. The transferred quantities nearly equal the annual discharge of the three main tributaries of the Jordan River. This is an illegal unilateral action that adversely affects the other riparian rights and embezzles water from the Jordanian River basin.

Table 6: Areas of Catchments and Rainfall Supply in the Jordan and Dead Sea Basin

Country	Name of Catchments	Area (Km^2)	Average Annual Rainfall over Basin (mm)	Average Annual Supply from Rain (MCM)	Area Covered by Isohyets over 300mm (Km^2)
Israel	Upper Jordan	1160	678	786	1160
	Jalout V.	560	441	247	560
	Hebron	1190	122	145	0
	Wadi Araba	4780	50	239	0
	Total	**7690**	**184**	**1417**	**1720**
Syria & Lebanon	Upper Jordan	1580	928	1466	1580
	Yarmouk	5840	395	2307	4532
	Total	**7420**	**508**	**3773**	**6112**
Jordan	Yarmouk	1410	343	483	710
	Ajlun	1250	525	656	1093
	Wadi Zarqa	2960	291	860	1050
	Salt	570	360	206	348
	Madeba	980	306	300	561
	Wadi Wala	2050	201	410	420
	Wadi Mojeb	4460	126	563	430
	Kerak	840	224	189	315
	Wadi Hesa	1750	162	283	250
	Wadi Araba	3020	112	338	200
	Total	**19290**	**222**	**4288**	**5377**
West Bank	Nablus - Jenin	1400	389	545	943
	Jerusalem - Hebron	1350	331	447	695
	Total	**2750**	**361**	**992**	**1638**
Egypt	Wadi Araba	3500	50	175	0
Total		**40650**	**---**	**10645**	**14847**

Source: Water and Environmental Studies Center (WESC), 1995, Middle-East Regional study on Water Supply and Demand, Revised Draft Reports Nablus.

Pre-1967, the Palestinian people in the WB were using and had developed the water resources in the Jordan River Basin. This increases their rights to the Jordan River resources according to the International Water Law, since they had 'prior use' of it and had developed the water resources.

Most of the Jordan River riparians consume water to fulfill their needs from the basin and the small quantity that reaches the WB is of bad quality and cannot be used. In addition, agricultural return flows and mismanagement of untreated wastewater by the Israeli colonies in the Jordan Valley are the main sources of pollution to the Lower Jordan River.

2.4 Present Water Supply

This section describes the present water supply conditions for the different sectors including domestic, industrial, and agricultural sectors.

2.4.1 Present Domestic Water Supply and Consumption

The water supply rates during occupation in the WBGS have been artificially constrained by non-market forces. Therefore, these rates cannot be used to forecast future water needs. In fact, on the basis of various world and regional water consumption levels, the present magnitude of unsatisfied demand in the WBGS nearly surpasses current quantities supplied. Thus it is necessary to plan for and develop more equitable, yet feasible, future water consumption rates and supply capabilities for needed social and economic development.

The total water use by the domestic and municipal sectors in the WBGS during 2006 was estimated to be 130 MCM/year. An amount of approximately 75 MCM/year was used in the WB, whereas a total of approximately 55 MCM was used in GS.

Water Supply and Consumption in the West Bank
Based on the above numbers, the overall supply rates (including losses) for urban domestic purposes in the WB were estimated to vary between 46 liters per capita per day (L/c/d) in Tubas and 175 L/c/d in Jericho. These figures give a weighted average (which also accounts for population and supply in piped and un-piped localities) of about 97 L/c/d is estimated.

The total water consumption for urban and domestic purposes in the WB is based on estimates for unaccounted-for water (UFW), losses, rates for various governorates and the above mentioned supply rate. The overall loss or unaccounted-for water (UFW) rate was estimated to vary between 25 percent (in Ramallah) and 45 percent (in Jericho), with an average of 37 percent of the total supply.

This UFW in piped areas comprises:

- physical losses at the source. main transmission system, and distribution network;
- unregistered connections, and
- meter losses

No accurate records of domestic water consumption rates are currently available, as quantities allocated to the various sectors (i.e., domestic, public, industrial, touristic, and commercial) cannot be separated. Domestic water consumption rates were grossly estimated to vary between approximately 50 L/c/d and 90 L/c/d with an average of about 70 L/c/d. These estimates were developed assuming that water consumption rates for public, industrial, and commercial uses are about 12 percent of the total consumption quantities, based on data available on selected area in the WB. These domestic water consumption rates are lower than the World Health Organization (WHO) minimum value of 100 L/c/d due to the Israeli restrictions on water usage by the Palestinians (WHO, 1993).

Some of the water supplied by the Palestinian utilities (approximately 7 percent of the total supplied water) is purchased in bulk from Israeli Utilities. Accordingly, only 76 percent of the water supplied to piped areas is owned by Palestinian utilities, whereas the remaining 24 percent is purchased from Israeli utilities.

The MOA has furnished data on the livestock water consumption in the WB. The data indicates that the total livestock water consumption was about 6.6 MCM/year during 1997. This quantity was estimated for various types of animals and livestock. Water for livestock consumption is supplied from different sources, which include the municipal system, irrigation wells, springs and cisterns.

Water Supply and Consumption in Gaza Strip

In GS, approximately 55 MCM/year was used in the urban domestic sector in 1997. About 52.1 MCM/year was supplied from wells and the remainder was purchased from Mekorot. For this analysis, all of the localities in the GS are considered to be connected to a pipe distribution system. The total average use is estimated to be 134 L/c/d.

In GS, the overall loss rate was estimated to be about 45 percent, of which 40 percent was estimated to constitute physical losses out of the system and 5 percent unregistered connections and meter losses. It is expected that some or most of the unregistered connections are included in the total use figure and, therefore, the actual consumption rate could be about five percent higher.

The per-capita domestic consumption rate was estimated to be approximately 80 L/c/d. The estimate was developed assuming that the public, industrial and commercial sectors (including minor quantities for livestock) would require approximately 12 percent of the total supply.

The per-capita consumption does not, however, present the entire picture in the GS. As mentioned in a previous section, the groundwater is of poor quality with only a small percent considered potable and the majority of the water is classified as having poor quality. Therefore, the poor water quality exacerbates the adverse impact of low per-capita consumption.

Only about 4 MCM out of the 52.1 MCM/year supplied by municipal wells may be considered acceptable (based on health considerations). Thus, the total acceptable quantity of water supplied would be about 8.9 MCM/year in GS. This 8.9 MCM/year corresponds to approximately 15 percent of the total supply quantity, and translates to an acceptable per capita supply rate for domestic use of only about 13 L/c/d. It should be noted that such a quantity may actually be less than that if the weighted average of concentrations is considered in the analysis.

No estimates were obtained for livestock water use in the GS; however, the consensus is that the quantities are minimal and are included in the estimates of supply for urban, industrial, and agricultural purposes.

2.4.2 Present Industrial Water Supply

Due to the constraints imposed on this economic sector in Palestine during the last 40 years of occupation, the industrial sector had a limited contribution to the overall economic development. Consequently, the existing situation of the industrial sector in Palestine, which consists mainly of light and small industries, does not represent the actual stable industry that should be achieved in Palestine. This implies that the current industrial water demand cannot be utilized for the projection of the future water needs. Types of existing Palestinian industries range between quarries and food processing and others.

The Present industrial Water consumption is included in the total present domestic consumption and is very difficult to estimate. The National vision regarding this sector in reference to different studies carried out by

MOPIC and MOIn is the establishment of 9-13 Palestinian industrial estates of which eight are distributed between the different Governorates of the WB and four in the GS.

The total area of the industrial zones that are in operation in the WB is around 7 Km^2 with some 14,105 industrial firms distributed inside the municipal areas as follows:

Table 7: Distribution of Industrial Zones (Palestinian Territories)

Location	No. of Industrial firms
Jerusalem	974
West Bank & Gaza Strip	13,131
Total	**14,105**

Source: Compiled by the Authors from unpublished Data from the Ministry of Industry.

The industries types and volumes are shown below in Tables 8 and 9 for Jerusalem Governorate and for WB and GS respectively according to data obtained from the Ministry of Industry.

Table 8: Jerusalem Governorate Industries

Industry	# Firms	% Percent
Mining & Quarrying	3	0.3
Food & Beverages + Tobacco Products	125	12.8
Textiles	24	2.5
Wearing apparel + Tanning of Leather	136	14.0
Wood Products	50	5.1
Paper Products + Publishing	44	4.5
Chemical Products + Rubber & Plastics	14	1.4
Non-Metallic Products + Basic Metals	63	6.5
Metallic Products	290	29.8
Machinery & Equipment + Electrical Machinery + Medical, Optical Equipment	20	2.1
Furniture and others	200	20.5
Electricity & Water Supply	5	0.5
Total	**974**	**100.0**

Source: Compiled by the Authors from unpublished Data from the Ministry of Industry.

Table 9: West Bank and Gaza Strip Industries

Industry	# Firms	Percent
Other Mining and Quarrying	228	1.7
Manufacture of Food and Beverages	1,372	10.4
Manufacture of Tobacco products	10	0.1
Manufacture of Textiles	273	2.1
Manufacture of Wearing apparel	2,421	18.4
Tanning of leather; Manufacture of bags	675	5.1
Manufacture of Wood and its products	713	5.4
Manufacture of paper and its products	50	0.4
Publishing, printing and reproduction	162	1.2
Manufacture of chemicals and its products	191	1.5
Manufacture of Rubber and Plastic	156	1.2
Manufacture of non-Metallic Products	1,902	14.5
Manufacture of Basic Metals	30	0.2
Manufacture of Metallic products excluding Machinery	2,784	21.2
Manufacture of Machinery and Equipment	215	1.6
Manufacture of Electrical Machinery	100	0.8
Manufacture of Medical, optical equipment	57	0.4
Manufacture of motor Vehicles, Trailers	22	0.2
Manufacture of other transport equipment	11	0.1
Manufacture of Furniture, Others	1,759	13.4
Total	**13,131**	**100.0**

Source: Compiled by the Authors from unpublished Data from the Ministry of Industry.

According to PWA estimates and the suggestions and proposals of Palestinian ministries and institutions, it was found that the present industrial water demand in Palestine represents 8% of the total municipal water demand. In fact, water municipal water demand is 101.3 MCM/year and industrial water demand is 8.3 MCM/year.

However, the available statistics on that figure vary considerably. This is mainly due to the difficulty in calculating the exact consumption of industry since it is combined with domestic consumption.

2.4.3 Present Agricultural Water Supply

In Palestine, agriculture is one of the main productive economic sectors. In the early 1970s, it used to contribute to about 36% of the Gross Domestic Product (GDP) and to employ 42% of the labor force (UNCTAD, 1991). In 2007, it contributed 8.2% of the GDP and employed 15.6% of the labor force (MAS, 2009). The agricultural sector plays a central role in ensuring Palestinian food security. Despite the small size of the WB, the area enjoys a diversity of climatic regions, which makes it possible to grow almost anything, all year round. In 2007, rain-fed cultivation formed the largest cultivated area, 88.2%, while irrigated land formed only 11.8%. Almost 92.7% of total irrigated areas in the WB are concentrated in the two agro-ecological areas, the semi-coastal region and the Jordan Valley. Vegetables constitute 67% of the total irrigated areas (PCBS, 2008a).

In the 2006/2007 agricultural season, fruit trees formed about 63.5% of the cultivated area in the Palestinian territory, while field crops and vegetables constituted 26.3% and 10.2%, respectively. More than 90% of the area cultivated with fruit trees in the GS was irrigated. On the contrary, almost 98% of the total cultivated area of the WB was rain-fed. As for vegetables, 75% of the vegetable area in the WB was irrigated while the rest was rain-fed. Field crops were mostly cultivated using rain-fed irrigation, almost 93% (PCBS, 2008b).

Table 10: Area and Total Production a of Crops in the WBGS, 2006\2007

Product	Area (dunums)	Production (Tons)
Irrigated Wheat	3,980	1,194
Rain-fed Wheat	198,353	38,679
Irrigated Citrus	23,326	58,238
Irrigated Fruits	22,263	40,572
Rain-fed Fruits	164,153	104,808
Irrigated Olives	23,961	16,413
Rain-fed Olives	875,762	34,155
Irrigated vegetables	150,622	624,606
Rain-fed vegetables	36,722	20,550

PCBS, Agricultural Statistics 2006/2007, December, 2008

During the period 1967-2008, a mix of economic and political considerations shaped Palestinian agricultural practices. In irrigated agriculture, economic issues forced Palestinians to shift from fruit trees to high cash value crops such as vegetables. In rain-fed farming, Palestinians shifted from field crops to olives because income generated from field crops is lower. Olives do not require a lot of work, and the planting of olives indicates that the land is cultivated.

As a result, it can be concluded that the country has moved away from agricultural food security. Palestine has not been self-sufficient in producing field crops and livestock products, particularly red meat and milk. Table 10 summarizes total area cultivated and total production of main agricultural products (PCBS, 2008).

Historical Consumption of Irrigation Water and irrigated Area

Due to enforced limiting conditions through out the years of occupation, the amount of water for irrigation remained nearly constant. The Israeli authorities have denied Palestinian farmers the right to drill new wells, install gages on all irrigation wells to monitor pumping rates and to enforce a certain quota on the amount of water pumped. After the 1967 war, the Israeli authorities closed the Ghor area next to the Jordan River for military reasons. It also destroyed or confiscated about 140 pumps, which were installed on the Jordan river to pump its water. As a result of this closure, the cultivated area in the Jordan Valley dropped from 110,000 dunums in 1967 to around 50,000 dunums in 1995, (according to data collected from the Ministry of Agriculture).

Moreover, many irrigation wells either dried up as a result of Israeli wells or were closed. In addition, there are about 50 MCM/year of water utilized by Jewish settlements for irrigation purposes. This amount would have been used by the Palestinian farmers had they were allowed to do so.

Unlike many Middle Eastern countries, WB irrigated agriculture has missed out what might be called ‘the hydraulic revolution’. Mainly taking place after World War II, this ‘revolution’ took the form of major irrigation works enabling a considerable expansion of irrigated land. It is exemplified by projects such as the Aswan High Dam in Egypt, al-Thawra or Tabaqa Dam on the Euphrates in Syria, the Ataturk Dam in Turkey and on smaller scale, the Water Carrier in Israel and the King Abdallah Canal in Jordan.

The WB had no such water projects and its irrigation system has remained decentralized, consisting of springs and individually owned wells. The volume of irrigated water in the WB fluctuates between 70-90 MCM/year.

Likewise, the irrigation system in GS is still decentralized and made up of hundreds of individually owned wells. Gaza's irrigated area is constrained by the limited availability of land and water.

The irrigated area in the WB initially declined after the occupation, reaching about 50,000 dunums in the year 1968, from 110,000 dunums in 1967 (see Table 11). The data in Table 11 is compiled from different sources including PCBS agricultural reports and data from the MOA. During the 1970s, the irrigated area was gradually restored to its pre-occupation level, vacillating around 85,000 to 125,000 dunums. The irrigated area in GS also grew steadily, to 90,000 dunums in 1968 from 75,000 dunums in1966.

Table 11: Historical Development in the Irrigated Area in the West Bank: 1967-2007

Year	Irrigated area in 1000 dunums	Year	Irrigated area in 1000 dunums
1967	110.0	1996	104.9
1968	50.0	1997	126.8
1973	82.0	1998	108.6
1974	81.0	1999	112.0
1975	83.0	2000	115.0
1976	89.0	2001	119.0
1980	92.0	2002	116.8
1981	98.0	2003	120.8
1982	90.0	2004	131.4
1984	101.0	2005	122.5
1994	93.2	2006	137.6
1995	102.8	2007	136.9

Source: PCBS, (2008), Agricultural Statistics 2006/2007, December 2008
Records of the Ministry of Agriculture

Current Irrigated Area and Cropping Patterns:

The total irrigated area in WB is currently around 136,866 dunums. Although this area constitutes about 6% of the total cultivated area, it makes up more than the half of the agricultural production in the WB. In the Jordan valley, most of the land is flat or gently sloping towards the east and lies below mean sea level. Due to the prevailing climatic conditions characterized by low precipitation and high potential evaporation, rain-fed farming is not feasible. However, because of the possibility of producing off season crops, known for their high returns, this region is considered of high importance in planning future irrigation expansion. On the other hand, the northern Governorate areas in the WB have relatively large plains and plateaus favored for rain-fed farming.

For the GS, only 200,000 dunums are suitable for cultivation. The rest is estimated to be sand dunes and areas not suitable for cultivation. Irrigated areas are currently estimated at 132,826 dunums. However, this area is likely to reduce due to urbanization resulting from the high population growth.

Current Supply of Water through Irrigation

The current supply of water in WBGS through irrigation is about 172 MCM, roughly 89 MCM of which is used in WB. This water comes from springs and wells, as shown in Table 12. It is important to note that water supplies for agriculture are either shallow small old wells or natural springs. Natural springs face severe problems of discharge variability and thus these sources are not reliable. Although the average discharge of these springs is about 49 MCM/year, this discharge is low in dry years and high in wet years. Due to lack of storage structures, large volumes are lost in wet years, thus the actual average of the amount utilized from springs is much lower than the arithmetic mean of spring discharge.

Table 12: Estimated Total Water Supply for Agriculture in the West Bank and Gaza Strip (MCM)

Governorate	Wells	Brackish	Springs	Total
West bank total	40.3	0	49	89.3
Gaza strip total	40	43	0	83
Total	**80.3**	**43**	**49.1**	**172.3**

Source: Comiled by the Authors from unpublished Data from the Palestinian Water Authority.

3. Future Water Needs

Future Palestinian water needs is this quantity of water that will be needed for the state to survive and be able to meet all sectors' needs including domestic, public, industrial and agricultural. To be able to make an estimate and projection for these needs, a number of assumptions need to be taken. These assumptions, in the case of Palestine, will not be entirely based on present water consumption data, due to the fact that present water consumption is suppressed. Nevertheless, data on present water consumption is needed and is available for three sectors: municipal, industrial and agricultural consumption. Municipal consumption includes in domestic, commercial, livestock, touristic and public consumption.

In this paper, future water needs estimates are based on the following:

1. Needs forecasts are based on target consumption rates, particularly for domestic, public, commercial and touristic consumption rates based on average WHO standards.
2. A water needs principle is not a replacement for water rights.
3. Rates are increased gradually, as shown in tables 16 and 17, during the early planning period until target levels are reached. These rates are then increased at a declining rate to reflect various constraints that are imposed on these rates.
4. Water conservation is inherent in these rates, as it is assumed that losses will be gradually reduced from current levels. This reduction is predicated on the assumption that the water supply system will be adequately managed by well-staffed and equipped utilities along with the necessary maintenance programs.
5. The assessment assumes no resource constraints and no political constraints.

3.1 Future Municipal Water Needs

The municipal future water needs for this report comprises: domestic, public, livestock, commercial and touristic water needs. Population increase is the fundamental parameter affecting municipal future water needs. This determines not only domestic needs, but also agricultural/livestock needs (to feed the population) and commercial/ industrial needs (to provide an economy to support the economic development of the population).

3.1.1 Estimation of Future Municipal Water Needs

The assessment of the future population uses the PCBS census results as a base, from the end of the year 2007, and onto to which population growth rates are applied. The same methodology has been used to estimate the future population until 2020 (see Table 13). The short-term growth rate is very similar to the 3.2% seen in Jordan in 2004, which is a country with similar economic and cultural conditions as those expected for Palestine.
In addition to the natural growth of the base population, allowances have also been made for returnees, who are defined as those Palestinians displaced to other countries following 1967 and their dependents. Various estimates of the number or returnees have been given and it is generally accepted that 500,000 will return as Palestine continues to be established as an autonomous political entity. It is assumed that 120,000 have already returned and that the remainders will come in equal numbers annually for the next 7 years, (as shown in Table 14). .

Table 13: Population Growth Rates

Period	Growth Rate	
	Gaza Strip	West Bank
2008-2010	3.7	2.8
2010-2015	3.4	2.4
2015-2020	3.0	2.0

Source: PCBS, (2008 b).

Table 14: Expected Number of Returnees

Period	Returnees	
	Gaza Strip	West Bank
Pre 2007	24,000	96 ,000
2007-2010	28,500	114,000
2010-2015	47,500	190,000
Total	100,000	400,000

Source: PCBS, (2008 b).

Total population projections for the various planning years based on the above assumptions are shown on Table 15 below.

Table 15: Population Projections

Year	Population 1000s				
	Gaza Strip		West Bank		Total
	Urban	Rural	Urban	Rural	
2007	1,346	77	1,260	1,117	3,801
2010	1,530	86	1,483	1,213	4,312
2015	1,856	102	1,860	1,366	5,184
2020	2,152	118	2,054	1,508	5,832

Source: PCBS, (2008 b).

The municipal future water needs for this report comprises the domestic, public, livestock, commercial and touristic water needs. The needs projections are estimated based on the WHO standards of 100 L/c/d as minimum water consumption and 150 L/c/d as an average domestic water consumption. Other consumption rates including commercial, industrial and livestock consumption rates are projected as a percentage of the Municipal and Industrial water needs. A summary of these target consumption rates is shown in Table 16 and 17 below.

Table 16: Target Consumption and Needs Rates: (Urban Areas)

Target Year	Domestic Consumption		Public Consumption		Livestock Consumption		Total Municipal	Physical	Total
	Rate (L/c/d)	Ratio of Municipal (%)	Rate (L/c/d)	Ratio of Municipal (%)	Rate (L/c/d)	Ratio of Municipal (%)	Consumption Rate (L/c/d)	Loss Rate (%)	Needs Rate (L/c/d)
2010	100	0.90	7	0.06	4	0.04	111	12	**111**
2015	110	0.90	8	0.07	3	0.03	121	10	**121**
2020	120	0.90	10	0.08	1	0.01	131	8	**131**

Table 17: Target Consumption and Needs Rates: (Rural Areas)

Target Year	Domestic Consumption		Public Consumption		Livestock Consumption		Total Municipal	Physical	Total
	Rate (L/c/d)	Ratio of Municipal (%)	Rate (L/c/d)	Ratio of Municipal (%)	Rate (L/c/d)	Ratio of Municipal (%)	Consumption Rate (L/c/d)	Loss Rate (%)	Needs Rate (L/c/d)
2010	80	0.90	5	0.05	5	0.05	90	12	**90**
2015	90	0.90	4	0.04	6	0.06	100	10	**100**
2020	100	0.90	3	0.03	8	0.07	111	8	**111**

Based on these target consumption rates and an estimated physical loss rate ranging from 12% to 8% by the year 2010, Table 18 shows estimated water needs. With total needs of 268 MCM/year projected for the year 2020, the total municipal annual per capita water needs are 46 CM/year. According to numbers quoted in Israeli publications, (such as Mekorot reports), the total annual municipal per capita water demands in Israel are around 107 CM/year.

Table 18: Projected Municipal Water Needs in MCM/year

Year	2010	2015	2020
West Bank	100	132	160
Gaza Strip	65	86	108
Total Palestine	**165**	**218**	**268**

3.1.2 Growth in Municipal Demand for Water

In order to predict future demand growth of a certain good, economists usually use a formula that takes into account three important socio-economic factors. These factors are population growth, income growth, and income elasticity of demand for the good under consideration. The formula takes the following form (Fan and Wailes, 1995):

$$G = PG + \eta (IG)$$

Where G: demand growth for the good,

PG: population growth,

η : income elasticity of demand for the specified good, and

IG: Income growth.

Data on the three variables needed for water demand growth prediction are available. The results of the 2007 population census that was conducted by the PCBS show that population growth of the Palestinian people is 3.3% per year (PCBS, 2008c). In a previous study (Zawahra, 2003), it was found that the income elasticity of demand for water in Palestine is estimated to be (0.1587) which means that water is a normal necessary good.

As for the annual growth in GDP in Palestine, it is difficult to specify a certain figure for the growth of such a variable, because the level of GDP and hence its growth change from one year to another is affected by the political situation in the region. Table 19 illustrates this fact.

Table 19 shows that there is large variability in both GDP level and its growth from one year to another. This can be explained by the political unrest in the region. Following the establishment of the Palestinian National Authority, high growth rate levels in real GDP were achieved in the late 1990s (12% in 1997 and 1998). Negative growth rates; however, prevailed in the early years of this century as a result of the Israeli military actions against the territories after the break through of the Second *Intifada* 2000. Due to the relatively stable situation in the years 2003-2005, positive growth rates were retained. Negative growth rates in 2006 were the result of the Israeli and American, and later global boycott of the *Hamas* government formed after the victory election early in 2006.

Table 19: Gross Domestic Product (GDP) in Remaining West Bank and Gaza Strip (1994-2006) 1997=100

Year	GDP (Million $)	Growth in GDP (%)
1994	3,012.30	---
1995	3,193.30	6.00
1996	3,285.90	2.90
1997	3,701.60	12.65
1998	4,147.90	12.06
1999	4,511.70	8.77
2000	4,261.10	-5.55
2001	3,988.50	-6.40
2002	3,838.90	-3.75
2003	4,165.30	8.50
2004	4,247.70	1.98
2005	4,502.60	6.00
2006	4,107.00	-8.79

Source: PCBS, Statistical Abstract of Palestine, (various issues).

- Remaining West Bank refers to all West Bank excluding those parts of Jerusalem which were annexed by Israel in 1967
- The data for 2001-2006 is Preliminary Estimates and will be revised

Based on the discussion above, it is possible to draw three scenarios for future growth in Palestinian GDP. First, the economy is stagnant with 0% growth. Second, the economy grows where GDP reaching its highest level at almost 13% between 1996 and 1997. Third, the economy declines where GDP growth is negative reaching the lowest draw back near -9% in 2006.

Using the three scenarios outlined above, growth in demand for water can be predicted. Table 20 shows the results of estimating that growth using the three scenarios outlined above.

Table 20: Estimating Growth in Demand for Water in Palestine using Three Scenarios

Scenarios*	Assumption	Calculations	Result
Scenario 1	Stagnant Economy (GDP growth = 0)	3.3+0.1587(0)	3.30%
Scenario 2	Growing Economy (GDP growth is positive at 13%)	3.3+0.1587(13)	5.36%
Scenario 3	Declining Economy (GDP growth is negative at -9)	3.3+0.1587(-9)	1.87%

* 3.3:population growth; 0.1587: Income elasticity of demand

The three estimated figures, using the three different scenarios, show that demand for water in Palestine will be growing, regardless the status of the economy: stagnant, growing or declining. This can be explained by two important factors: high population growth (3.3% per annum) and the fact that demand for water is income inelastic: if income decreases by a given proportion, then demand for water will decrease but by a smaller proportion. This implies that water is a normal necessary good with income elasticity of demand (0.1587). That is, any decrease in growth of demand for water due to a decrease in income will be offset by the growth in population.

3.2 Future Industrial Water Needs

Based on the present industrial demand section and the data collected from different sources, the following can be stated:

1. Based on the fact that the existing industrial sites will not be suitable for industrial expansions, both in terms of size and infrastructure, the need for industrial development in Palestine is considered as a major issue.

2. The Palestinian National Vision, according to the MOIn, regarding the development of the industrial sector, is mainly based on the establishment of twelve industrial estates in Palestine by the year 2020 (8 estates in the WB and 4 estates in GS). The average area of each site is estimated at 4000 dunums. The proposed sequence of development of the industrial estates is shown below:

   BY Year 2015
   - Establishment of Gaza Industrial Estate.
   - Establishment of Jenin Industrial Estate.
   - Establishment of Nablus Industrial Estate.
   - Development of other industries inside Municipal borders.

   BY Year 2020
   - Establishment of Jericho Industrial Estate.
   - Establishment of Hebron Industrial Estate.
   - Establishment of additional three industrial Estates in the WB.
   - Establishment of additional three industrial Estates in GS.
   - Development of other industries inside Municipal borders.

3. To meet the expected development in the industrial sector presented above and to reach to a sustainable industrial sector, additional amounts of water should be allocated to its needs. The need for these additional quantities is justified on the basis of the industrial de-development during the years of occupation.

4. Estimates for the industrial future water needs for this report are based on the World Health Organization (WHO) standards. These standards recommend that the industrial sector should represent about 16% of the domestic water needs. When these standards were checked against countries with similar socio-economic background for certain periods of these countries industrial development to the ones we are forecasting for Palestine, the standards show that they are applicable.

5. Based on the above findings and using the population projections and domestic water needs estimated in the previous section, Table 21 shows the projected industrial water needs for the different planning years.

Table 21: Future Industrial Water Needs

Year	Industrial Needs MCM/year
2010	24
2015	31
2020	39

3.3 Future Agricultural Water Needs

Many factors affect future agricultural water needs estimates. In addition to technical and environmental factors, social, economic, political and cultural factors also affect these needs. In this section of the study, five main questions are addressed with the aim of reaching a realistic estimate of Palestinian future agricultural water needs. These questions are:

1. What is the irrigated and irrigable land available in Palestine?
2. What are the present and future agricultural water demand estimates in neighboring countries?
3. How are Palestinian future agricultural water needs related to food security?
4. What are the comparative advantage and the competitiveness of irrigated agriculture in Palestine?
5. If water needs of Palestine were met, what would be their impact on employment, local production, poverty, income distribution and food security?

3.3.1 Irrigated and Irrigable Land

According to land surveys and data from the Ministry of Agriculture in 2007, if sufficient water were made available, the total potentially irrigable area in the Territory is 745,000 dunums. Table 22 gives more detail on currently irrigated land and on irrigable land in different Governorates of Palestine. Many conclusions can be made from this data: First, the land area currently irrigated in the WB is slightly larger than that in the GS. The WB accounts for 51%, the GS 49% of total irrigated land in the Palestinian Territory.

Second, the GS reached its potential using the irrigable land available. The existing arable land of 133,000 dunums is almost all under irrigation. In the WB however there are still large areas of rain-fed agricultural land that could be irrigated. In fact, the potential irrigable area in the WB is 612,000 dunums. The irrigated area in the agricultural season 2006/2007 was only 136,866 dunums; just 22.4% of irrigable land in the WB.

Third, the bulk of irrigated land is available in Jericho Governorate, about 17% of the total irrigated land in the Territory. In fact, this makes about one third of the irrigated land in the WB. Other important Governorates in this regard are Jenin, Tubas, and Tulkarm, where each contributes to 8%, 7.5%, and 6% of the total irrigated land in the Territory, respectively.

Fourth, irrigable land in the WB makes more than 82% of total irrigable land in the Territory, while it is about 18% in the GS. Within the WB, land that could be irrigated is mainly located in Jenin, Hebron and Tubas Governorates (22%, 15%, 11% of the total irrigable land in WBGS respectively). The governorates with the least land available for irrigation are Jerusalem (less than 1%) Bethlehem (2%).

Table 22: Irrigated and Potentially Irrigable Lands in Palestine

Governorate	Irrigated Land		Irrigable Land	
	Area	%	Area	%
Jenin	20,727	7.69	163,000	21.90
Tubas	20,160	7.48	82,000	11.00
Tulkarm	16,927	6.28	27,500	3.69
Qalqilia	9,095	3.37	17,500	2.35
Salfit	1,566	0.58	49,000	6.58
Nablus	9,827	3.64	68,000	9.13
Ramallah	988	0.37	35,000	4.70
Jerusalem	103	0.04	3,000	0.40
Jericho	45,607	16.91	45,000	6.04
Bethlehem	1,844	0.68	12,000	1.61
Hebron	10,022	3.72	110,000	14.77
Sub-Total West Bank	136,866	50.75	612,000	82.15
Gaza Strip **	132,826	49.25	133,000	17.85
Total	**269,692**	**100.00**	***745,000***	**100.00**

Source: PCBS, (2008), Agricultural Statistics 2006/2007, December 2008
Records of the Ministry of Agriculture

3.3.2 Agricultural Water Demands in Neighboring Countries

It is useful to look at how much land per capita is being irrigated in neighboring countries in estimating how much WBGS land will be irrigated in the future. Various studies have been reviewed, the main results of which are summarized in Table 23.

Table 23: Present Irrigation Water and Irrigated Area in Palestine, Israel and Jordan, Per Capita

State	Irrigated Area (Dunums)	Per Capita Irrigated Area (Dunums)	Per Capita Irrigation Share (Cubic Meter)
Jordan* (Middle East Study)	675,000	0.134	135
Jordan** (World Bank)	643,200	0.117	143
Israel* (Middle East Study)	2,000,000	0.370	222
Israel** (World Bank)	1,943,000	0.333	218
Palestine ***	270,000	0.071	45

* GTZ, 1996, Middle East Study.
** World Bank, 1994.
*** PCBS, 2008 b.

Based on the table above, it is clear that both the per capita irrigated area and the per capita irrigation share in Palestine are much lower than in the neighboring countries. This is obviously not due to lack of irrigable land. In fact, during the 2006/2007 season in Palestine, only 269,692 dunums out of the 745,000 dunums available were irrigated. That makes only 36% of the irrigable land. Additional irrigable land could be put under irrigation, which would increase both employment levels and agricultural production. The increase in farmers' incomes and to hired agricultural labor would help reduce poverty and enhance food security in Palestine.

Table 23 demonstrates that the Israeli irrigated area per capita is threefold that of the average Jordanian. Nevertheless, if an average of the Jordanian and Israeli irrigated area per capita prevailed in Palestine, some 0.24 dunum per capita would be needed to be irrigated in the future, indicating that 180 cubic meter of water per capita annually is needed to fulfill irrigation water needs.

3.3.3 Agricultural Water Needs Based on Crop Water Requirement

Water requirements differ from: one crop to another, the method of irrigation, and the type of soil. Table 24 shows that the lowest seasonal water requirement is for cabbages and potatoes where a dunum requires 360 CM and 395 CM per year to produce each of the two crops respectively. Producing bananas requires the highest annual water for irrigation- where a dunum requires 3,000 CM per year.

Table 24: Water and Hired Labor Requirement for Main Vegetables and Fruits in Palestine

Crop	Quantity of Water Required (CM)	Hours of Labor Required (Hours)
Tomatoes	797	367
Cucumbers	620	277
Potatoes	395	395
Eggplants	800	229
Green Peppers	598	329
Cabbages	360	168
Cauliflowers	420	75
Beans	476	160
Broad Beans	400	116
Squash	428	158
Jew's Mallows	483	63
Onion Green	525	156
Oranges	688	60
Grapes	600	120
Lemons	600	112
Clementine	950	117
Dates	1,200	112
Bananas	3,000	126
Average	**741**	**174**

Source: Palestinian National Authority, Ministry of Agriculture, Data Handbook, 2000 and 2007, unpublished reports.

The average water seasonal requirement per dunum for all crops using different types of soil and different irrigation methods is calculated in Table 24. The average water requirement for all crops per season per dunum is 741 CM. That is, in order to meet the current requirements of the irrigated land, the Palestinian agriculture water needs is (741 x 270,000 = 200.07 MCM). Dividing this figure by the number of population (3.8m) gives around 53 CM per capita, which is greater than the prevailing situation (45 CM per capita). At the same time, 53 CM are still below the per capita irrigation share in Israel (218-222 CM) or even in Jordan (135-143 CM).

If all the irrigable land were brought under irrigation, the water requirement would be (741 x 745,000 = 552 MCM) for all crops in all agricultural seasons. Calculating this figure on a per capita basis, the Palestinian per capita irrigation share would be 145 CM. This makes the situation similar to that of Jordan, but is still below the figure in the case of Israel.

3.3.4 Agricultural Water Needs and Employment

Putting more land under irrigation requires the use of other resources, especially labor. The additional irrigable land that could be put under irrigation is (745,000-270,000 = 475,000 dunums). Table 24 also shows employment requirements per dunum for various irrigated crops. Labor requirements per dunum range from (60-395) man hours per year. Average labor requirements per dunum of all representative crops per year are 174 man-hours. If the agricultural laborer works 7 hours a day, then the labor requirement per dunum is (174 / 7 = 25 man-days) per day. The total man-days generated by putting the additional irrigable land) would be 118.75 million. Dividing this figure by 365 man-days per, it can be concluded that 32,534 agricultural jobs can be generated on full time basis.

3.3.5 Agricultural Water Needs and Income

Putting more land under irrigation generates more income to farmers. The additional irrigable land is (745,000-270,000 = 475,000 dunums). The MOA defines Gross Margin as the difference between total revenues and total variable cost. Table 25 shows calculations of gross margin (income generated) per dunum for various irrigated crops. Income generated per dunum ranges from (308-2,577) $ per year. Average income generated per dunum of all representative crops per year is $891. If the 475,000 dunums were put under irrigation, total income generated to farmers would be $423m.

Income earned by hired labor can also be calculated. In the previous section it was shown that, on average, a dunum requires 174 man-hours of hired labor. If the prevailing wage per hour is 10 NIS, then hired workers will earn an annual 1,740 NIS per dunum. When land is irrigated, total income earned by hired labor is 826.5m NIS (about $197m).

In sum, the income that could be generated from farmers and hired laborers, as a result of irrigating all the potentially irrigable land, is $620m. This makes 1.4 of the total value added of the agricultural sector in

Palestine. It should be emphasized, however, that income of related activities, such as income of the agricultural inputs traders and intermediaries, was not taken into account in these calculations.

Table 25: Gross Margins from a Dunum of Main Irrigated Vegetables and Fruits in Palestine, 2007

Crop	Quantity Produced (kg)	Price (NIS)	Total Revenue (NIS)	Total Variable Cost (NIS)	Gross Margin (NIS)	Gross Margin ($)
Tomatoes	10714	1.52	16286	5487	10799	2577
Cucumbers	6200	1.64	10168	4082	6086	1453
Potatoes	3833	1.72	6593	3112	3481	831
Eggplants	5500	1.64	9020	3221	5799	1384
Green Peppers	3250	2.12	6890	3905	2985	712
Cabbages	2000	1.72	3440	1546	1894	452
Cauliflowers	2467	1.68	4144	1479	2665	636
Beans	1640	4.28	7019	2548	4472	1067
Broad Beans	800	3.28	2624	1139	1485	354
Squash	2300	1.92	4416	2034	2382	568
Jew's Mallows	1900	1.44	2736	1411	1325	316
Onion Green	3500	3.08	10780	2209	8571	2046
Oranges	2025	1.71	3463	1784	1679	401
Grapes	2000	2.24	4480	2524	1956	467
Lemons	3733	1.6	5973	2006	3967	947
Clementine	3000	1.17	3510	2220	1290	308
Dates	1000	3.23	3230	621	2609	623
Bananas	4000	1.68	6731	2974	3757	897
Average	3326	2.09	6195	2461	3733	891

Source: Palestinian National Authority, Ministry of Agriculture, Data Handbook, 2000 and 2007, unpublished report.

3.3.6 Agricultural Water Needs and Food Security

According to FAO’s definition, food security is achieved "When all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." (World Food Summit, 1996) The definition implies that nations must secure enough food for their population. This can be achieved by producing food locally, importing it from abroad or by a combination of both. Food security has a specific position and definition in Palestine. It has direct relation to people's existence in their homeland. Investment in the agricultural sector is critical to national survival.

The fast growing population, rapid urbanization, food security policies and the expansion of development and economic activities all exert pressure on available water resources. As competition for water grows among users, and within the limits of water availability and/or accessibility, the call for limiting the size of the agricultural sector in favor of domestic and industrial sectors will be strong. On the other hand, many scholars and politicians call for food security based on producing all food locally. These latter ideas are popular because agriculture plays a central role in the economy and culture of Palestine. This conflict requires the adaptation of a methodology of Water Resource Management that offers a means to reconcile competing demands with supplies, integrates various needs against available water resources, and achieves sustainable development.

The continuous enhancement and development of technical, managerial, and financial capacities in the agricultural sector are critical to national survival. Agricultural water management is crucial for such development. In Palestine, water management and food production enhancements have more specificity than elsewhere: it is connected not only to securing food or sustenance, but also to the Palestinian struggle to exist in Palestine and to protect land from being colonized.

In 2003, FAO found that the occupied Palestinian Territory, by itself, does not have sufficient food to feed its population and so relies upon commercial imports to meet domestic demand. It was also found that with rising poverty and unemployment, the food security situation has considerably deteriorated over the past three years, with four out of ten Palestinians being food insecure. Food insecurity is a reality for 1.4 million people (35% of the population) and a near constant worry for an additional 1.1 million people (30%) who are vulnerable to becoming food insecure should current conditions persist. People's physical access to food and farmers' physical access to the inputs and assets to produce food have been severely affected by restrictions on the movement of people and goods and the damages to personal property caused by constant Israeli measures.

Based on the above, it is obvious that food security conditions need improving. A great restriction to this is the present lack of accessibility to additional water sources. In this regard, one of the most devastating realities is that Palestinians have not been permitted to develop a single groundwater well into the most productive basin, the western aquifer. Moreover, restrictions have been placed on Palestinians drilling new wells into other aquifers, and in some cases on the maintenance of existing wells within the West Bank (Palestinian Hydrology Group, 2006).

To solve this issue, additional water quantities need allocating to irrigation and more land needs irrigating. This goes in line with the per capita figures that were presented in an earlier section of this study.

3.3.7 Comparative Advantage and Competitiveness of Irrigated Agriculture Crops

The Domestic Resource Cost indicator (DRC) is widely used in developing countries to measure comparative advantages and guide policy reforms. The DRC is a ratio that represents a shadow price value of non-tradable factor inputs used in an activity, per unit of tradable value added (Williams, 1995). The comparative advantages of irrigated agricultural crops discussed in this section are based on the results of different studies, including a draft study by Abdel-Aziz (1996). DRC and water efficiency parameters were used to compare the advantages between different crops in the five agro-climatic zones in Palestine. The DRC compares the opportunity costs of domestic production to the value added that it generates. The DRC is a social cost-benefit ratio, which helps to determine the efficiency of domestic production relative to the international market. If DRC < 1, it indicates that the domestic input cost is less than social benefit generated by the domestic input. In this case, the country generates a comparative advantage in producing the commodity. Thus, it is better to produce the product locally than import it from international markets.

Table 26 shows the DRC for dominant irrigated crops in the coastal, semi-coastal and Jordan valley zones. All of the DRC values in the table are less than 1, indicating that Palestine enjoys a significant comparative advantage in the production of irrigated agriculture crops in these three zones. Therefore, increasing these crops should be encouraged with the aim of significantly increasing the value added in the agricultural sector subject to market and domestic constraints. The data used is from the year 1996 and represents conditions of economic growth and stability, where the average annual growth in the GDP during the period (1995-1997) was about 7% (see Table 19 in part 3.1.2), which was as twice as the population growth. These conditions are seen to be plausible and feasible under an independent Palestinian state.

In the light of the discussion above, it could be concluded that local consumption of irrigated agricultural crops should be satisfied from crops produced locally. The comparative advantages that Palestine enjoys in irrigated agricultural crops could be explained from the relatively low cost of labor, the relatively high efficiency of water and resource utilization, the use of good varieties with high productivity and other factors. However, there is a need to evaluate DRC for all irrigated agricultural crops at all agro-climatic zones to determine the zones of expansion for each crop.

Table 26: The DRC for Dominant Irrigated Crops in Palestine

Crop	Season	Coastal	Semi-Coastal	Jordan Valley
Tomatoes	Spring	0.454		0.461
Cucumbers	Spring	0.391	0.506	0.401
Potatoes	Spring	0.568	0.507	0.481
Squash	Spring	0.603	0.507	0.579
Tomatoes	Autumn			0.559
Cucumbers	Autumn			0.519
Potatoes	Autumn	0.616	0.547	0.501
Squash	Autumn			0.469
Onions	Autumn	0.471		
Cauliflower	Autumn	0.547	0.458	
Squash	Plastic-Tunnels	0.433		
Strawberry	Plastic-Tunnels	0.558		
Tomatoes	Greenhouses	0.446		0.433
Cucumbers	Greenhouses	0.372		0.368
G. Peppers	Greenhouses	0.603		0.464
Cut-Flowers	Greenhouses	0.722		0.464
Oranges	Fruits	0.57	0.864	0.602
Grapes	Fruits			0.476
Bananas	Fruits		0.864	0.462
Olives	Fruits	0.585		

Source: Abdel-Aziz, 1996

As water is a critical factor in irrigated agricultural production, the DRC analysis is not sufficient for irrigated agricultural development. Water efficiency should be taken into consideration for such development. Water efficiency is expressed in social net return to water and is calculated by dividing social net profit (excluding water cost) by water consumption. Table 27 shows the value of water efficiency, calculated by Abdel-Aziz 1996, for different crops in Palestine. Results highlight that vegetables grown in greenhouses with economic water efficiency range between 5-13 NIS /CM unit of what???, and have a higher water use efficiency than crops grown outside greenhouses- where the economic water efficiency in most cases is less than 5 NIS /CM.

A DRC value below 1 means that it is better to produce the crop locally than importing it as long as it is demanded in the market. The above analysis showed DRC values below 1 for irrigated agricultural crops in Palestine.

Table 27: Economic Water Efficiency (NIS/CM) for Major Crops in Palestine

Crop	Season or Method of Planting	Coastal	Semi-Coastal	Jordan Valley
Tomatoes	Spring	4.9		4.45
Cucumbers	Spring	8.04	5.58	7.03
Potatoes	Spring	4.74	5.42	5.45
Squash	Spring	3.60		2.43
Tomatoes	Autumn			2.16
Cucumbers	Autumn			3.44
Potatoes	Autumn	3.26	4.00	4.10
Squash	Autumn			3.66
Onions	Autumn	4.64		
Cauliflower	Autumn	4.04	4.43	
Squash	Plastic-Tunnels	7.78		
Strawberry	Plastic-Tunnels	6.88		
Tomatoes	Greenhouses	10.99		6.70
Cucumbers	Greenhouses	12.89		10.25
G. Peppers	Greenhouses	4.88		7.02
Cut-Flowers	Greenhouses	5.70		
Oranges	Fruits	2.29	1.14	1.60
Grapes	Fruits	3.87		2.34
Bananas	Fruits			1.29
Olives	Fruits			

Source: Abdel-Aziz, 1996.

3.3.8 Summary of Agricultural Water Needs

Based on the water requirements for different irrigated crops in different agricultural seasons and using different irrigation techniques, an estimate in sub-section 3.3.3 showed that the average water requirement per dunum is 741 CM. Using this estimate, total agricultural water needs for the different targeted years (2010, 2015 and 2020) are shown in Table 28 below.

In order to reach the Palestinian potential of irrigating all potentially irrigable land by 2020, estimated at 745,000 dunums, calculations in Table 28 are made based on three assumptions: First, in 2010, it is assumed that the current cropping pattern will prevail and the current irrigated land, 270,000 dunums, will continue to be irrigated. In this case, future water needs in the year 2010 will be (270,000 x 741= 200 MCM).

Second, in 2015, it is assumed that Palestinians will be able to irrigate a total of 500,000 dunums. In this case, future agricultural water needs in 2015 will be (500,000 x 741= 370 MCM).

Third, in 2020, it is assumed that Palestinians will manage to irrigate all potentially irrigable land, 745,000 dunums. Future water needs, in 2020, therefore will be (745,000 x 741= 552 MCM).

This means that, by the year 2020, the Palestinian water sector should develop an amount of around 552 MCM/year for irrigation purposes. This amount is about three-fold the available supply at present, (about 200 MCM).

Table 28: Projected* Agricultural Water Needs in MCM/year

Year	2010 Current Cropping Pattern Prevails (270,000 Dunums)	2015 Putting 500,000 Dunums Under Irrigation	2020 Putting the Whole Irrigable Land Under Irrigation (745,000 Dunums)
Agricultural. Needs	200	370	552

*Projections are made using the average water requirement (741 CM) for irrigated crops

Putting more cultivable land under irrigation will raise productivity per dunum. . In fact, data for the year 2007 shows that productivity of the irrigated land, 4,713.5 kg/dunum, is more than 27 folds of that of the rain-fed land, 171 kg/dunum, (PCBS, 2008a). For specific crop produce, the yield of an irrigated dunum of olives is 685 kg, while it is 39 kg in the case of a rain-fed dunum. In the case of tomatoes, yield of rain-fed dunum is 559 kg, while it reaches 4,628 kg of an irrigated dunum using the surface irrigation and 16,744 kg of an irrigated dunum planted using plastic houses (PCBS, 2008b).

Based on farmers' income generated per irrigated dunum, the study estimated total farmers' income that can be generated, by putting an extra 475,000 dunums under irrigation to be $ 423 million. Moreover, hired labor income generated is estimated at $ 197 million. That is, a total of $ 620 million will be generated. In fact, this makes more 13% of the Palestinian GDP of 2007 at current prices. Finally, satisfying Palestinian future water needs by will create estimated agricultural jobs of more than 32,500.

4. Summary of Total Future Water Needs

In section 3, future water needs for the major three consuming sectors (municipal, industry and agriculture) were estimated. Future water needs for both the municipal and the industrial sectors were estimated based on their current consumption levels and the expected growth in population, including some estimates for returnees. Future water needs for the agricultural sector however were estimated based on the average crop need for water. Total future water needs by the three sectors for (2010, 2015 and 2020) are shown in Table 29 below. According to these calculations, the Palestinian water sector should develop a total amount of around 860 MCM/year by the year 2020. This amount is about three fold the supply available at present. At the same time, however, it is not higher than the Palestinian water rights according to International water laws or the amount potentially available from the renewable sources and other non-conventional water resources.

Table 29: Projected Total Water Needs in MCM/year

Year	2010	2015	2020
Municipal	165	218	268
Industrial	24	31	39
Irrigation	200	370	552
Total Palestine	389	619	859

Based on the table above, it is worth mentioning:

- The estimates of future water needs do not here include the water needed for biodiversity and environmental protection purposes.
- According to the estimates above, Palestinians should develop some 550 MCM/year in addition to the quantities available at present.
- To develop this quantity, it is necessary to develop policies and strategies to secure these additional quantities of water.
- Unconventional sources of water may also be developed. Water Desalination may be used for drinking purposes, as well as gray water. Treated sewage water may be used for irrigation.

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