An-Najah National University
Faculty of Graduate Studies

Evaluation of Agricultural Water Management Options in the Lower Jordan Valley – Palestine Using "WEAP"

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Dedication

This thesis is dedicated to my parents, for my wife who has always been there through the hard times, for my kids, Khalid, Saja, Saje. Thank you for all the unconditional encouragement, and support that you have always given me. Thank you for everything.

Acknowledgment

Thank and praise to Allah for it is through Him all things are possible. I would like to express sincere appreciation to Dr. Marwan Haddad for his guidance and insight throughout the research.

Great thanks to Salam Abu Hantash for her help to build the WEAP Model. Again my thanks and appreciation to my family for their understanding, motivation and patience. Lastly, but in no sense the last, I am thankful to all colleagues and friends at the university.

الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Evaluation of Agricultural Water Management Options in the Lower Jordan Valley – Palestine Using "WEAP"

تقييم خيارات الإدارة المائية للقطاع الزراعي في غور الأردن– فلسطين باستخدام برنامج "WEAP"

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

Declaration

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

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Date:	……………………………………………	التاريخ:

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Abbreviations

Applied Research Institute	(ARIJ)
Cubic Meters	(CM)
Dunum ($1000M^2$)	(du)
Food and Agriculture Organization	(FAO)
Gaza Strip	(GS)
Gross Domestic Product	(GDP)
Jordan Valley	(JV)
Joint Water Committee	(JWC)
Lower Jordan Valley	(LJV)
Kilogram	(kg)
Kilometer	(km)
Liters per Capita per Day	(L/c/d)
Millimeters	(mm)
Million Cubic Meters	(MCM)
Ministry of Agriculture	(MoA)
Ministry of Health	(MoH)
Palestinian Central Bureau of Statistics	(PCBS)
Palestinian Water Authority	(PWA)
Occupied Palestinian Territories	(oPT)
Study Area	(SA)
Scenario	(Sc)
Virtual Water	(VW)
Water Evaluation and Planning System	(WEAP)
Water use efficiency	(WUE)
West Bank	(WB)
West Bank and Gaza Strip	(WBGS)
World Bank	(WB)
World Health Organization	(WHO)

Evaluation of Agricultural Water Management Options in the Lower Jordan Valley – Palestine Using "WEAP"

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Abstract

Water is needed in all aspects of life and it is one of the most valuable resources in the world. Agriculture is the largest user of fresh water. In arid and semiarid areas, water resources are limited. Allocation of limited water resources, environmental quality and policies for sustainable water use are highly concerned. Water resource planning and predicting its availability and managing requires the application of a lot of related sciences. Lower Jordan Valley (LJV) is the most important agricultural area in the West Bank (WB). The objective of this research study is to evaluate the best sustainable water management options for future agriculture in the LJV. For this objective 'WEAP" (Water Evaluation and Planning System) was used as a tool. The study area is dominantly a Mediterranean characterized by long, hot, dry summer and short and moderate winter. Its water resources are restricted with groundwater with 42 MCM yearly. Six scenarios were run (optimal water use, optimal land use, supplementary water resources, food security, Poverty and socioeconomic linkage) under three main Political scenarios. Comparing the scenarios and their assumptions and outcomes, it was concluded that one scenario will not lead to optimal water management in agriculture in the LJV and a combination of scenarios would better achieve this goal.

Accordingly a combination of the three scenarios (water and land use efficiency and supplementary water resources scenarios) is the best combination to achieve better water management in Palestinian agricultural area in the LJV (under prevailing situation). Other scenarios or water management options will follow and indirectly will be optimized. Full-state scenario is the most suitable and applicable scenario in water and land management. It is clear that with full-state scenario there will be enough water supply for different agricultural activities and for other sectors at least for the near future. It is noteworthy that the findings of this study are general, local, and partial in nature and are considered as local water management solutions for Palestinian agriculture in the LJV suitable for the current or expected other political situations in Palestine. These findings should help Palestinian decision makers either in the Ministry of Agriculture, Water Authority, or the Ministry of Planning under the prevailing or predicting conditions.

Chapter One

1.1 Introduction

Water is needed in all aspects of life and it is one of the most valuable resources in the world (Quran: Ayah 30, Sura 21). Agriculture is the largest user of fresh water, accounting for 75% of current human water use (Wallace, 2000).

In arid and semiarid areas, water resources are limited and the shared available water in agriculture is decreasing due to combination of population growth, economic and agriculture development (Wallace, 2000).

The world is facing huge freshwater management challenges. Allocation of limited water resources, environmental quality and policies for sustainable water use are highly concerned. Water resource planning requires the application of scientific principles of hydrologic and environmental engineering, economics, system analysis, and information management for the purpose of predicting the availability and managing of water resources (Wallace, 2000).

It is expected that water availability will be negatively changed in future. This change is due to general and worldwide reasons and influences such as population growth, agricultural development, socioeconomic conditions and poverty, environmental pollution ... etc., or it may be due to specific reasons and influences concerning that part of the world such as Palestinian case, where the Israeli military occupation of land and water resources is the main influence on water management and economic development.

1.2. Literature Review

Worldwide, there is an imbalance between water supplies and demands in about 80 countries and more than 40% of the population (Qadir et al., 2003). Almost 75% of freshwater is globally used for irrigation. Both natural growth in population and development in industry will result in higher water demands at the expense of the water share for agriculture. Therefore, the need for studies in agricultural water management is increasingly growing.

For Palestinians, the water sector is not going to develop without understanding the current situation. Agriculture contributes to 12% of the GDP and about 117000 people are working in this sector (The World Bank, 2009). Hence, the economic situation will be significantly improved once both rain-fed and irrigated agriculture bloom.

It is no surprise the LJV is of great importance to any agricultural development in Palestine. Agriculture is the predominant profession to most people in the region. The reason refers to the unique combination of suitable climate, available land and water resources, fertile soil, appropriateness to a wide variety of crops, and experienced and low-paid labor. This area can be considered as a pilot area that may secure food for the whole region. In general, most of water resources are consumed for agricultural purposes. Therefore, agriculture development necessitates secured access to water resources which is more challenging in the LJV region where resources are shared. In the Palestinian side of the LJV, the Israeli occupation exercises full control over their water resources, and therefore, their accessible water share has to be ‘carefully and wisely planned and managed. In this context, many studies had been conducted to attain such goals by offering tools and techniques that might help potential stakeholders manage water resources most efficiently (e.g., Bushnaq, 2004; Sabbah, 2004).

A GIS and hydrological modeling based approach to manage water resources in the West Bank was developed by Sabbah (2004). In this approach, the social, economic, demographic, environmental, and institutional components were considered. From the water balance equation, the total annual rainfall and groundwater recharge were estimated at 2508 and 823 million cubic meters, respectively (Sabbah, 2004). Samples from the Jordan Valley wells showed high levels of electric conductivity, chloride, and sodium. Projected scenarios for water demands by 2025 were set by Sabbah (2004) in the different sectors. For the household sector, for example, the natural population growth, the returnees, and visitors to Palestine were all considered. The current Palestinian water use for the residential, agricultural, and industrial sectors are 48%, 46%, and 6%, respectively (Sabbah, 2004). Now, Palestinians face serious water crisis particularly as water poverty index is exceeding 39% (Bushnaq, 2004). By the year 2025, however, the water demand for the household might increase to 69% at the expense of the irrigated water which will decrease to 27%. While results did match to the Israeli estimates of recharge, yet calculations of the evapotranspiration are highly uncertain while runoff estimates are critically low. In the LJV, large quantities of water are consumed in irrigation due to the high rates of evapotranspiration experienced in the region. In addition, the cropping pattern which definitely governs the consumption of water for irrigation should have been carefully selected.

Nazer et al. (2010) had built an optimization model to the irrigation water allocation in the West Bank. The Solver function enabled by Microsoft Excel is used to build the linear model because it is simple to use and easy to manipulate for end users. Five agricultural zones and five fruit and vegetable crops under three scenarios were considered. The main goal was to maximize the profit under the constraints of land and water availability as well as local consumption of the crops. It was found that changing the cropping pattern may reduce water used for irrigation by 10%. It was also found that water scarcity problem can be well coped with if rain-fed agriculture replaces irrigated agriculture.

In order to better manage water resource under these water-stressed conditions, socio-economic implications have to be also considered. Although water scarcity could be largely alleviated if virtual water is imported to Palestinians, but the economic wheel in the agriculture sector would be negatively impacted (Bushnaq, 2004). Therefore, importing virtual water is not recommended by Bushnaq (2004) under the current situation in which there is no complete control to Palestinians on the ground. Instead, the different aspects of water should be taken into consideration through an integrated water resources management system (see Agarwal et al., 2000; Qadir et al., 2003).

More specifically, the organization of Friends of the Earth Middle East (FoEME) has conducted many studies on the LJV in the last few years. In FoEME (2010) study, the opportunities to rehabilitate the Lower Jordan Valley (LJV) hydrologically and environmentally were explored. The hydrology, morphology, water quality, and biodiversity of the LJV were tested using field measurements and found to be all impaired. Almost 98%

of the river flow is diverted by the riparian countries, the water quality of the river is deteriorated due to the high salinity caused by the discharge of sewage and saline springs into the river, and consequently 50% of the biodiversity of the river is lost (FoEME, 2010). It was found that 400 million cubic meters of water with less than 750 parts per million of salinity must be returned to the river each year in order to restore this ecosystem.

A refined version of the FoEME (2010) report was recently published (FoEME, 2012) to rehabilitate and promote prosperity to the LJV region politically, economically, and ecologically. The impacts of the continuous degradation in water quantity and quality on the endangered flora and fauna species were discussed. An ecological rehabilitation to the ecosystem of the LJV has to be made in order to save these endangered species. There is no way to do so without decreasing water diversions and reviving that threatened river (i.e., LJV). In this context, Israel had recognized that the LJV is not accessible to Palestinians. It was recommended for Palestinians to set up policies to manage water demands for the different uses (see FoEME, 2012). There is a call in the FoEME reports (2010, 2012) to imitate the Israeli model by the other stakeholders which is invalid to pose in most cases due to the power equation in the region.

The LJV extends from the south of Tiberius Lake on the north to the northern shore of the dead sea on the south, with an area of 1,300 km^2 and a population of 250,000 approximately , This includes areas from west Jordan, historical Palestine (where the eastern part of West Bank is included) (Rudolf et al.,2004).

The economic development of the LJV is entirely depend upon the control, conservation and efficient use & distribution of water resources. The restriction of rainfall to the winter (with a range of 120 -250 mm in the southern part of the valley), high evaporation rate (mainly from May to September which characterized by high temperature, low humidity, and intensive sunshine), and limited water resources, beside the Israeli imposed military control over Palestinian water resources, Palestinians in LJV are living under conditions of repressed water demand as result of the limitations on supply. This situation is expected to be harder and complicated for the near future

For the Palestinian side, LJV (eastern West Bank) stretches in two areas (Jericho and Tubas) with 520 km^2 and 97,373 persons, the population growth rate is 3.8 % and 3.6% respectively which are comparatively higher than the population growth rate of Palestine(3.3%) (PCBS, 2005).

The LJV have two main advantages concerning agriculture and agricultural production: the first is that LJV is a natural green house(give advantage of planting in cold season), where the second about the LJV it is the food basket of Palestine. These two factors indicate the importance and necessity of LJV and its agriculture to Palestinian people.

Because of its arid and semiarid climatic condition with low rainfall and high temperature, Palestine suffers from water scarcity. The abnormal political situation and Israeli's complete control of natural resources lead to more scarcity. 89MCM is the total annual water use in irrigated agriculture in West Bank, only 36 MCM/year of this amount comes from quota (Palestinian limited share from water) whereas 53 MCM/year are from springs and wells in West Bank. While 85 MCM/ year in Gaza Strip are pumped from shallow coastal aquifer for agriculture use (Arij, 1996). It is estimated that 75% of the total water consumption is for agricultural sector. Only 6% of the cultivated area is under irrigation giving 52.6% of the agricultural production (Ministry of Agriculture, 2006).

In Palestinian side of LJV about 94% of all usable water is used for agriculture with about 2/3with drinking quality.

A lot of studies were found that deal with water status in West Bank and Gaza strip in general (World bank,2008) and (Palestinian Water Authority"PWA",2007). Others focus their efforts on Lower Jordan Rift valley as a one geographical unit stretch from south of Yarmouk River to the northern shore of the Dead Sea (Rodulf Orther et al.,2002). Nitrate level was an important topics concerning the water quality in Jordan lift valley- Palestinian side (Saed et. al.,2009).

In this study seven inputs(scenarios) will be taken in consideration for the study area (Optimal water use, optimal land use, Supplementary water resources, Food security, Poverty and Political status scenarios).

Old and new published data and statistics concerning both the water and land use efficiency in agriculture sector showed that the majority of land is rain fed or irrigated by surface methods and a large area are irrigable but not irrigated yet (PCBS,2000-2008). All these data push us toward optimizing the land and water use.

In Middle East, mainly in our region due to water scarcity, the (Virtual water expression is highly used and become of great importance. It is defined as " the quantity of water used in the production process of an agricultural or industrial product" (Hoekstra,2002). It is also defined as ;

"the water requirement to provide the essential food import needs by an economy" (Allan,1997). Nassar on his study concentrated on the virtual water trade as policy instrument for the achieving water security in Palestine (Nassar,2007).

Economically, agriculture shares about 18% of total Palestinian exports in the year 2003 with a value of 54.4 million US dollars. While Palestinian imports reached 522.5 million US dollars (FAO, 2006).

Previous studies concentrated on the general aspects of water resources in Palestine and did not emphasize the future of agriculture in the LJV such as the feasibility study on water resources in the mentioned area carried recently (2008) as a joint project between Ministry of Agriculture (MOA), Palestinian Water Authority (PWA) and Japan International Cooperation Agency (JICA).

With time agriculture sector faces a complex of challenges: produce more food of better quality while less water per unit of output is used. Agriculture production with its two main parts, plant and animal, is the main source of human food. A series of definitions were used to describe food security. The World Food Summit of 1996 defined food security as “Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (FAO,2006). The West Bank is self-insufficient in food and relies upon commercial imports to supply domestic demand. Generally imports of cereals, sugar and vegetable oils that accounted for 65 percent of dietary calories (Butterfield, 2000).

Poverty is a factor that engaged both directly and indirectly in water management options. While the proportion of poor people may be decreasing, more than 1 billion people in the world still live on less than $1 a day, and 2.8 billion live on less than $2 a day (OECD, 2001). According to the UN Millennium Project (2005), the number of people living on $1 a day barely dropped from 1990 to 2001, declining from 1.218 billion to 1.089 billion. In some developing countries the absolute number of poor people is still increasing. Nowadays, the understanding of poverty has advanced and become more holistic. Once understood almost exclusively as inadequacy of income, consumption and wealth, many dimensions of poverty and their complex interactions are now widely recognized (Smith, 2004). These include isolation, deprivation of political and social rights, lack of empowerment to make or influence choices, inadequate assets, poor health and mobility, poor access to services and infrastructure, and vulnerability to natural hazards such as droughts and floods. Here in Palestine the Palestinian Central Bureau of statics (PCBS) defines the poverty with relating to the budget of a standard household (six members: two adult and four children),showing that we have two poverty lines: First, deep poverty, in (2007) it was 1886 New Israeli Shekel (NIS) (one USD approximately 4.06 NIS) covering : food, clothing ,and house costs. Second relative poverty with monthly budget 2362 NIS covering food, clothing, housing, health care, education, transportation and housekeeping supplies. Investment and using modern technology as irrigation system will contribute to poverty alleviation. Irrigation is defined as anti-poverty factor, improving the performance of irrigation systems by enhancing land and water productivity, diversifying cropping patterns and improving water distribution will help reducing poverty (Hussain, 2006). The increase in farmers' incomes and to hired agricultural labor would help reduce poverty and enhance food security in Palestine (Jayyousi, 2009).

All the aspects of life and so the agriculture with its all involved factors, mainly water is still influenced by the present political situation of the valley as an occupied territory where access and mobility of Palestinians to their water and land resources is prohibited and/or very limited. For the future, where peace is expected to prevail, proper planning is very important for this area. Sustainable water resources management is defined as ones where the needs of the present generation are met without compromising the needs of future generations (Haddad,2007).

In 1995, the Oslo II agreement Article 40 (Appendix No.2) contained provisions on water and sewage that recognized undefined Palestinian water rights, and returned some West Bank water resources and services responsibility to the Palestinian Authority (World Bank ,2009), it says that :

- Set governance arrangements for a five year interim period, notably a Joint Water Committee (JWC) to oversee management of the aquifers, with decisions to be based on consensus between the two parties.

- Allocated to either party specific quantities of the three West Bank aquifers underlying both territories - the share allocated to the Palestinian West Bank was about one quarter of the allocation to Israel and the settlements.

- Provided for interim extra supplies from new wells and from Israeli water company (Mekorot) - an extra 28.6 MCM was to be allocated to Palestinian needs.

- Estimated “future needs” for the Palestinian West Bank at 70-80 MCM.

The expectation of this interim arrangement is that it would be revised within five years, but still governs the water sector thirteen years after Oslo and nine years after the expected end of the interim arrangement (World Bank, 2009).

Chapter Two

Site Description

2.1. Location

Lower Jordan Valley is a part of the Jordan lift valley extending from the east of the West Bank to the Jordan River on the east. Figures (2a+b) show the location of LJV and the study area under investigation that extended to further area to the west exceeding LJV confines which was divided into three district: Jericho district, Tubas and part of Nablus directorate with a total area of 1070.66 km^2 (Table 1).

a b

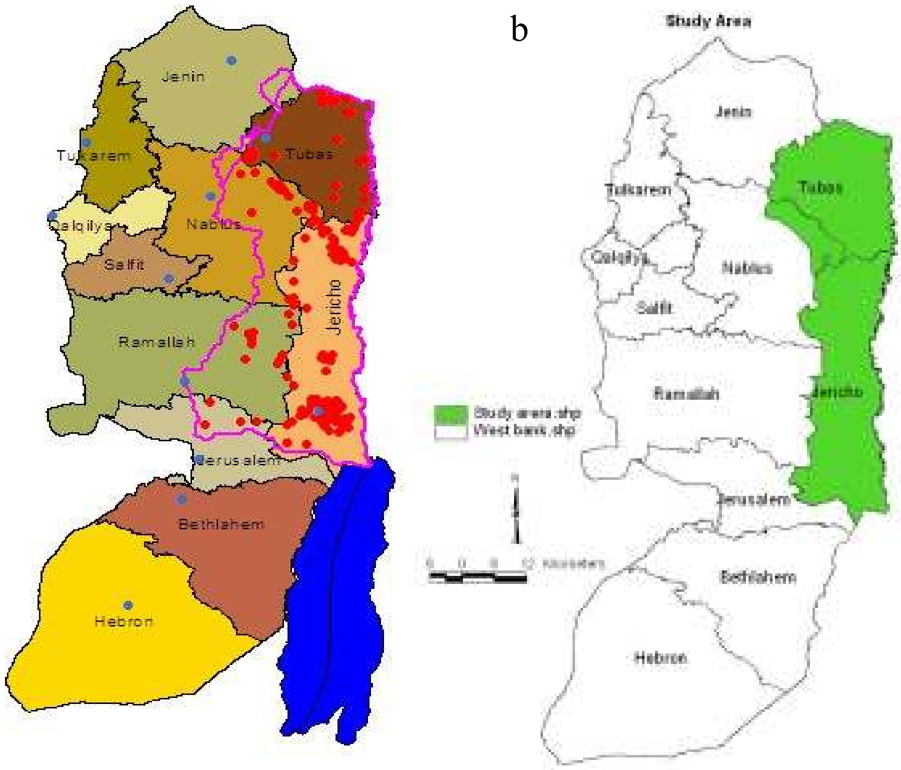


Figure (1): West Bank map (a) and Study Area in green (b)

Table (1): Study area in Km^2

District	Tubas	Jericho	Nablus part	Total
Area ($km^{2)}$	401.67	592.8	76.19	1070.66

2.2 Topography

Lower Jordan Valley consists of three main parts that varied widely in elevation and climatic condition:

1 The upper part: represents the west part, sloppy and mountainous. The climate is semi- arid, typically Mediterranean climate with two well- defined dry and wet seasons each with six months long. Rainfall exceeds 400 mm and precipitation of 5 months of the year. The elevation is over 200 m above sea level.

2 The Central part: lies to the east of the upper zone with shorter rainy season, higher temperature and precipitation ranging from 200- 400 mm as in the northern part of LJV. Evaporation is less than precipitation only in 3 months around the year. Elevation between 0 – 200 m above sea level.

3 The LJV part: arid, very low rainfall with more than 10 months evaporation that exceeds precipitation. Elevation is less than 0 m and in some regions below sea level.

2.3 Climate

Lower Jordan Valley is characterized by long, hot, dry summer and short and moderate winter. Within few kilometers toward east and south, the climate changed dramatically to a more arid and hot. This high variability is caused mainly by the elevation, desert and circulation of air-stream.

This section presents the main findings of meteorological condition situation, including the main indicators of the meteorological reality in West Bank and the study area. The Study Area is thus known as an area with long, hot, dry summers and short and moderate winters. The climate conditions described as in the following sections:

2.3.1 Temperature

Geographical condition, altitude and marine exposure are considered the main factors involved in determining temperature. Data obtained from the Palestinian Meteorological Directorate revealed that the annual mean of air temperature during the period 1975-2005 was between 15.4 and 22.7°C in Hebron and Jericho respectively. In 2008 the annual mean temperature ranged between 16.9°C in Hebron and Ramallah to 24.2°C in Jericho (Figure 2).

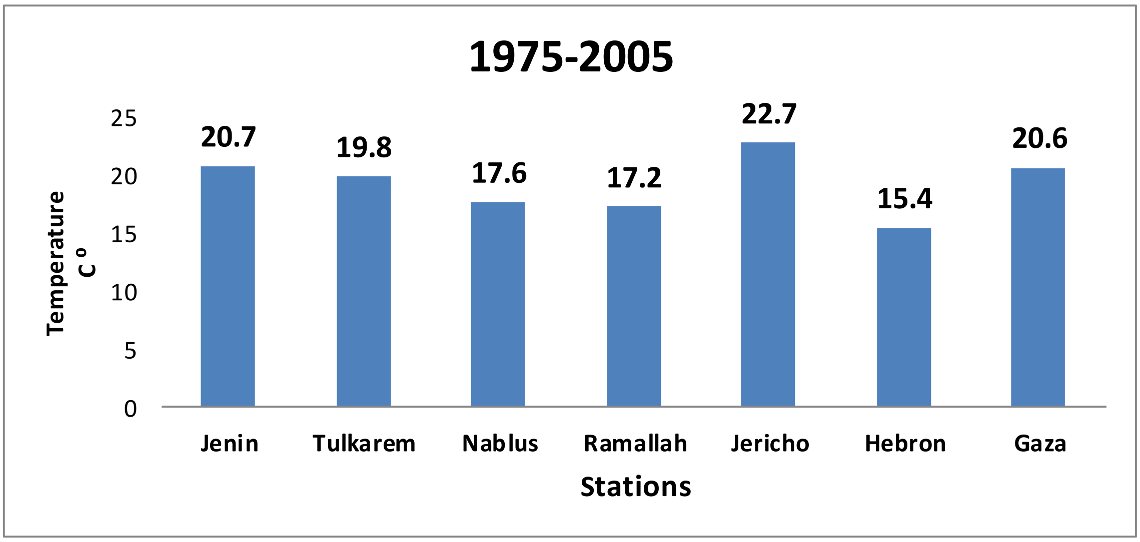


Figure (2): Mean of Air Temperatures in the Palestinian Territory by Year and Station Location, 1975-2005, 2008 .
***Source*: Palestinian Central Bureau of Statistics, 2009. *Meteorological Conditions in the Palestinian Territory Annual Report 2008*. Ramallah - Palestine.**

Figure (3) shows that in Jericho (the major part of the study area) has the highest maximum day temperature around the year (39.7°C).

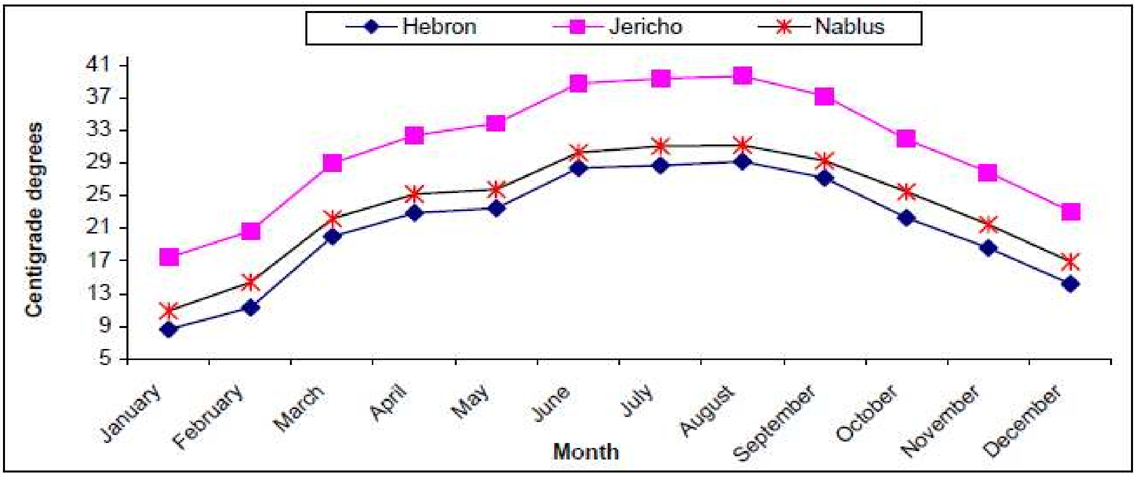


Figure (3): Mean maximum air temperature in the West Bank by month for three stations, 2008.

2.3.2 Rainfall

The annual precipitation ranges from less than 100 mm to around 400 mm per year. Winter is the rainy season and lasts from October to April in the west and from November to March in the central and LJV parts of the study area (Figure 4).

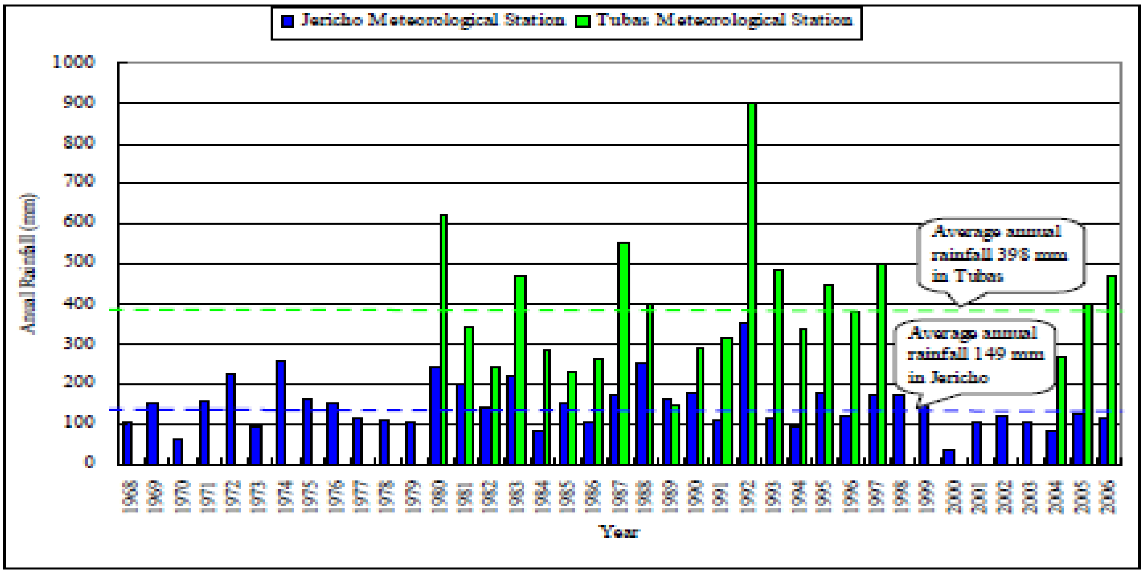


Figure (4): Comparison of Annual Rainfall for Jericho and Tubas Metrological Stations

Figure (5) illustrates the rainfall map and the distribution of annual precipitation. Lower rainfall (less than 100 mm) is recorded in the eastern parts.

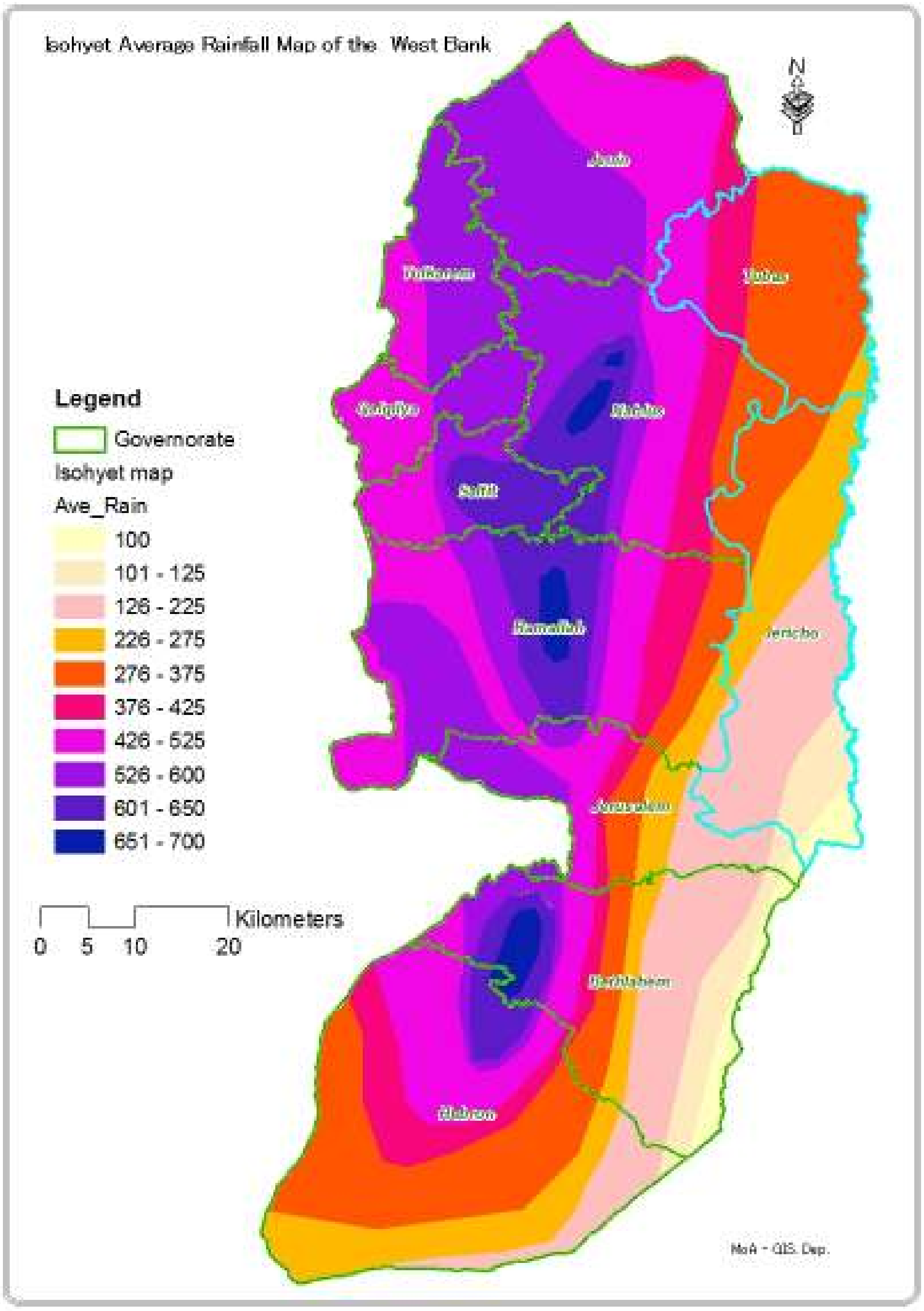


Figure (5): Average rainfall map.

2.3.3 Evaporation

As mentioned before, the Mediterranean climate is dominant on the study area with more than seven dry and hot months resulting in high evaporation rate (2192.7 mm in Jericho in 2008**,** Figure 6). Only 2- 3 months per year during winter is the evapotranspiration less than precipitation. Scarcity of water beside the high evapotranspiration cause extreme shortage on water for both domestic and agriculture mainly during summer time.

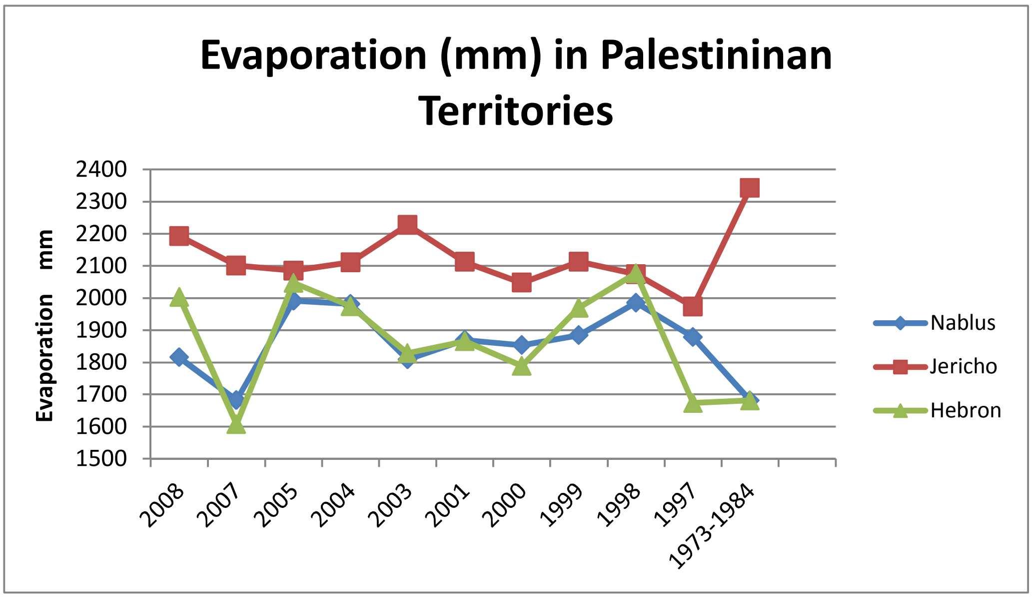


Figure (6): Evaporation (mm) in Palestinian Territories during the year 1973-1984 and 1997-2008.

Source: Department of Meteorology – Ministry of Transportation, 2009.

2.3.4 Humidity

According to the department of Meteorology department the least mean of relative humidity in the West Bank occurred in summer, this might be due to the fact that no wind is blowing from the sea (west) and dry wind coming from the desert. However, in winter season higher relative humidity is recorded (Table 2).

Table (2): Mean relative humidity in West Bank in 2008.

Month	Station Location					
	Hebron	Jericho	Ramallah	Nablus	Tulkarm	Jenin
January	72	59	76	64	55	65
February	68	62	76	65	64	67
March	54	47	59	52	51	58
April	55	41	57	49	49	52
May	56	44	64	58	55	59
June	52	40	60	53	56	57
July	57	45	71	62	56	62
August	60	47	72	65	63	66
September	71	50	77	67	58	64
October	78	57	84	68	63	68
November	63	56	68	58	49	64
December	66	55	69	62	62	68
Annual mean	**63**	**50**	**69**	**60**	**57**	**63**

Source: Department of Meteorology – Ministry of Transportation, 2009.

2.4 Demography and socioeconomic

2.4.1 General

The population of the study area is either native to this area living on villages or main towns or refugees that live in Camps who came from the coastal of the historical Palestine. Beside that there are several minor groups of Bedouins spread in the area (there native are from south (Negev desert) and living in tents as mentioned in a report (PCBS,2009).

2.4.2 Demography

The total population in the West Bank and Gaza strip is estimated 2,513,283 and 1535120 respectively at (PCBS, 2010). The population of the study area which include Both Jericho and Tubas governorates and a small part of east to Nablus governorate (6 villages: Bani Hasan, Ein Shibli, An-Nasareyah, Froosh Beit Dajan, Al-Bathan, Al-Aqrabaniyah) is estimated to be 110443in the year 2010 (Table 3). The average growth rate in Palestinian territories is 3.3% with 3.6 and 3.8% in Tubas and Jericho respectively. The estimated growth rate for the study area can be considered 3.7% .

Table (3) : Mid-year estimated population in WBGS by governorate. 1997-2010 (Revised Estimates)

Governorate	1997	2002	2003	2004	2005	2006	2007	2008	2009	2010
Palestinian Territory	2,783,084	3,225,214	3,314,509	3,407,417	3,508,126	3,611,998	3,719,189	3,825,512	3,935,249	4,048,403
West Bank	1,787,562	2,042,306	2,093,381	2,146,400	2,203,738	2,262,735	2,323,469	2,385,180	2,448,433	2,513,283
Tubas	34,755	41,631	43,039	44,510	46,111	47,770	49,489	51,192	52,950	54,765
Jericho and Al Aghwar	31,089	36,154	37,173	38,232	39,378	40,559	41,776	42,964	44,183	45,433
Nablus part	6347	7522	7800	8089	8388	8698	9527	9354	9880	10245
Study area	**72191**	**85307**	**88012**	**90831**	**93877**	**97033**	**100792**	**103510**	**107013**	**110443**
Gaza Strip	995,522	1,182,908	1,221,128	1,261,017	1,304,388	1,349,263	1,395,720	1,440,332	1,486,816	1,535,120

2.4.3 Health

The Palestinian Ministry of Health, UNRWA and NGOs provide medical services to people in the study area. The infant mortality rate decreased from 30 per to 22 per 1000 in 1997 . The life expectancy was improved from 56.6 in 1975 to 72.4 in 2005.

2.4.4 Population density and employment

Tubas and Jericho have low population density (136 and 77 person / km^2, respectively) compared to other Palestinian governorates (444 person / km^2 and 673 person / km^2 in West Bank and Gaza Strip, respectively.

During the last 10 years the unemployment percentage from the labor force reduced significantly to 9.9% in Jericho and 16.7% in Tubas compared to 19% in the West Bank.

2.4.5 Poverty

Data obtained from the Palestinian Central bureau of Statistics in 2006 regarding poverty in Palestinian territory revealed that poverty rates are higher for people who depend on agriculture as a source for income (Table 4).

Table (4): Poverty with respect to monthly consumption (1998- 2005)

Year	1998		2001		2004		2005	
Poverty line	Deep poverty	poverty	Deep poverty	poverty	Deep poverty	poverty	Deep poverty	poverty
Palestinian Territory	12.5	20.3	16.4	25.6	19.5	27.9	18.1	29.5
West Bank	8.4	14.5	11.6	19.8	12	18.9	13.1	22.3
West Bank-North	9.9	18.3	11.7	22.2	15.8	24.9	12.4	22.5
West Bank-Middle	4.6	6.9	3.7	6.7	3.9	6.7	6.7	11
West Bank-South	12.2	20.4	20.6	31.2	16	25	21.4	34.9
Poverty by main source of income								
Agriculture	24.7	32.2	25	37.5	32.3	13.5	29.7	50.4
Other household business	16.6	24.6	14.5	21.9	24.6	11.5	16.1	27.1
Wages and salaries – public sector	18	26.1	9.4	16.5	26.1	9.2	10.8	22.9
Wages and salaries – private sector	21.9	28.8	19.4	28.9	28.8	13.4	19.4	32.6
Wages and salaries – Israeli sector	15.9	22.6	11.4	21.8	22.6	9.3	13.2	20.1

Source : Poverty in the Palestinian Territory , 2006 PCBS

West Bank-North: Jenin, Tubas, Tulkarm, Nablus, qalqilya, and Salfit governorates

West Bank-Middle: Ramallah, Jerusalem, and Jericho governorates

West Bank-South: Bethlehem, and Hebron

2.5 Geology and Hydrology

The study area is part of the Jordan lift valley which is part of the Dead Sea Transform. Geologically, it forms a plate boundary between the Southern Arabian Plate and Western African Plate.

The area is divided longitudinally into three regions; south- north belts represented by the Jordan Valley surrounded by two mountainous belts the Jordanian east side and the Israeli-Palestinian West side. The average annual precipitation in mountainous belts ranges 400-600 mm of which 30-50% of this amount is infiltrated into the groundwater (Flexer et al.,2007).

The groundwater flows to the Jordan valley from the mountainous parts is affected by the structure and lithostratigraphy.

2.6 Water Resources

The main water resources in the study area are surface water and groundwater.

2.6.1 Surface Water

Little attention is paid to surface water resources due to the fact that there are no dams or catchments to utilize the surface runoff in the eastern slopes. Surface runoff decreased in the eastern parts of the Jordan valley because the slope decreases and the area become more flat. The second source of surface water is the Jordan River which is not available to the Palestinian. However, Johnson's plan for sharing the water of JV allocated 250 MCM/year from the Jordan River with Palestine; a project called the West Ghore Canal was supposed to utilize these quantities side by side with eastern Ghore canal that was established by Jordan on the east side.

2.6.2 Groundwater

Palestinian (West Bank and Gaza strip) water resources are mainly restricted to groundwater (wells and springs) and water purchased from Mekorot. Water quantity from these sources was 308.7 MCM (The Palestinian Central Bureau for Statistics, 2008) of which 225.7 MCM from wells representing 73.1% from the total ground water amount. The amount of water purchased from Mekorot was 57.8 MCM. The remaining water is supplied from springs.

In the study area total amount of available water is 56.58 MCM (39.2 MCM from the spring and 12 MCM form wells). Compared to the amounts in 2004 and 2007 great reduction in the water quantity was recorded mainly from spring due to misuse and rainfall decrease (Table 5).

Table (5): Water resources for WBGS and the study area (Wells and Springs).

Area	No. of springs	No. of wells	Quantity spring MCM	Quantity wells MCM	Mekorot* MCM	Total MCM
West Bank & Gaza	117	470	44.8	241.2	49.4	335.4
Study area	49	93	39.2	12	5.38	56.58

Source : PCBS, 2008

*: Israeli company for water distribution.

117 springs are located in West Bank, 49 (86.35%) are in the study area. 272 wells of 470 in West Bank and Gaza Strip are used for agricultural (figure 7).

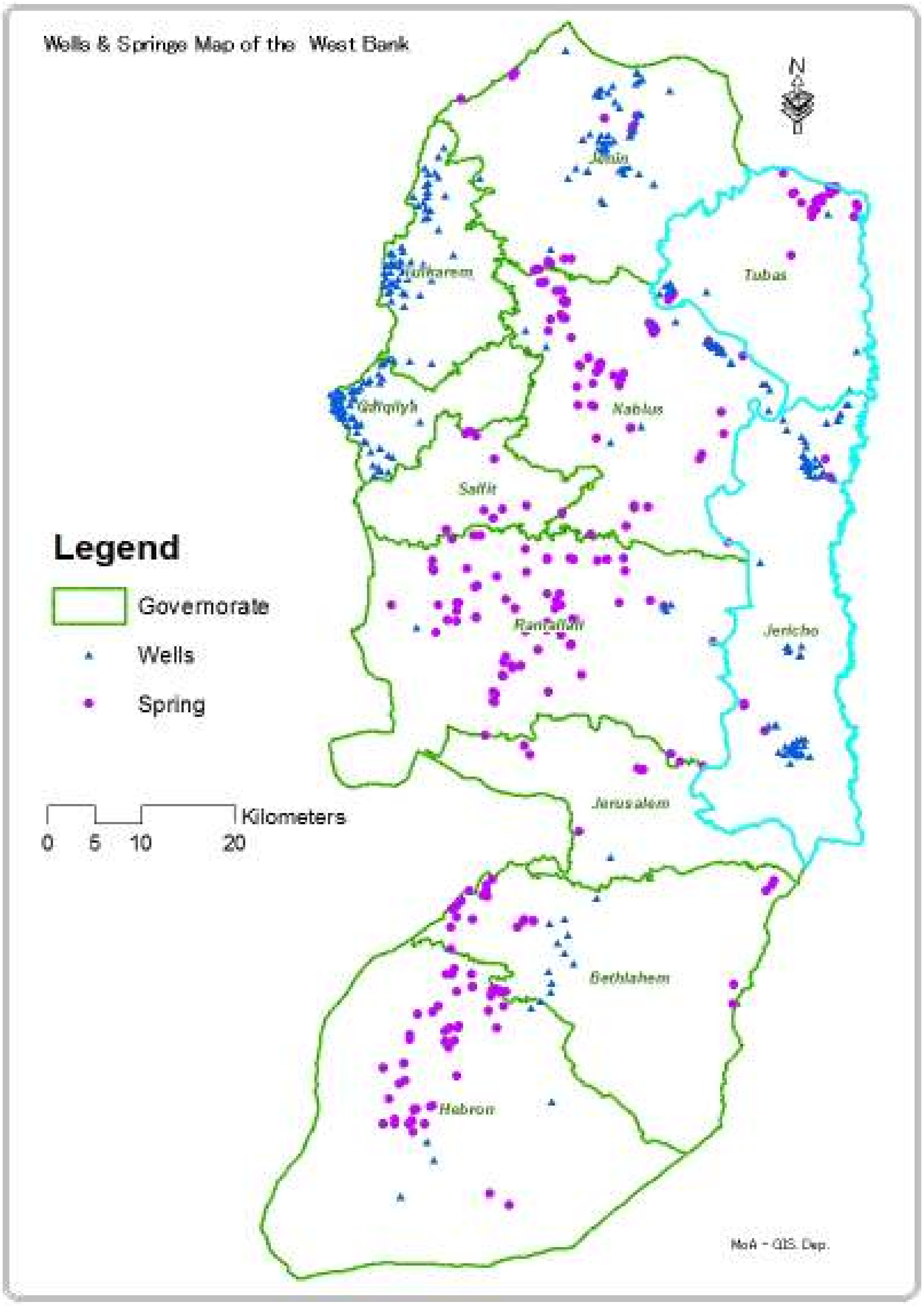


Figure (7): Wells and springs distribution in WB and SA

Chapter Three

Objectives and Methodology

3.1 Research Objectives

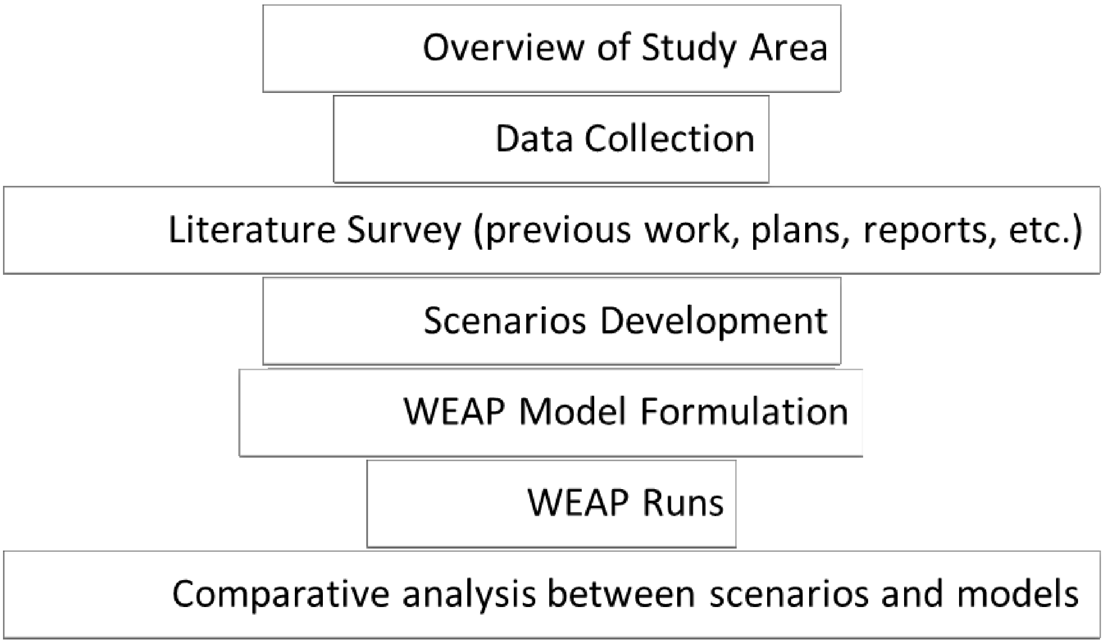
The aim of this work is to use a water management model to assess water management options in the LJV under different scenarios. The main objective of the work is to achieve the best sustainable water management options in agriculture in the LJV through detailed water management scenarios using computer water planning model “WEAP” (Water Evaluation and Planning System) as a tool.

The study will focus on a very vital area for Palestinian agriculture future which is considered as the food basket for Palestine since it contains both agricultural land and water resources where 94% is used for agricultural purposes. In addition to that, the climate is suitable, mainly during winter, for different type of crops. Beside that LJV is a margin area with low developmental and economical level which needs more care and attention. So the study will concentrate on managing water for agriculture under the future possible scenarios (not only one scenario).

3.2 Research Methodology

To predict the future water management and agriculture scenarios, we need to well know our current situation and the factors with time and space and with quality and quantity which affect water availability for agriculture. This knowledge and understanding will enable to formulate future management scenarios. Comparative analysis between scenarios will enable choosing the best scenario leading to toward the best water management option and sustainable development of water resources.

The following is step by step implementation plan of the anticipated research activities:



3.3 WEAP

What and why Water Evaluation and Planning System (WEAP)

Conventional water supply-oriented simulation models are not always suitable and integrated approaches due to various factors affecting water management. Over the last decade, an integrated approach of water development (The Water Evaluation and Planning System (WEAP) was established (figure 8). The WEAP places water supply projects in the context of demand-side issues, as well as issues of water quality and ecosystem preservation (SEI, 2001). WEAP system aims to incorporate these values into a practical tool for water resources planning. The WEAP is distinguished by its integrated approach to simulating water systems and by its policy orientation. It places the demand side of the equation--water use patterns, equipment efficiencies, re-use, prices and allocation--on an equal footing with the supply side--stream flow, groundwater, reservoirs and water transfers. WEAP is a laboratory for examining alternative water development and management strategies (SEI, 2001).

The WEAP program is used in this work because of the following points:

1. It is comprehensive, straightforward and easy-to-use, and attempts to assist rather than substitute skilled planner.
2. As a database, WEAP provides a system for maintaining water demand and supply information.
3. As a forecasting tool, WEAP simulates water demand, supply, flows, storage, pollution generation, treatment and discharge.
4. As a policy analysis tool, WEAP evaluates a full range of water development (SEI, 2001).
5. It is an integrated tool, easy to handle and manage, having the ability to deal with several scenarios with time, obtaining powerful means of viewing and data shows, its applicability as a tool for decision support system. All these advantages, beside that WEAP as a tool never been done for this area before, enhance using the program in this study.

WEAP applications involve the following steps (SEI,2001)

1. Defining the problem including time frame, spatial boundary, system components and configuration.
2. Establishment of the current account which give a snapshot of actual water demand, resources and supplies for the system.
3. Building different scenarios based on sets of future trends depending on policies, technological development and other factors that affect demand and supply.

4. Evaluating the scenarios with respect to water resources, benefits….etc.

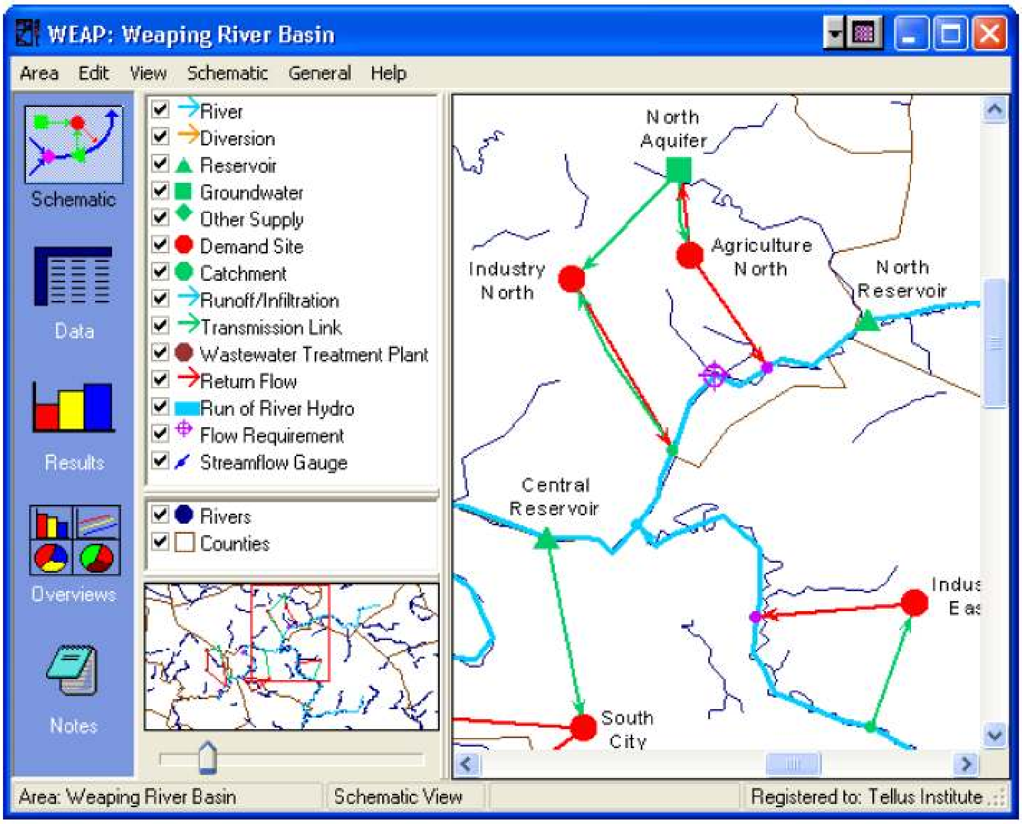


Figure (8): Main WEAP Screen Having the Five Main Sites.

"What if question" is very familiar in WEAP scenarios such as: what if population growth rate changed? Or what if irrigation technique and growth pattern are altered?

When using WEAP program, graphical interface provide a simple and powerful tools for constructing, viewing, and modifying the system and its data. All functions such as date entry, calculation reviewing result are handled through interactive screen structure. Few studies were done in Palestine using the WEAP model (Sivan, 2007). In West Bank WEAP model was applied on other areas for different issues. Its applicability as water management decision support system tool on localized area of watershed scales (Tulkarem) was tested successfully by (Haddad, 2007) in Tulkarm district. It was also used as planning tool to develop an integrated water resources management system for the area served by Jerusalem Water Undertaking (JWU), mainly Ramallah and Al-Bireh area, the results reveal that applying a demand management program and involvement the private sector resulted in decreasing the water demand by significant value (Leen, 2009). WEAP is also used in the surrounded country as Jordan where Water Management Support System for Amman Zarqa Basin in Jordan has been developed and WEAP was used as a tool for Evaluation and Planning system (Al-Omari, 2009).

3.4 Scenarios Development

The study will evaluate water management options for LJV using WEAP. This model will help to identify management options under different scenarios which in turn will help as a decision support tool to identify the best options concerning water management in LJV. The following scenarios represent the most important water management options that will be developed and analyzed in this study:

1- Optimal water use.

2- Optimal land use.

3- Supplementary water resources including water harvesting and treated wastewater.

4- Virtual water.

5- Food security.

6- Poverty and socioeconomic linkage.

7- Political status (main scenario)

3.4.1 Current Situation

Before running the mentioned scenarios, it is necessary to have clear idea and sufficient data about water and agriculture. Agricultural patterns, crops type, irrigation system and method of irrigation must be studied. Two types of agricultural pattern (rainfed and irrigated agriculture) are currently applied in the LJV.

3.4.1.1 Rainfed Agriculture

Even rainfed farming in Jericho and Nablus districts is reduced with time due to limited rainfall, it is still common in Tubas area where rainfall is more sufficient (more than 300 mm). Cereals such as wheat and barley and Olive tree are the most grown crops . Other rain fed vegetables such as tomato, cucumber, squash are also grown (Table 6).

It is well known that irrigated agriculture is more costly, but at the same time is more productive than the rainfed one (see table 6). For each type of Crops grown in the LJV there are specific considerations to be kept in mind:

- Potato:
    - Field crop, relatively higher productive than other filed crops.
    - Palestine has a trend to expand in its plantation.
    - It is considered as a beneficial crop (i.e. planted more than one time per year).
    - It is a rich source of carbohydrates.
    - In the SA (mainly the northern parts), there are plenty lands are suitable for its plantation
    - Production in WBGS is less than demand.

- Dates :
  - Tolerate salinity
  - Adapted to high temperature and arid areas.
  - Has great food value
  - Good returning back crop
  - The production still below the local market demand.
- Banana:
  - Highly water consumer.
  - The cost production is higher than import from outside (not an economic crops).
  - The present cultivars are of low productivity.
  - There is a direction to minimize or even not planting it.
- Grapes:
  - Northern and mountainous parts of the study area are good for its plantation.
  - Compared to other fruit trees such as citrus, dates and banana, it needs less water.
  - Farmers in this area are familiar with this crops and have a good experience in its cultural practices .
  - There is an ability to produce more than one crop in the same season (intensive production) with earlier production which means good prices.

Table (6): Area, production, productivity and annual water requirements of crops planted in the study area.

Crop	Area (dunum)	Productivity (ton)*	Production (ton)*	water CM /dunum	Water needed CM/kg	Needed water MCM
Greenhouse	2369	12.4	29375.6	1000	0.08	2.37
Tunnels	5193	3.8	19735.0	500	0.132	2.60
Irrigated field vegetable	46745	2.45	114514	500	0.2	22.90
Irrigated field crops	13091	1.4	18327	300	0.21	3.93
Irrigated Banana	1540	4	6160	1500	0.375	2.31
Irrigated Date	428	1.0	428.0	1100	1.1	0.47
Irrigated Citrus	4379	1.94	8320	850	0.44	0.37
Irrigated Grape	557	2.0	1114	500	0.25	0.28
Irrigated fruits	12154	1.5	18231	850	0.57	10.39
Rain fed crops	40994	0.3	12298	0	0	0
Rain fed vegetables	5320	0.46	2447	0	0	0
Rain fed trees	17561	0.35	6146	0	0	0
TOTAL	**150331**					**45.62MCM**

Source: Collected data from MoA and PCBS,2008.
*:*Calculation done by the researcher*

Figure (9) shows the percentage and distribution of water in different growth patterns in the study area (SA). The percent of open irrigated vegetable is 57% followed by citrus, tunnels and greenhouses agriculture (9, 6, and 6%, respectively).

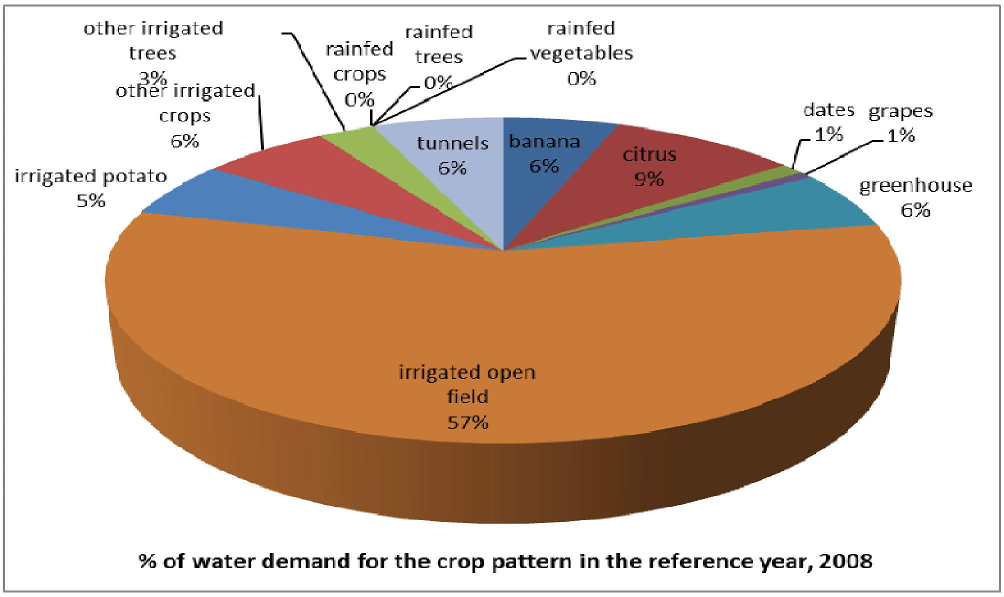


Figure (9): Percentage of water demand for each irrigated crop pattern

3.4.1.2 Irrigated agriculture

Irrigated farming is the dominant pattern in Jericho and Nablus governorates of the study area. It consists of tunnels, greenhouses and open field irrigation (Table 6). Drip irrigation in covered crops is the most used and with less used in open field. In tree the percent of drip irrigation is less important.

Chapter Four

Running Scenarios

4.1 Scenarios Formulation

A scenario is defined as reasonable description of how the future may develop, based on coherent and internally consistent sets of assumptions about key relationships and driving forces. It is clear that scenarios are not forecasted or predicted. Because it is impossible to have precise prediction how water demand and other factors that affect the water resources of the study area will be changed in the future, the scenarios proposed in this study will be based on the current situation.

4.2. First Main scenario: current political scenario

1st scenario: Optimal land use:

The optimal land use scenario aims at finding the best growth patterns and crop types to obtain the best benefits from the same amount of water. Knowing that we are talking about area with water scarcity, very few resources and governed by the political situation (water resources are controlled by Israeli side).

Concept:

This scenario assumed that:

1. Having limiting water resources under the current political situation
2. Intensive agriculture (greenhouses and tunnels) are more productive than open field agriculture.

3. Northern part of the LJV is famous in field crops while both irrigated open field vegetables and covered farming are existed in the south and center parts.

Both tunnels and open field vegetables need the same water requirement (around 500 mm annually). Tunnels are more productive (3.8 ton/dunum) resulting in more yield (Table 7) . In greenhouse agriculture, higher amounts of water are used compared to open irrigated vegetables, but productivity more than 10 times greater.

Table (7): Crop pattern and their productivity and the annual CM needed per dunum.

Crop pattern	Productivity (ton)	CM water /dunums	CM/Kg
Greenhouse	12.4	1000	0.08
Tunnels	3.8	500	0.13
Irrigated field vegetable	2.45	500	0.20
Irrigated field crops	1.4	300	0.21
Irrigated Banana	4	1500	0.375
Irrigated Date	1.0	1100	1.1
Irrigated Citrus	1.94	850	0.438
Irrigated Grape	2	500	0.25
Irrigated other fruits	1.5	850	0.57
Rain fed crops	0.3	0	0
Rain fed vegetables	0.460	0	0
Rain fed trees	0.35	0	0

Source: Collected data from MoA and PCBS,2008.

The area has large irrigable capacity, where additional 145000 dunums are extent with no irrigation. With limited water resources from wells and springs (52 MCM in good season), there are no alternatives to expand the irrigation area. Thus for the land use scenario the following suggestion and/or assumptions are applied:

1. Increase the area of irrigated potato by 5000 dunums in the 15 coming years. Potato is considered as field crops and its production is less than the annual Palestinian demand (Table 8). And by near future , the gap between demand and production will be increased (Table 9).

Table (8): Potato production and demand, calculation depend on data from PCBS, 2008

CROP	Potato
Consumption per capita (KG)/YEAR	25
Current demand (TON)	100000
Productivity (TON/ Dunum)	3.3
Planted in SA (Dunum)	4570
Production of SA (TON)	14718
TOTAL WBGS Production (TON)	62841
% from total demand	14.72
% of production	23.4
% of sufficiency	62.84

Table (9): Increase In common crop Demand For the Coming 15 Years (population Growth Rate 3.2 %)

Crop	Consumption capita (kg)/year	Demand 2010 (ton)*	Demand 2015 (ton)*	Demand 2020 (ton)*	Demand 2025 (ton)*
vegetables	98.4	393600	475500	556600	644000
fruits	58.8	235200	284100	332600	384800
tomato	31.88	127500	154000	180300	208600
cucumber	15	60000	72500	84800	98200
squash	6.56	26200	31700	194000	43000
bean	0.83	3300	4000	4700	5400
Egg plant	8.0	32000	38700	45300	52400
Date	1	4000	4800	5700	6500
Grape	5.43	21700	26200	30700	35500
banana	8.44	33800	40800	47700	55200
citrus	14.93	59700	72100	84500	97700
wheat	135(different uses)	546000	639800	749000	904600
potato	25	100000	120800	141400	163600

***Quantity demand are around to 100 tons.**

2. Adding around 3000 dunums of new greenhouses in the coming 15 years.

3. Adding 10050 dunums of covered tunnels until the 2025.

4. Increasing the grape area by 7500 dunums until 2025.

5. The central and southern part have climatic condition which is very favorable and suitable for date. It suggested to increase the small area planted by 6500 dunums.

6. Another suggestion is to increase rain fed agriculture as follows:

   - Planting 1000 dunums annually for the coming 15 years with rain fed trees such as stone fruits with root stocks that are drought tolerance.
   - Planting 9000 dunums for the coming 15 years with rain fed crops as wheat, corn, legumes).
   - Planting 5000 dunums for the coming 15 years with rain fed vegetables such as grafted watermelon, muskmelon, okra, onion…etc.

Table (10) and figures (10 and 11a+b) summarizes the suggested changes and the results of this scenario, showing that 19000 dunums are added as a new plantations in the above irrigable area which represented only 13.1% .

Table (10): Changes in areas due to scenario optimal land use.

Crop pattern	Area 2008 (du)	Changes	Area 2025	notice
Irrigated potato	4570	+ 5000	9570	500 du annually
greenhouses	2369	3040	5409	200 du annually
tunnels	7193	+10500	17693	1000 du annually
Irrigated open vegetables	46745	-31000	15745	2000 du annually
Irrigated grapes	557	+ 7500	8057	500 du annually
Banana	1540	-1540	0	100 du annually For the 1st 10 years
Dates	428	+ 6500	6928	500 du annually
Rain fed trees	17561	+15000	32561	1000 du annually
Rain fed vegetables	5320	+15000	20320	1000 du annually
Rain fed crops	40994	+9000	49994	1000 du annually
TOTAL	127277	39000	176277	

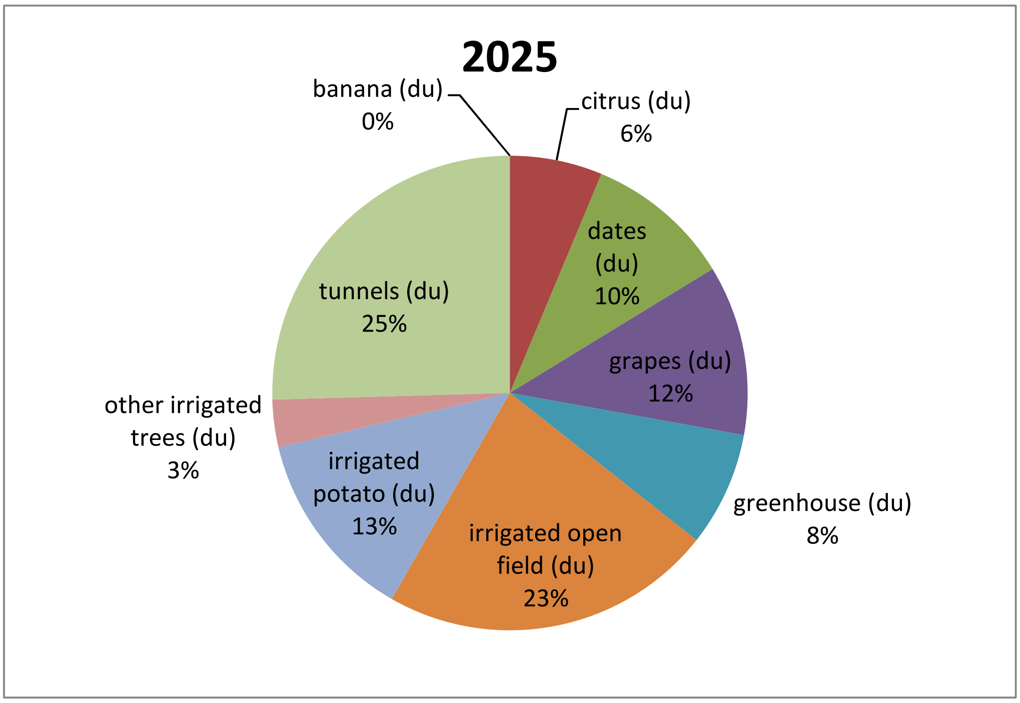


Figure (10): Percentage of the crop pattern from the planted SA when applying optimal land use scenario.

The positive effects of increasing the total planted area and changing growth pattern will be more obvious when the total production is increased (Table 11).

Table (11) : Changes in the total production due to scenario optimal land use.

Crop pattern	Changes in area dunum	Productivity (ton)	Changes in production (ton)
Irrigated potato	+ 5000	3.3	16500
greenhouses	+3040	12.4	37696
tunnels	+ 10500	3.8	39900
Irrigated open vegetables	-31000	2.45	-75950
Irrigated grapes	+ 7500	2	15000
Banana	-1540	4	-6160
Dates	+ 6500	1	6500
Rain fed trees	+15000	1.5	22500
Rain fed vegetables	+15000	0.46	6900
Rain fed crops	+9000	0.3	2700
TOTAL CHANGE	**39000 dunums**		**+ 65586 tons** *(33486 from irrigated fields & 32100 ton from new rainfed fields)*

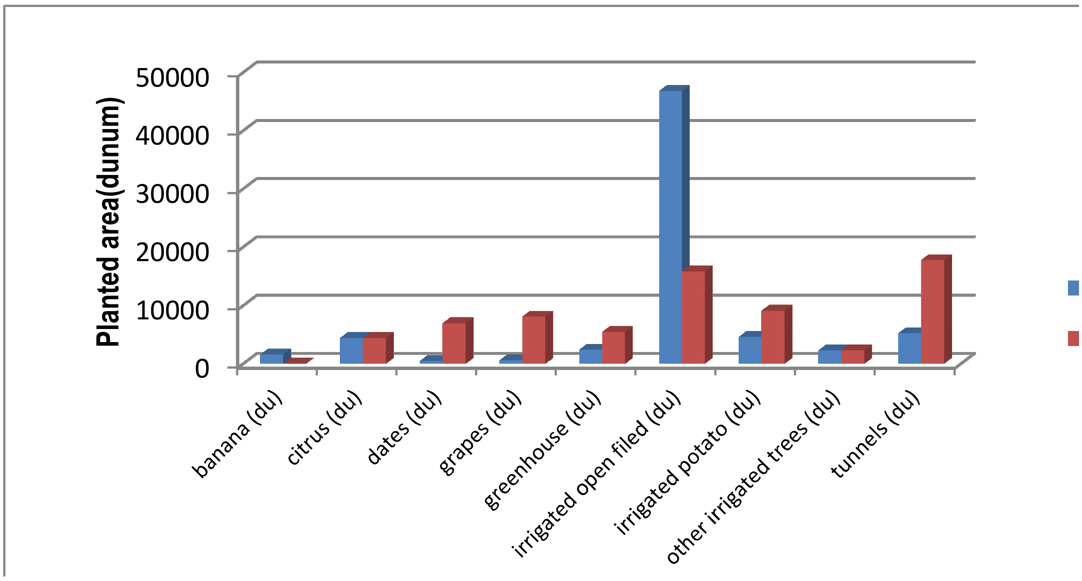


Figure (11a): Comparison between crop pattern of the optimal land use with reference to current situation

<u>Scenario Outcome</u>: The output of optimal land use scenario model shows significant increase in total production (around 65586 tons) due to the fact that in the LJV the productivity of irrigated intensive culture (greenhouses and tunnels) is five and two times respectively greater than the productivity of irrigated open vegetables in the same land area and water requirement. In addition to that, planting new rainfed land will significantly increase the production (49% from increasing the production of cultivated area).

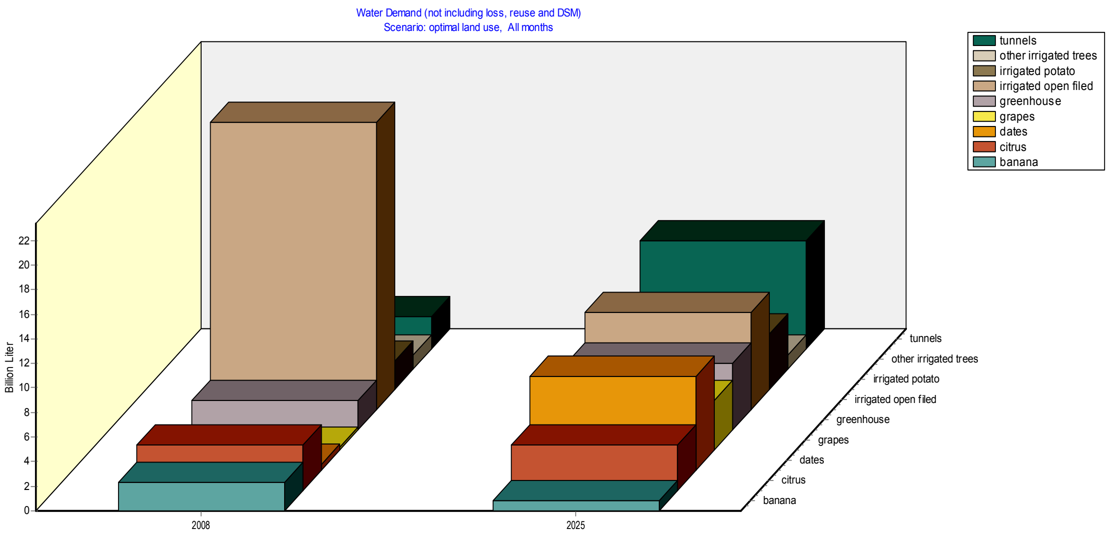


Figure (11b): Changes in water demand by time for different crops.

<u>2nd scenario: Optimal water use</u>

Globally, water scarcity is the biggest water problem (Jury and Vaux, 2005). Inefficient use of water in agriculture systems is a clear criteria due to low efficiency in irrigation chain. Irrigation efficiency started from the demand site including the conveyance system and the farm irrigation until yield production. Thus efficient use of the water must be a major focus in coping with the growing water scarcity (Gleick 2003).

For the LJV, where only around 100000 capita are lived, with an average of 132.9 liter of water per capita are daily consumed (Palestinian average) for domestic purposes, nearly 4,818 MCM are allocated for the domestic purposes and 56 MCM (in the good year) for the agriculture sector (91.5% of water resources available for the LJV are used for agricultural sector) (PCBS,2009).

Going through the irrigation system, its total efficiency is formed from several efficiencies. To achieve an appropriate level of irrigation efficiency it is better to make improvements in all irrigation chain, instead of concentrating in improving one or two steps in the irrigation chain.

Usually efficiency of any production process is defined as the ratio between output and input. The irrigation system is formed from a chain of efficiencies which we have to take into consideration to obtain effective irrigation efficiency. The following are types of efficiencies included in this chain :

1. Conveyance and farming efficiency (E_{conv}): it is extend from the demand site until the farm gate.
2. Application efficiency (E_{appl}): starts after the arrival of water to the the field. E_{appl} is closely related to the uniformity of the distribution of the irrigation system (irrigation method used such as surface, sprinkler or drip irrigation). E_{appl} in surface irrigation is the least effective (80%); (Howell, 2003) due to several factors including infiltration rate and slope. Sprinkler irrigation is more efficient than surface irrigation. However, it might have poor application efficiency due to inadequate pressure, windy days or poor distribution of the nozzles (Playan et. al.,2005). Sprinkler method may reach 90% . While drip irrigation has the potential to give the highest irrigation efficiency (95%), in under poor condition such as poor design or emitter closure it reach 70%. In addition to that, E_{appl} is a function of soil and root zone storage capacities which reflect the percentage of

water that might be drained or available for plant. To minimize the losses during this step and to increase the E_{appl}, changing the distribution system or improving the present one are two possibilities to be considered. Capture and reuse of the runoff is another choice for improving E_{appl} (Theodore et. al., 2007).

3. Consumptive efficiency (E_{et}): defined as the ratio between water evapotranspired and the amount stored in the root zone. This efficiency is considered for the whole growing season. E_{et} is neglected due to its minor effect (the water content in the root zone always match the cumulative evapotranspiration which is slightly different than the amount of water left in the root zone at harvest time (Theodore et al.,2007).
4. Transpiration efficiency (E_{tr}): reflects the actual amount of water taken by the crop and the total evapotranspiration (ET). Wetness of the soil surface and energy of the soil surface determine the level of evaporation. Transpiration is an indication for carbon dioxide assimilation which varies according to surrounded conditions and crop growth rate (Fischer and Turner, 1978)
5. Assimilation efficiency (E_{as}): described as photosynthetic water productivity (Steduto et. al., 2007).
6. Biomass efficiency (E_{bm}): the biomass produced for the amount of carbon dioxide and water assimilated. E_{bm} is affected by conditions that affect plant respiration (mainly temperature) and the chemical composition of the crop (Steduto et. al., 2007).
7. Yield efficiency (E_{yld}): known as harvest index. E_{yld} is the biomass produced at the harvested (Donald, 2006). E_{yld} might reach 0.99 in forages and 0.5 in new grain cultivars.

The above mentioned efficiencies form a chain and for each efficiency there is a range between both poor and good circumstances and practices (Table 12).

Table (12): Range of efficiencies in efficiency chain

Type of efficiency	Unit	symbol	Efficiency level	
			Poor circumstances and practices	Good circumstances and practices
Conveyance	unitless	(E_{conv})	0.5 – 0.7	0.8– 0.96
farming	unitless	E_{fam}	0.4 – 0.6	0.75– 0.95
Application	unitless	(E_{appl})	0.3 – 0.5	0.7– 0.95
Consumptive	unitless	(Eet)	0.85 – 0.92	0.97– 0.99
Transpiration	unitless	(E_{tr})	0.25–0.5	0.7– 0.92
Assimilation	kg CO2 m^{-3}water	(E_{as})	6.0–8.0	9 –14
Biomass	Kg biomass kg^{-1}CO2	(E_{bm})	0.22–0.36	0.4 – 0.5
Yield (for grain)	unitless	(E_{yld})	0.24–0.36	0.44 – 0.52

To proceed with the estimated percentage of conveyance and irrigation the following practices must be accomplished:

1. Rehabilitation and maintenance of the existing springs and wells.
2. Rehabilitation of the conveyance and distribution systems by using closed and pressurized pipe and reduce or eliminate open irrigation systems mainly for springs.
3. Construction of storage reservoirs such as pools, closed tanks or other reservoirs that decreases evaporation and water loss.
4. Use of devices to monitor water at farm level such as flow meters, tensiometers, irrigating at field capacity, meteorological stations and irrigation systems and network with high efficiency
5. Improving the extension serves and establishment of water associations and framer unions.

Scenario Outcome: Even the water use efficiency level is good in the study area, mainly for protected agriculture which uses drip irrigation and some modern technologies, more efficient water use in agriculture is still needed. It is expected to optimize and increase the water use efficiency in an average of 10% for saving more than 6.4 MCM for agriculture. Table (12) illustrates the expected water saving percentage for each crop assuming that all saved water will be used for the same crop and expanding the area of its plantation giving an increase of 11137.7 dunums for all crop type listed in Table (13):

Table (13): Estimated percentage of saving when applied optimize water use.

Crop	% of saving	MCM needed	MCM saved	Additional area(du)	Change in production
Greenhouse	5	2.369	0.12	118.5	1470
Tunnels	7.5	2.5967	0.2	390	1482
Irrigated field vegetable	15	20.62	3.1	6184	14568.2
Irrigated potato	15	2.285	0.343	686	2263.8
Irrigated field crops	15	3.93	0.59	197	59
Irrigated Banana	15	2.31	0.35	231	924
Irrigated Date	15	0.4708	0.070	64.5	65
Irrigated Citrus	15	0.365	0.06	64.7	126
Irrigated Grape	15	0.2785	0.040	84	168
Irrigated fruits	15	10.39	1.56	3118	4677
TOTAL			**6.43**	**11137.7 dunums**	**25803 ton**

Application of the above mentioned scenario increased the agriculture area (11137.7 dunums) (Figure 12,table 13). The amount of water saved was also increases (Figure 13).

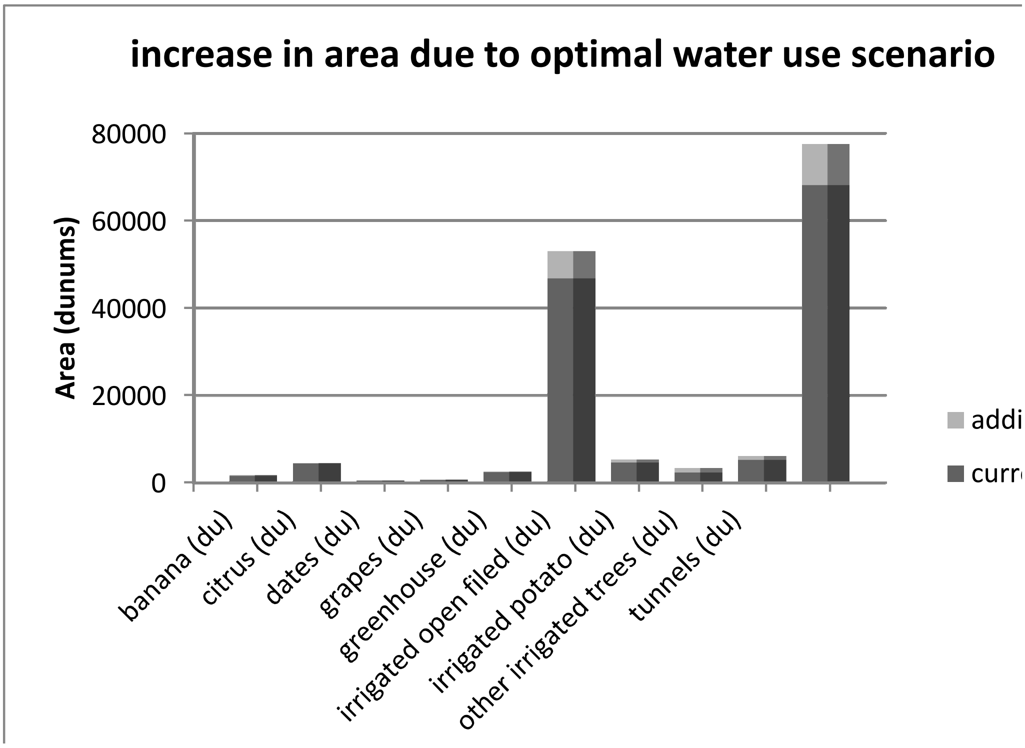


Figure (12): Increase of planted area due to optimal water scenario, current main political scenario

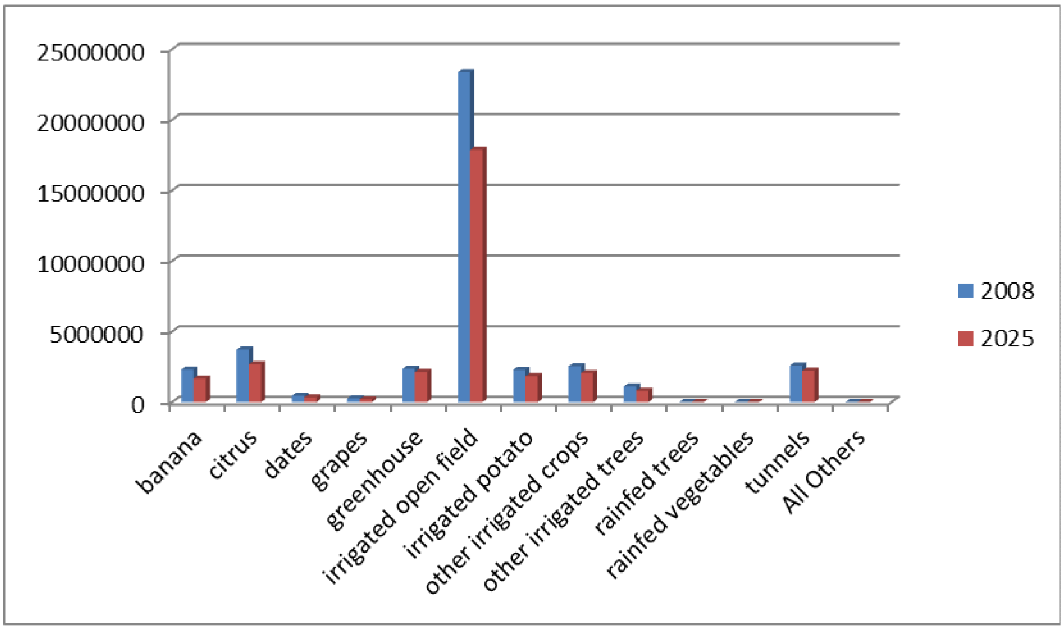


Figure (13): Water saving due to applying optimal water use scenario (CM).

In summary applying optimum water use efficiency scenario in the LJV as stated above would save 5 and 15% of water for tunnels and trees agriculture, respectively, with total of 1 MCM of water annually.

3rd scenario: Supplementary water use

The demand on water is increased in all aspects of life due to many factors such as development and population growth .In Palestine, water scarcity more critical because of unbalanced situation between demand and supply of water and the increasing demand with limited water resources.

Re-allocation of conventional water resources might be a promising choice to minimize the future gab between water demand and supply. Rehabilitation of water resources and sufficient use of the available conventional water buy applying wise control and new techniques is another choice.

The previous mentioned procedures to maximize the benefit of conventional water supply and controlling the demand still not enough to cover the current and future water requirements. There is a need to seek for non-conventional water resources which is considered the potential of future water resources.

In our region, it is of great importance to search for new conventional and non- conventional water. Water resources in the study area are either from wells or springs (ground water) and no surface water from Jordan river can be used due to the current political situation.

The possible supplementary water recourses for the study area are:

1. Water Harvesting

- At farmer level collecting water rainfall from the surface of the greenhouse in pools or reservoir and use of contours lines.
- At large scale level, Storm water harvesting during winter from the flood water of small Wadis, is another source of water. However, their

cost are relatively high and requires some infrastructure such as establishment dams on Wadis . Surface water flow in Wadis is referred to as surface runoff, which depends mainly on quantities and duration of rainfall during the winter season. It was found that surface runoff occurs when rainfall exceeds 50 mm in one day or 70 mm in two consecutive days (Jayyusi,2009). Wadis in the West Bank are divided into two major groups: eastern and western Wadis. Eastern Wadis flow from the central mountains toward the Jordan Valley, and contribute to the recharge of shallow aquifers and the Jordan River. Western Wadis flow from the central mountains to the west Mediterranean Basin. Some studies estimated that about 20 MCM out of 64 MCM total runoff in WB could be utilized (Jayyusi,2009).

2. Reuse of Treated Wastewater

In arid and semi- arid region the reuse of treated wastewater is of great importance as non-conventional water resources. In West Bank and Gaza Strip, water resources are highly valuable due to rapid population growth, drought and increasing in industrial and agricultural activities as well as the domestic needs.

Wastewater contains nearly 99% of water and only 1% solid waste.

Treated wastewater can be used in many agricultural practices as follows:

1. Irrigation of landscape and perennial trees.
2. Irrigation fodder, fiber and pasture.
3. Solve the water shortage problem.
4. The nutritional value in the reclaimed wastewater can be used as fertilizer (rich with phosphorous, nitrate and other minerals).

5. Reduce the environmental contamination

Although, using treated wastewater in irrigation in agriculture has some disadvantages:

1. The effluent may contain heavy metal.
2. Low quality .
3. Increase the salinity with continuous irrigation
4. Microbial infection.

Summary of Wastewater situation in WBGS :

- In WBGS, Wastewater is non- conventional water resources, that is newly adapted.
- There are only eight wastewater treatment plants (five in west bank and three in Gaza strip)
- The only partially functional is located in Albierh (2 MCM per year).
- For the near future only the area containing network collecting sewage system will get benefits from treated wastewater (around 30% of the population in WBGS).
- Most villages and small town have no sewage network
- The total production of wastewater is estimated to 70 MCM, where 30 MCM goes during sewage network while the remaining without, 2-4 MCM treated by Albierh treated wastewater plant, only 13 MCM goes east direction to the Jordan Valley (towards the study area).

- Nablus wastewater treated plant is under construction. It suppose that it will provide the study area with 2- 3 MCM per year
- There are some small scale treated wastewater plants:
  - Low- scale treatment(10 – 120 m^3 /day)
  - On-site (household level).
- The Palestinian sub strategy include:
  - Develop and enhance water supplies
  - Rehabilitate the water infrastructure.
  - Reuse of non-conventional water resources.
  - Desalinize the brackish and saline water.
  - Enhance the water harvesting on small and medium scale.
- Recently, The Palestinian National Authority issued the Palestinian guidelines and regulations concerning wastewater reclamation and reuse **(Appendix No.3)**

In Palestine the experience in wastewater reuse is poor and there is a lack of proper sewage collection and treatment system. Political and public acceptance are farther Constrains that affect the wastewater reuse.

3. Desalination of Brackish water

About 71% of earth's surface is covered with water; the majority of it comes from salty ocean and seas, 1.6% are found in the ground in aquifers and about 0.001% exists in the air as vapor. Fresh surface water is only 3% of the total water on the earth surface

All water in nature contains soluble salts. The concentration of the salts determines whether the water is of high quality (drinkable or usable for irrigation without need for special precautions) or of low quality (brackish or saline). Water in the soil also has soluble salts (sometimes are free or non-attached salts). The amount of salts in the root zone (or the salt concentration in the soil solution) determines whether the soil is “normal” or “salt-affected” (saline, sodic, or salinesodic).

There are three main sources for salts in soil and irrigation water:

- naturally present as products of geo-chemical weathering of rocks and parent materials
- derived directly from sea water by flooding, spray, or intrusion into groundwater resources
- caused by irrigation mismanagement, particularly when internal soil drainage is impeded.

Brackish water is water that has more salinity than fresh water but less than seawater. The name is derived from the Dutch word “Brak” which means saltine. It may result due to human activity such as dikes and flooding of coastal marshland or from mixing seawater with freshwater. Brackish water contains 0.5 - 30 g per liter salt.

Brackish water is an additional source of fresh water and can be achieved by desalination, mixing with freshwater to reduce its salinity to the range acceptable for some crops such as dates, corn, beets. etc.

Desalination is any process that leads to removal of salt from water. It is mainly performed on seawater to make it potable, and it is also used on brackish water.

In the study area, Brackish water is present in some wells mainly in Jeftlik area (due to heavy water extraction from well) and Fashkha Springs (group of spring near the Dead Sea to the south of the study area with 20-30 MCM).Also unpublished data obtained from Ministry of Agriculture on the year 2010 for 88 wells with around 11 MCM discharge in the study area shows that :

- Twenty two wells are considered non-saline with electro conductivity ranges between 0.0 and 0.7 ds/m
- Seventeen wells are considered slightly -saline with electro conductivity ranges between 0.71 and 2.0 ds/m.
- Twenty six wells are considered moderately-saline with electro conductivity ranges between 2.01 and 4.0 ds/m.
- Twenty three wells are with electro conductivity more than 4.0 ds/m.

Table (14) shows total additional available water resources that give 7 MCM that can be used in agriculture sectors

The supplementary water resources scenario suggested that the 7 MCM will be saved as a result of applying this scenario and will be used for growing seven crops (Table15).

Table (14): Supplementary water resources for each plant type and the area increased.

Crop	Extra water	CM Water need \du	Extra dunum	Changes in Production (tons)
Greenhouse	1 MCM	1000	1000	12800
tunnels	1MCM	500	2000	7600
Open irrigated potato	1 MCM	500	2000	6600
grape	1 MCM	500	2000	12000
Date palm	1 MCM	1100	900	900
Other irrigated trees	1 MCM	500	2000	3000
Open irrigated vegetables	1 MCM	500	2000	4900
AREA INCREASED IN DUNUM			**11900 dunums**	**47800 tons**

Scenario Outcome: Applying the WEAP model on the supplementary water resources scenario could increase the planted area by 11900 dunums (Table 14) as a result of using the 7 MCM of water in green houses, tunnels, potatoes, grapes, dates, irrigated trees, and open field irrigated vegetables. As a result 8% of agriculture land will be added in the SA.

4th scenario: Virtual Water

Virtual water is defined as the water needed for the production of a certain product or the water embodied in the product. It is sometimes called exogenous or embedded water (this depend on place and time of production). for example producing one kilogram of wheat in arid region requires more water than that in a humid area. Virtual water definition takes in consideration the user view (water that is required to produce the product at the area where needed).

Practically virtual water has two uses:

1. It is used commercially as a tool to achieve efficient use and water security. The nation’s water resources can be relieved from pressure by net import of virtual water. So it is considered as an alternative source of water which can achieve regional water security (Allan,

1997). Hoekstra (2002) stated that while using high technology and pricing to increase water use efficiency, virtual water is a tool to increase *global* water use efficiency.

2. Water footprints: links between consumption patterns and the impacts on water. The virtual water content of a product indicates the environmental impact of consuming this product. Knowing the virtual water content of products, creates awareness of the water amounts needed to produce the various goods, thus providing an idea of which goods have impact on water system and where water savings could be achieved. Hoekstra (2002) have introduced the concept of the *water footprint* which is defined as the cumulative virtual water content of all goods and services consumed by individual or individuals of a country.

Applying the concept of virtual water in the study area on crop pattern is achieved by planting crops with least virtual water and avoids planting crops with high virtual water as follows:

- In general, vegetables have the least virtual water, while fruit trees have more virtual value (i.e. m^3/kg) due to the fact that vegetables are produced annually and have no training and preproduction stage as fruits which may need more than 5 years before production phase. Also vegetables have no secondary growth or large root system which means that most of the consumed water is allocated for production.
- Protected vegetables such as greenhouses and tunnels have less virtual water value than open field due to the fact of less evapotranspiration and more efficient irrigation techniques.
- Table (15) illustrates the suggested changes for this scenario which basically depend on the mentioned on shifting from open field to protected agriculture and from trees to annual crops.
- To apply this scenario the following suggestions must be considered :

- Replace banana area with protected vegetables
- Shift Citrus fruit to protected vegetables.
- Shift dates and other fruit trees to grape (knowing the fact that stone fruit has limited age).
- Shift 50% from open vegetables to protected vegetable agriculture and irrigated open field potato.
- Shifted 5000 dunums from open irrigated field crops to irrigated potato

Table (15): Changes on crops pattern due to virtual water scenario

Crop	Virtual water (m3)\kg	Area du	Changes in dunum	Total area (dunum)	Changed in production
Greenhouse (vegetables)	0.065*	2369	+1540+4379= +5919	8288	73396
Tunnels (vegetables)	0.158*	5193	+20372.5	25566	77416
Irrigated field vegetable	0.2*	46745	-23372.5, -10000= -33372.5	13373	-81763
Irrigated field crops	0.214*	8486	-5000	3486	-7000
Irrigated Banana	0.75*	1540	-1540	0	-6160
Irrigated Date	0.73*	428	-428	0	- 428
Irrigated Citrus	0.44*	4379	-4379	0	-8495
Irrigated Grape	0.25*	557	+ 2250 + 428= +2678	3235	5336
Other Irrigated fruits	0.53**	2250	-2250	0	-3375
Potato	0.15	4570	+ 9000 + 4000 + 5000 = +18000	22570	59400
Total increase in production due to applying the virtual scenario				**+ 76517 total area changed (dunum)**	**+ 108327 ton**

*: *These values where calculating depending on the mean productivity of the crop pattern and the annual water needed as estimated by MoA.*

Scenario Outcome: Living in a region with water scarcity, there is a need to think about producing crops with least water needs and trying to import others that have higher virtual water value. Applying this scenario in agricultural sector in the LJV and under the above mentioned assumptions using the WEAP model will lead to a trend of producing vegetables in protected greenhouses, tunnels and potato and reduce irrigating bananas and citrus and importing fruits and cereals. A reasonable increase in production (108327 tons) is the result of this scenario as seen in table (15). As shown in (table 16, Figures 14 and 15), no water demand was obvious in WEAP model.

Table (16): Changes on water requirements due to virtual water scenario

Crop	Changes in area dunums	CM/du	Changes in Water MCM
Greenhouse(vegetables)	+5919	1000	6.0
Tunnels(vegetables)	+20372.5	500	10.2
Irrigated field vegetable	- 33372.5	500	-16.7
Irrigated field crops	-5000	500	-2.5
Irrigated Banana	-1540	1500	-2.3
Irrigated Date	-428	1100	0.5
Irrigated Citrus	-4379	850	-3.7
Irrigated Grape	= +2678	500	1.4
Other Irrigated fruits	-2250	850	-1.9
Potato	+18000	500	9
Water unmet demand due to Virtual water scenario		**0.0 MCM**	

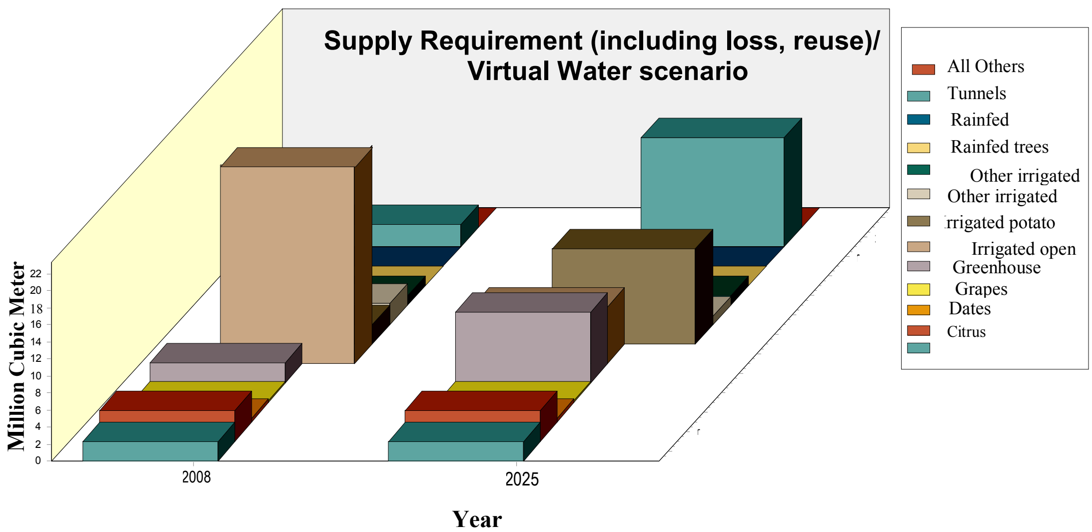


Figure (14): Distribution of available water as suggested by virtual water scenario (2008 & 2025)

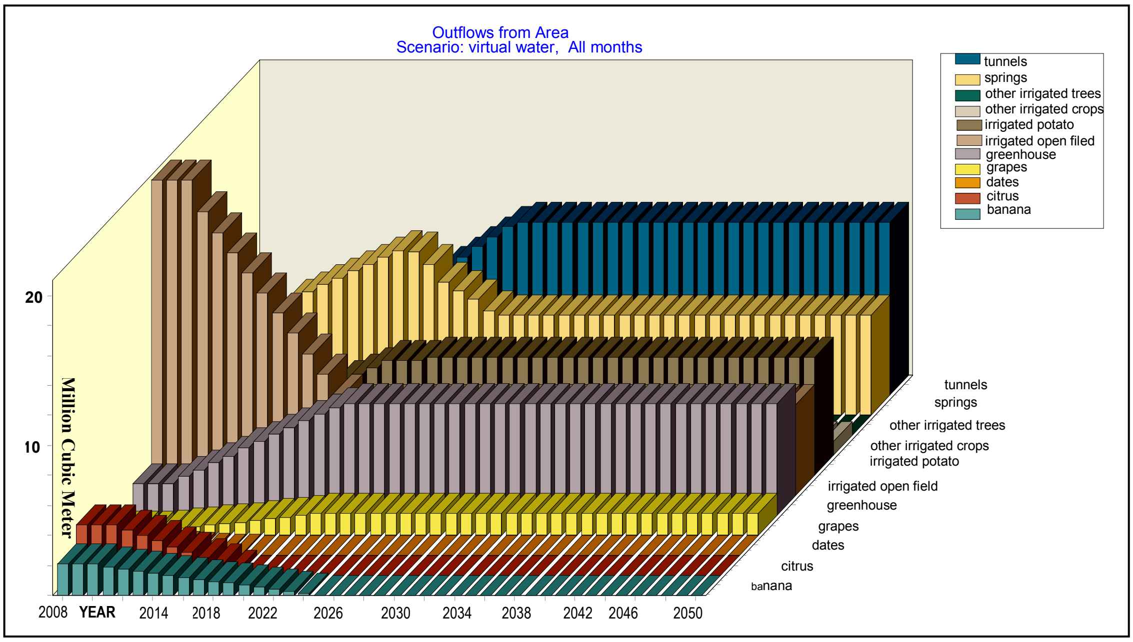


Figure (15): Distribution of available water as suggested by virtual water scenario(coming 15 years).

5th Scenario: Poverty:

In WBGS around one-third (approximately 1,207,240 individuals) of the population are below poverty line (PCBS, 2008).

The poverty level in 2010 in West Bank and Gaza Strip according to PCBS (2010) for a household of 2 adults and 3 children were 478 and 609 USD, respectively.

Water, poverty and health are closely linked to each other. Water is at the center of this relation and contributes to both health and poverty.

Water influences health directly by drinking, sanitation and use in food and nutrition in the households. Water also contributes to livelihoods of the poor as a key input in agricultural and non-agricultural uses as well as in the environment. Good human and environmental health contribute to poverty reduction. Poverty causes natural resources degradation, influencing environmental health, which in turn creates more poverty.

Improving the living level by reducing poverty of farmers and increasing their income by means of return profits, new markets, planting high cash crops, applying new technologies in irrigation and agricultural practices and good postharvest and marketing will affect positively the water using efficiency and the area and type of growth pattern towards more profitable crops. According to this assumption it is estimated that the water use efficiency will be improved by 5% as mentioned in previous studies (Haddad, et al, 2007) and crop pattern will shift as follows (Table 17):

a. All crop patterns except the protected will stay the same.

b. The saved water due 5% water using efficiency will be used for protected agriculture.

c. Around 2.2 MCM will be saved and used for both greenhouse and tunnels (50% for each).

Table (17): Suggested changes on poverty scenario & their effects in water demand

Crop	Area (dunum)	CM water /dunum	additional water	Area increased	Changes in Production (Tons)
Greenhouse	2369	1000	1.1 MCM	1100 dunums	+ 13640
Tunnels	5193	500	1.1 MCM	2200 dunums	+ 8360
Irrigated field vegetable	46745	500	0	0	0
Irrigated field crops	13091	300	0	0	0
Irrigated potato	4570	500	0	0	0
Irrigated Banana	1540	1500	0	0	0
Irrigated Date	428	1100	0	0	0
Irrigated Citrus	4379	850	0	0	0
Irrigated Grape	557	500	0	0	0
Irrigated fruits	12154	500	0	0	0
Rain fed crops	40994	0	0	0	0
Rain fed vegetables	5320	0	0	0	0
Rain fed trees	17561	0	0	0	0
				3300 dunums	22000 ton

Scenario Outcome: The effect of applying poverty scenario appears clearly on the WEAP charts (Figure 16). The model outcome shows a reversal impact between poverty and water use efficiency. Applying the scenario assumptions would lead to additional 5% increase in water use efficiency and thus increasing the irrigated area under cultivation (Figure 16). Also applying the scenario assumptions indicate that farmers will shift towards intensive agriculture as a result of improved socioeconomic conditions, leading to more use of greenhouses and tunnels with an additional irrigated area of 3300 dunums.

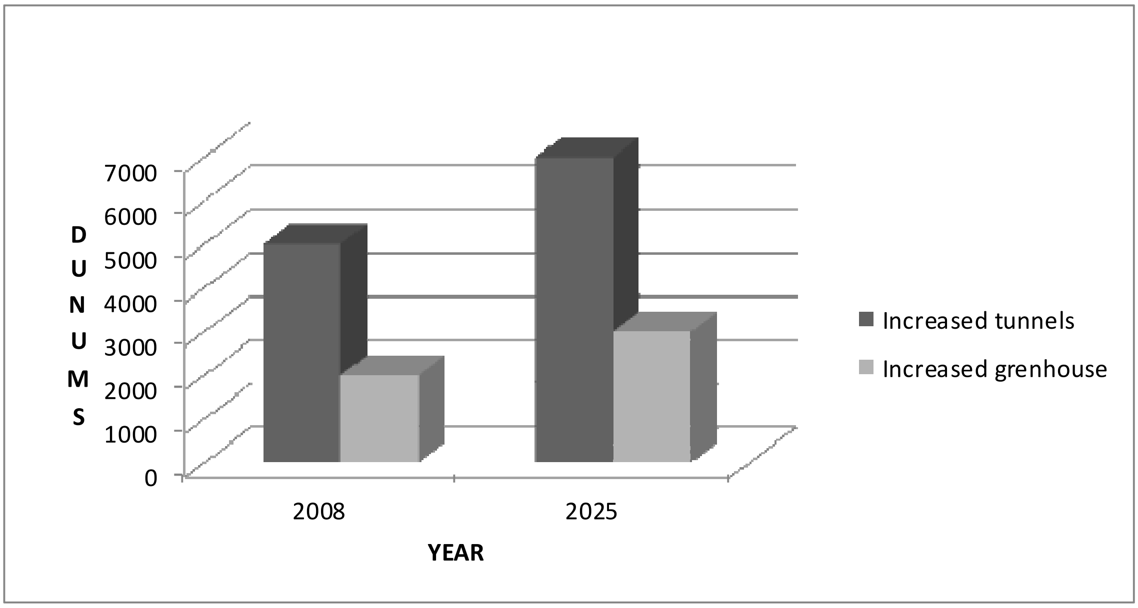


Figure (16): Protected agriculture area increased by poverty scenario

6th Scenario: Food Security

During the last 40 years the concept of food security and other related expressions and terms have evolved and developed to reflect and cope with changes in official way of thinking and the newcomers concerning food and poverty in the world.

Concerning food needs for people, two expressions are used continuously: food sufficiency and food security:

- ***Food self-sufficiency or food sufficiency***: is defined as being able to meet consumption needs (of staple food crops) from own production rather than buying or importing. This definition is applied at national and international level and not including the individuals and households. Although this situation is impossible to achieve in nearly all countries due to limitations on natural resources, climate conditions, other related production factors and more costly than importing food requirements from outside, it can help country and population to overcome problems of food unavailability and volatility in prices (FAO, 2002).

- ***Food security***: it is the most acceptable expression that passed a lot of changes and detentions. It is started to be familiar in the FAO summit held in 1974, since that time it has several detentions:

  - 1974 : availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices.(world food conference, 1975)

  - 1983: attention for the two part of food equation (supply & demand) so it was clarify that: '*ensuring that all people at all times have both physical and economic access to the basic food that they need'(FAO,1983).*

  - 1986: chronic and transitory food security began to be used to distinguish structural and continuous poverty and low income from the non-continuous one due to extraordinary conditions as earthquakes or flooding, so the following statement was included and emphasized: "access of all people at all times to enough food for an active, healthy life"(World Bank,1986).

- 1996: the food security definition was expand to include: individuals and global level, malnutrition, protein – energy concept, safety and nutritional balance, active health, so it became: 'at the individual, household, national, regional and global levels is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (FAO, 1996).
- 2001: New definition appeared that focused more in individuals and households and their social conditions: '*A situation that founds when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life'(FAO,2002).*

The last definition is considered broad statements with common objectives, to have practical implementations it is worthy to work and gather all the efforts in a more specify and narrower goal, so derived reduction and elimination of poverty and reducing of hungry or undernourished people.

So to have food security four conditions should be available, missing any of them lead to food insecurity (when people don't have adequate physical, social or economic access to food) (Pingali,2005, FAO,2006) :

1. Food availability: The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).

2. Food access: Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources).

3. Utilization: Utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security.

4. Stability: To be food secure, a population, household or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security.

Some references mentioned that there are more than 200 definitions for food security, but the mostly used and the formal one is what was adapted by FAO on 1996 and 2001.

Whatever the security food definition used, new or old, broad or close sense, here in WBGS we have food insecure condition due to the following points :

- Limited and disconnected area .
- Limited water resources under the prevailing conditions
- Limited other natural resources.
- Limited agricultural lands
- Occupation restrictions which represented major limitation.

Food as air and water are basic need for human beings. Unfortunately hunger and lacking of sufficient food is a major worldwide problem. Around one billion suffer from food shortage with fifth of them from children below five years old.

Food security classification in WBGS:

The World Food Program (WFP), Food and Agriculture Organization (FAO) and the United Nations Relief and Works Agency (UNRWA) divide Palestinian families into four categories with respect to food security (MAS,2008):

- Food secure: Households with income and consumption above USD2.6/capita/day.
- Marginally secure: Households with either income or consumption (but not both) above USD 2.6/capita/day.
- Vulnerable to food insecurity: Households with both income and consumption below USD 2.6/capita/day.
- Food insecure: Households with income and consumption below USD 1.9/capita/day.

In WBGS water scarcity with increasing demand by domestic and industrial sectors reduce the percentage of water localized for agriculture sector. Having such a limited water resources lead us toward more wise practices to obtain the maximum benefits from this highly valuable input.

From practical point it is waste of time to discuss the food full-sufficiency in Palestinian case due to previous limitations, but to reach sufficiency for few staple crops it is an idea acceptable from theoretical view, but hard to applied or when applied will face disadvantages like it is costly for both individuals and country.

Milk, Citrus, dates, some vegetables, some type of meats and fruits, Potato as a rich source of carbohydrates are all among products that it is possible to reach partial or full- food sufficiency .

Scenario Assumptions

For the LJV which is an agricultural area that participate significantly in the food basket of WBGS, applying the food security scenario will take these assumptions:

- The study area participate in about 25% of the irrigated area from WBGS, where 53% of the irrigated vegetables in WBGS are located.13091 dunums of irrigated field crops are present out of 54085 du the total.
- To achieve food security assumption it was assumed that: the consumption in kg per capita yearly will be the same (for the all period from 2010- 2025).
- Assumption concentrated only on plant production part, animal welfare was not considered.

- The goal was toward moving to better food security situation under the existing condition through reallocating the agricultural area and planting new crops.
  - The sub scenarios for this goal were as follows :
    - Keeping the area planted in vegetables as the same, we will reach an equivalent point between demand and supply.
    - Increase the area planted with both potato and wheat as follows:
      - At the year 2025 the consumption of potatoes will increase to reach 163605 tones which represent around 50000 dunums with productivity of 3.3 tones / du., assuming that the studied area will participate of 50% of our needs, so it is a need to raise the area planted with potato up to 25000 dunum (additional 20000 dunums).
      - For wheat which is a basic food with 135 kg/capita/ year ,and with the limited area in WBGS. It is impossible to reach sufficiency from this crop, but to reach 5 % of our demand (around 505000 ton) additional 75 thousand dunums are needed to be planted from the irrigable land in the study area with this important crop and increase the potato area which is another source of carbohydrates.
    - fruit trees : Nowadays, the study area participate with 13.5 % from the total fruits production with a 29650 ton annually. On the 2025 this amount will represent only 9% from the demand (estimated to be 384798),referring to previous tables (6 and 9), Table (18) shows the suggested changes in this sector to reach 15% from the needed fruits in WBGS .

Table (18): Suggested changes, % of sufficiency aimed due to food security scenario

Crop	Tons needed 2025	SA production (ton)	% of production needed	Aimed % of sufficiency	% difference	Increased in production (ton)	Increase in Area(du)
Fruit	448931*	34253	7.5	15**	7.5	34000	22500
Citrus	97705	8495.3	8.7	10**	1.3	1270	655
Dates	6544	428	6.5	40**	33.5	2192	2200
Grape	35535	835.5	2.35	20**	17.65	6272	3136
Banana	55233	6160	11.1	15**	3.9	2154	600
Other field crops	448931	13731	3	5**	2	8979	6000
potato	163605	14718	10	50%	40	66000	20000

** Citrus, dates, banana, grapes are not included*
***These percentages were assumed as the minimum level of sufficiency may be achieved.*

Scenario Outcome: Applying this scenario assumptions (above) indicate that under current conditions, complete food security is not achievable (see Table 18). From Figures 17, 18, and 19, we find that an additional water of around 27 MCM yearly is needed, so it is of great importance to search for water resources to close this gap either from supplementary resources such as using Al-Fashkha spring or from the Palestinian rights in Jordan River waters.

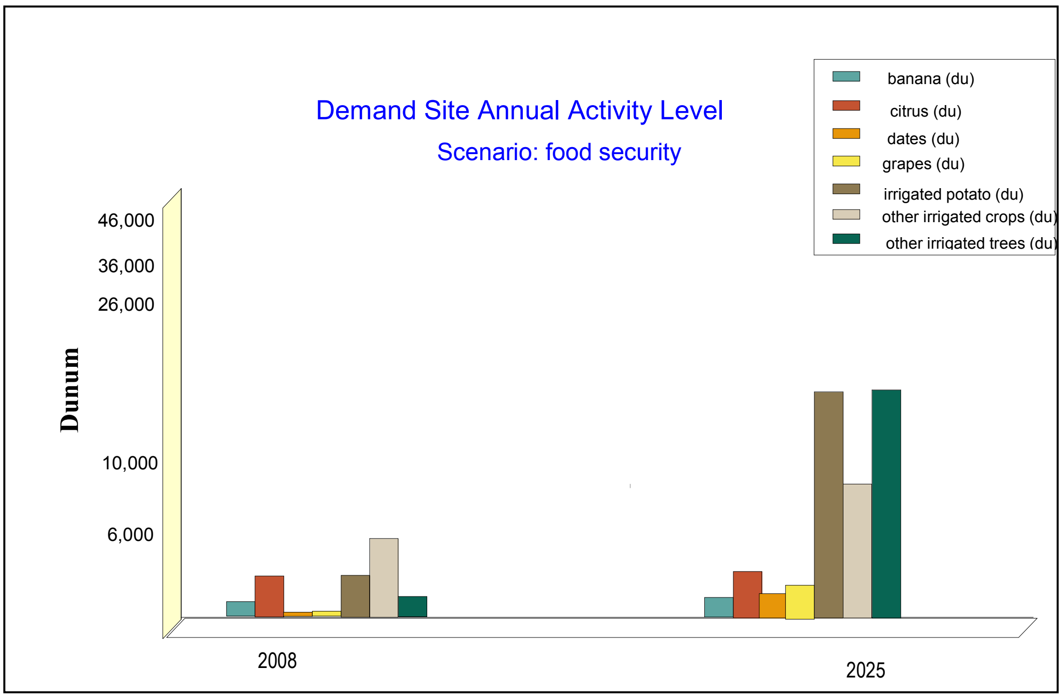


Figure (17): The big increase in planted area to achieve a relative food security in some important crops

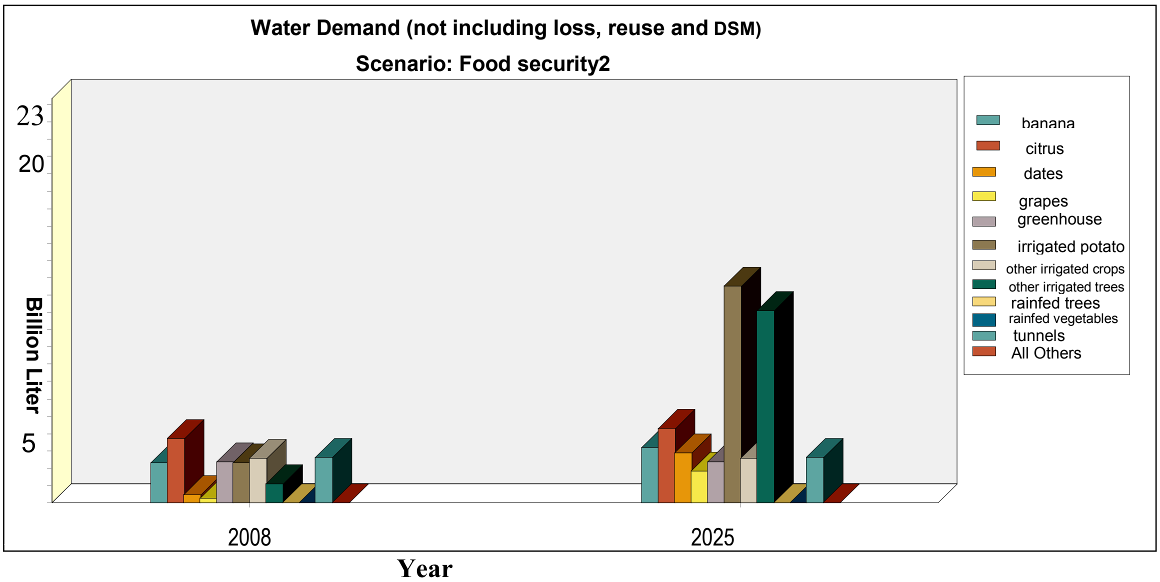


Figure (18): Water demand according to food security scenario

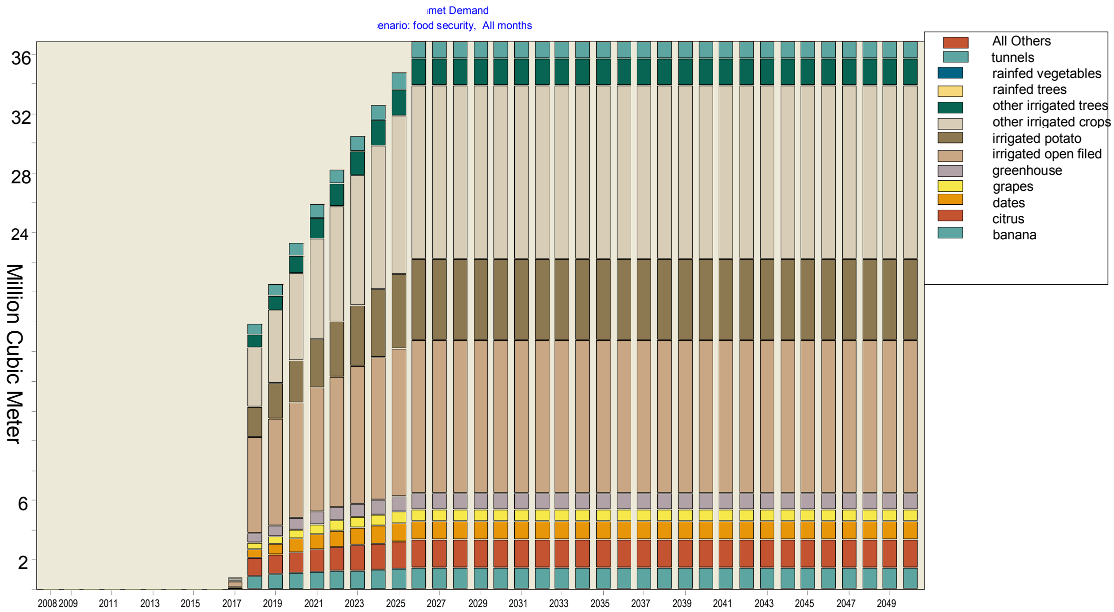


Figure (19): The water unmet demand, food security, around 27 MCM is needed to accomplish this scenario

Summary of the main scenario (current political situation)

When all the previous scenarios were applied, the current situation, mainly the political, are kept in mind. The political situation with its constrains affect extremely the agricultural sectors by affecting it is available resources such as water, land, and other related factors.

The current political situation for example limited the water resources availability by Oslo agreement 2, which says that Palestinian part have limited quota of water for all purposes (domestic, agricultural). This interim period agreement which was signed on 1995 should not exceed 5 years from that date (September 2000). (It is already exceed and still working). Simply till now, the Palestinian resources and rights on the water still controlled by Israel. So the optimal land uses, optimal water use, poverty scenarios are constructed under current water resources.

Table (19): input and outputs for different scenarios, current political situation

Developmental scenarios	Currnet politcal situation (MCM)	Output productions
1- Optimal land use	42	+ 45536 (28% from rainfed)
2- Optimal water use	42 +6.4=48.4	+ 25803
3- Supplemetry water use	49 +7=56	+ 47800
4- Virtual water	42	+ 108327
5- Poverty	42 +2.2 =44.2	+ 22000
6- Food security	69(27 as unmet demand)	+ 120867
7- Integration of scenarios(1,2,3,4,5)	42+ 15.6 =57.6	

Main-Scenario current political situation Outcome: To implement the assumptions of this scenario and for better optimization of land and water use (irrigated more irrigable land) in the LJV we need an additional 110 MCM of water. Under the limited water resources in the study area integrating all the scenarios (land use, water use, poverty, supplementary resources) rather than driven one scenario will be the better choice that will give additional 15.6 MCM to close the gap toward more food security as clear in table (19).

Water unmet demand for current political scenario: The unmet demand for this scenario is expected to be high compared to the water demand for optimal land use scenario under full-state which is the reference sub scenario (182 MCM). Table (20) and figure (20) illustrate the unmet demands under current situation that is ranged between 69-77% from the water demand for optimal land use .

Table (20): Unmet demand for current situation scenario

Developmental scenarios	Current political situation (MCM)		
	Water supply	Unmet demand	% of unmet demand
Optimal land use	42	140	77%
Optimal water use	48.4	133.8	73.5%
Supplemetry water use	56	126	69.2%
Virtual water	42	140	77%
Poverty	44.2	137.8	75.7%
Food security	69 **(27 MCM as unmet demand)**	140	77%

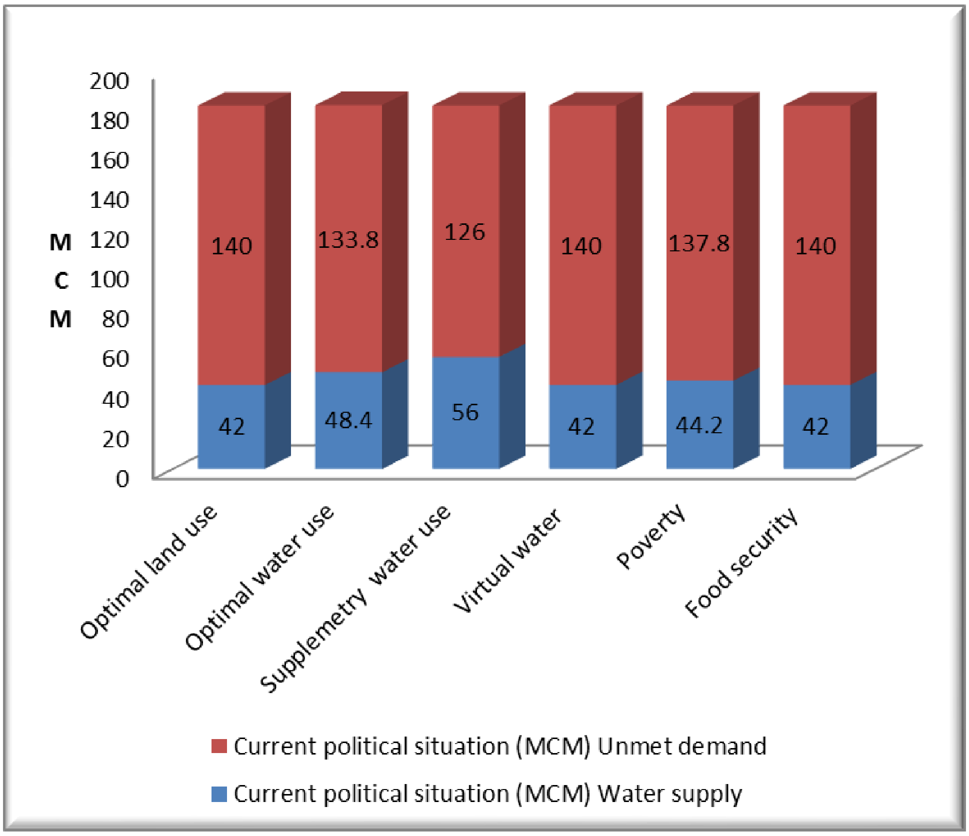


Figure (20): Unmet demand, water supply for current situation scenario

4.2.2 2nd Main scenario: Intermediate (compromise) political scenarios:

The previous tested scenarios (optimal land use, optimal water use, supplementary water resources, virtual water, poverty and, food security) were tested considering a different political situation assuming a positive change with an intermediate Palestinian state, where Palestinian could control some of their water resources.

This scenario assumed **15 MCM** of water from Palestinian' right accompanied by an additional quantity from other non- conventional resources.

1st Optimal land use

Assuming the availability of 15 MCM of water, the following assumptions might be suggested:

- Higher amount of water will be used for planting productive crops in greenhouses and tunnels.
- A second priority for planting some economical crops in the SA (potato, some fruit crops as grape and dates and stone fruits). Table 21 illustrates the changes in agriculture patterns. Figure 21 illustrated the changes of water quantity that will be saved due to the assumed increase in water use efficiency.

Table (21): Changes in crop pattern due to new share of water, compromise scenario

Crop pattern	New share of water (MCM)	Area 2008(du)	increase du	Area 2025 dunums	Changes in prodution (ton)
Irrigated potato	4	4570	8000	12570	26400
greenhouses	4	2369	4000	6369	49600
tunnels	4	7193	8000	15193	30400
Irrigated open vegetables	0	46745	0	46745	0
Irrigated grapes	1	557	2000	2557	4000
Banana	0	1540	0	1540	0
Dates	1	428	900	1328	900
Other irrigated fruits	1	2250	1200	3450	1800
	15 MCM	**65652**	**28100**	**93752**	**113100**

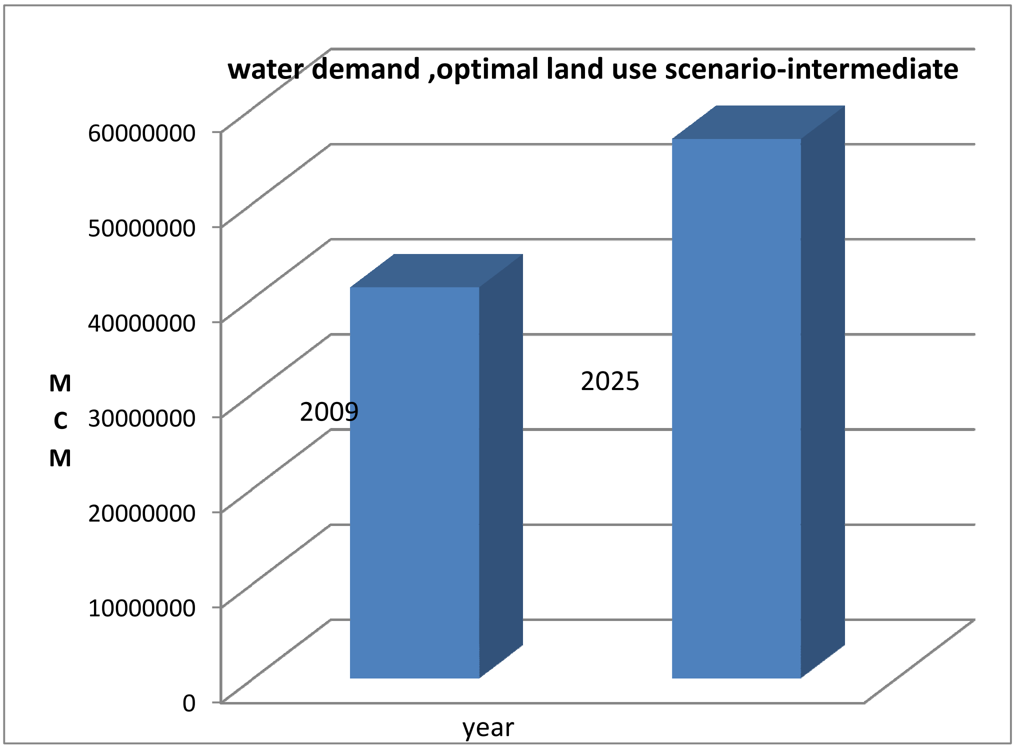


Figure (21): increasing in available water for irrigation due to increase of WUE.

Scenario Outcome: Availability of 15 MCM water has significantly increased production (113100 tons) in 28100 dunums in the newly cultivated land which represent about 30% of the irrigated area.

2nd *Optimal water use*

An improvement of the political situation will cause better socioeconomical situation which mean more trend toward investment in agriculture infrastructure, intensive plantation and technology application. Consequently, irrigation will be more efficient leading 10 – 20 % of water saving depending on crop pattern (open field or protected, vegetables or trees).

Scenario outcome: applying WEAP model, 9.14 MCM of water will be saved (table 22) that will be used for irrigating farther areas for the same crop. More area will be planted compared to the optimal land scenario since it includes the land use scenario plus the irrigation efficiency.

Table (22): Assumed changes due to optimal water use scenario and their effect

Crop	% of saving	MCM needed	MCM saved	Additional area(du)	Additional production (ton)
greenhouse	10	2.37 + 6 =8.37	0.84	840	10416
Tunnels	10	2.6 + 6 =8.6	0.86	1720	6536
Irrigated field vegetable	20	22.9	4.58	9610	23545
Irrigated field crops and potato	20	3.93 + 3 =6.93	1.39	2772	3881
Irrigated Banana	20	2.31	0.46	307	1228
Irrigated Date	20	0.471	0.09	80	80
Irrigated Citrus	20	0.365	0.07	80	155
Irrigated Grape	20	1.28	0.26	520	1040
Irrigated fruits	20	2.93	0.59	694	1346
TOTAL			**9.14**	**16623 dunums**	**48227tons**

3rd *supplementary water use*

In addition to the 15 MCM assumed above, other reasonable water quantities are assumed to be saved from non-conventional water resources:

- 15 MCM from brackish water of Al-Fashka spring and other wells.

– 8 MCM from wastewater treatment

– 7 MCM catchment from surface water

The assumptions of this scenario are:

– Additional 45 MCM will be available for cultivation.

– Valuable quantity of the additional water will be used for different fruit trees production such as date, stone fruit, grape, etc.

– New area planted with vegetable and some field crops are assumed to be irrigated with water resources (table 23):

  - mixing brackish water with freshwater.
  - Shifting some good water quality from trees irrigation to vegetable lands.

Table (23): distribution of the new water resource for supplementary water resources, intermediate

Crop	Extra water	CM Water need \du	Extra dunum	Increase in production (ton)
Greenhouse	4 MCM	1000	4000	49600
Tunnels	4MCM	500	8000	30400
Open irrigated potato	4 MCM	500	8000	26400
Grape	10 MCM	500	20000	40000
Date palm	9 MCM	1100	8200	8200
Other irrigated trees	10MCM	500	20000	15000
Open irrigated vegetables	4 MCM	500	8000	19600
TOTAL			**66200 dunums**	**189200**

<u>Scenario outcome</u>: about 51690 thousand dunums will be irrigated by applying this scenario which is larger than that in optimal land use (figure 22) .

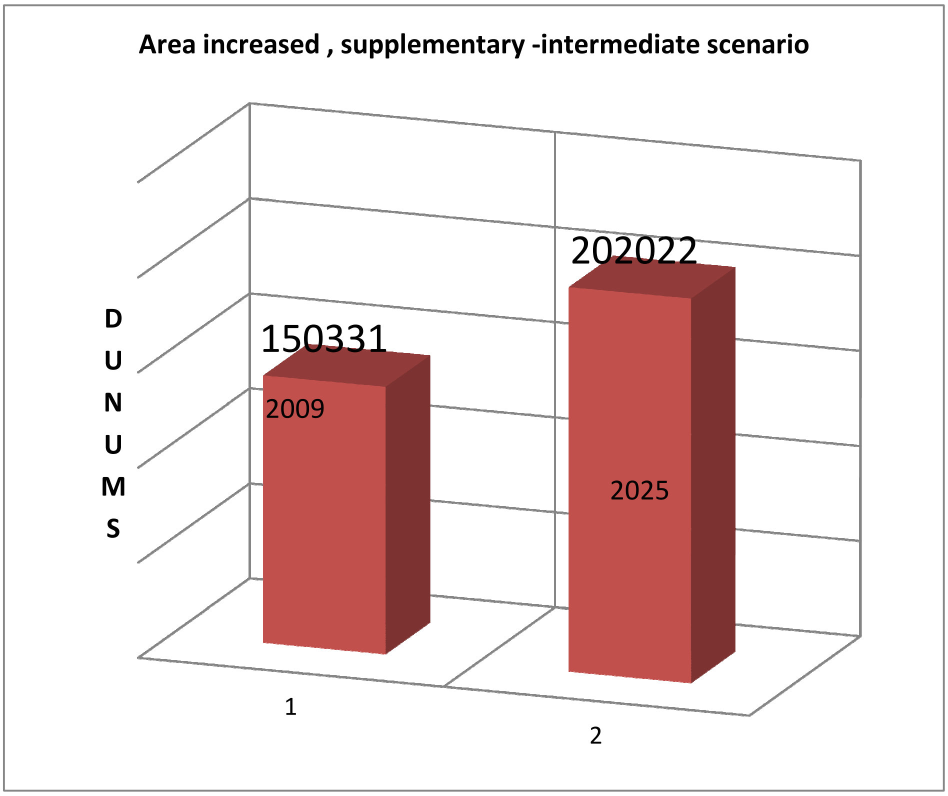


Figure (22): Comparing the area between supplementary –intermediate scenario (2) and the current situation (1) in dunums.

<u>4th scenario: virtual water scenario</u>

Despite the increased water quantity according to the above scenario, the SA suffers from water scarcity. Virtual water is a concept that has its importance. The aim of this scenario is to produce crops of annual and protected crops and avoid moving toward production of trees (table 24). It is assumed that

– Using the virtual water scenario in the current situation as a reference.
– Adding new planted areas as follow:
  - 4 MCM for greenhouse
  - 4 MCM for tunnels
  - 4 MCM for potatoes
  - 3 MCM for grapes

Table (24): Changes in crop pattern, areas, & production under virtual water scenario, intermediate.

CROP	Virtual water (m3/kg)	New share of water MCM	area dunums*	Additional change Intermediate state Area (dunum)	Total area Dunum	Changes in Production (TON)
Greenhouse (vegetables)	0.065	4	8288	4000	12288	49600
Tunnels (vegetables)	0.158	4	25566	8000	33566	30400
Irrigated field vegetable	0.2	0	13370	0	13370	0
Irrigated field crops	0.214	0	3486	0	3486	0
Irrigated Banana	0.75	0	0	0	0	0
Irrigated Date	0.73	0	0	0	0	0
Irrigated Citrus	0.44	0	0	0	0	0
Irrigated Grape	0.25	3	3235	6000	9235	12000
Other Irrigated fruits	0.53	0	0	0	0	0
Potato	0.15	4	22570	8000	30570	26400
Total increase in production due to applying the virtual scenario				**26000**	**102515**	**118400**

***: represented the resulted area from applying virtual scenario on the current situation**

Scenario outcome: This scenario consists of the current virtual water scenario (table 15) and the new available 15 MCM. It might be suggested to plant additional 26000 dunums in greenhouses, tunnels. Potato and grape might be chosen because they require less water than other fruit trees, mountainous area suitable for its plantation is available. This assumption leads to an increased production in the SA by 227 thousand tons (figure 23).

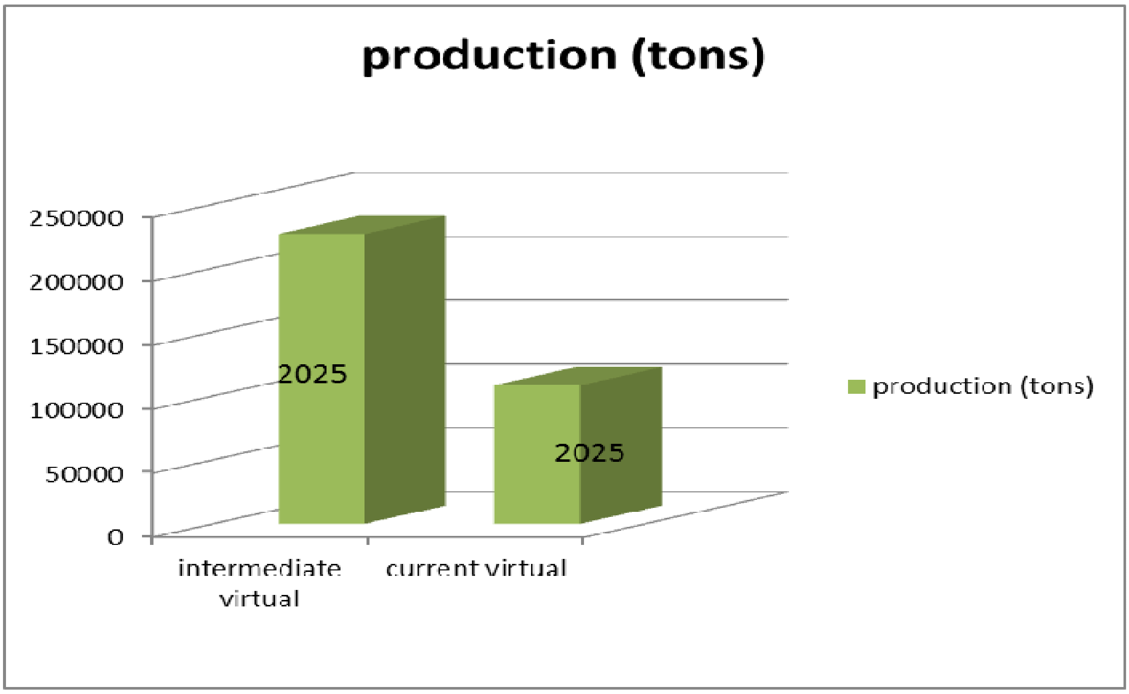


Figure (23): comparison of changes in production between current & intermediate sc. For virtual water

5th Poverty scenario

Improving livelihood and life level of SA cause 10% increase in using water efficiency due to this scenario, the agricultural land in the study area was divided as table (25) :

- Having 15 MCM additional shared as follows :
  - 3 MCM for greenhouses
  - 3 MCM for tunnels
  - 1 MCM for open vegetable field
  - 2 MCM for irrigated potato
  - 2 MCM for grapes
  - 2 MCM for dates
  - 2 MCM for other fruits
- Water supply for this scenario will be 57 MCM (42 MCM current situation + 15 MCM new).
- Under the compromise situation the framer life will be in a relatively better situation and a reduction in poverty and increase people health

and a trend to invest in modern technology resulted in saving around 10% from the water used, that means saving 5.7 MCM, which will be shared as follow:

- 1 MCM for greenhouses
- 1 MCM for tunnels
- 1 MCM for open vegetable field
- 1 MCM for irrigated potato
- 0.7 MCM for grapes
- 1 MCM for dates

Table (25): Changes cause of poverty scenario, intermediate situation

Crop	Area (dunum)	CM water /dunum	Additional water MCM	Area increased dunum	TOTAL area dunums
Greenhouse	2369	1000	4	4000	6369
Tunnels	5193	500	4	8000	13193
Irrigated field vegetable	46745	500	2	4000	50745
Irrigated field crops	13091	300	0	0	13091
Irrigated potato	4570	500	3	6000	10570
Irrigated Banana	1540	1500	0	0	1540
Irrigated Date	428	1100	3	2730	3158
Irrigated Citrus	4379	850	0	0	0
Irrigated Grape	557	500	2.7	5400	5957
Irrigated fruits	12154	500	2	0	12154
Rain fed crops	40994	0	0	0	40994
Rain fed vegetables	5320	0	0	0	5320
Rain fed trees	17561	0	0	0	17561
TOTAL AREA increased			30130 dunums		180652

<u>Scenario outcome</u>: valuable increase in production will be achieved after applying the poverty scenario as a result of the expected improvement in livelihood and reduced poverty level.

6th : Food security

The assumption for food security scenario in the current situation (table 18) will be applied for this scenario and run on WEAP model, but the additional 15 MCM water supply will be included in the calculations to reduce the demand from 27 MCM to 12 MCM.

Scenario outcome: reducing the unmet demand on water to 12 MCM will certainly lead to partial food sufficiency in several vegetable crops, and minor sufficiency in fruit trees and other plants. Two possibilities can be concluded: 1) Search for additional water resources to reduce this gap, and 2) Reduce the level of aimed relatively food security for some suggested crops.

Table (26): Input and outputs for different sub- scenarios, intermediate political situation

Developmental scenarios	**Inputs for Intermediate political situation (MCM)**	**Output Increase in productions (tons)**
1. Optimal land use	57	113100
2. Optimal water use	57+9.14 =66.14	48227
3. Supplemetry water use	57 + 30 =87	189200
4. Virtual water	57	226727
5. Poverty	62.7 (5.7 MCM additional)	180652
6. Food security	57 **(12 MCM as unmet demand)**	120867
7. Integration of scenarios(1,2,3,4,5)	**115.38 MCM**	**757906**

Main-Scenario intermediate political situation Outcome: Running WEAP model in the assumptions of this scenario with its six elements (optimal land use, optimal water use, supplementary water use, virtual water, poverty and food security), shows the same trend, and integration of all scenarios more than applying one scenario alone (table 26). The increase in cultivated area and production were significantly higher than current political situation scenario and lead to partial tested food security. The new water resources and the saved water will be sufficient for all the irrigated and irrigable land.

Unmet water demands for intermediate scenario: Table (27) and figure (24) show that the gap between water demand and supply are high and may reach to 75% from the demand for optimal land use.

Table (27): Unmet demand for compromise scenario

Developmental scenarios	Compromise state (MCM)		
	Water supply	Unmet demand	% of unmet demand
Optimal land use	57	125	68.7%
Optimal water use	66.14	115.86	63.7%
Supplemetry water use	87	95	52.2%
Virtual water	57	125	68.7%
Poverty	62.7	119.3	65.5%
Food security	57 **(12 MCM as unmet demand)**	137	75.2

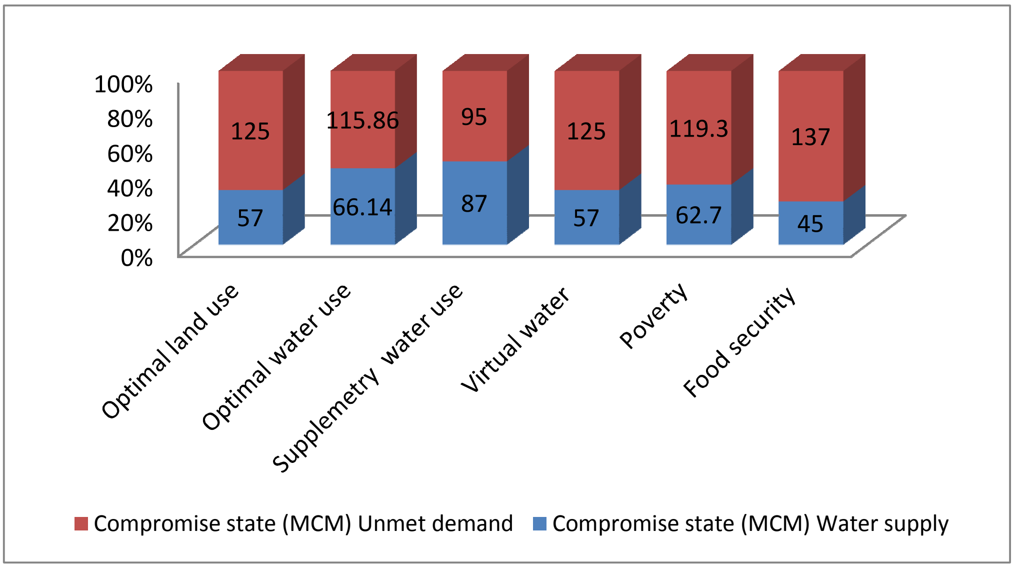


Figure (24): Unmet demand, water supply for intermediate scenario.

4.2.3 3rd Main political scenario: Full Palestinian state

The previous tested scenarios (optimal land use, optimal water use, supplementary water resources, virtual water, poverty and food security) are tested under comfortable political situation when complete independence is achieved and Palestinian control all their water resources and a highly improvement in their life level will be expected.

The 3rd supposed case (achieving a state with complete independence) go side by side with the following changes:

1. The Palestinians will control all their resources including water, land, etc
2. The Palestinians will control their boarders (import and export the goods)
3. The Palestinian will be able to move freely in their land including the SA.
4. Gaining Palestinian rights in water means 1107 MCM will be available for all their needs (domestic, industrial, tourism and agricultural).
5. The socioeconomic situation expected to be better with good growth economic rate.
6. The SA (Low in people density compared to other parts in WBGS) will attract other Palestinians from other parts from WBGS and as well as refugees.
7. The SA will gain more than 255 MCM from different water resources:
   - 135 MCM from aquifers
   - 70 MCM from Jordan river
   - 50 MCM from Wadis

8. 75% (more than 190 MCM) of this water will be used in agricultural sector.

1st: Optimal land use

The assumptions will be considered this scenario:

- There will be no water shortage.
- The agricultural sector takes its needs from water for the developments.
- Great shift toward intensive agriculture.
- The water will not be a limiting factor
- All the irrigable land (**135** thousands dunums).will be irrigated
- The rain fed areas (**64** thousand dunums) will be irrigated.
- Total of **199** MCM thousands will be used in irrigated agriculture.
- The assumed crop pattern is given in table 28.

Table (28): Changes in the planted land under applying land use scenario, full state

Crop pattern	New share of water (MCM)	Area 2008(du)	Increase du	Area 2025	Increase in production (TON)
Irrigated potato	15	4570	30000	34570	99000
greenhouses	25	2369	25000	27369	310000
tunnels	20	7193	40000	47193	152000
Irrigated open vegetables	10	46745	20000	66745	49000
Irrigated grapes	10	557	20000	20557	40000
Banana	5	1540	3500	5040	14000
Dates	15	428	13500	13928	13500
Other irrigated fruits including citrus	30	2250	35000	37250	52500
Irrigated field crops	6	13091	20000	33091	6000
TOTAL	**136 MCM**	**78743**	**207000**	**285743**	**736000 tons**

Scenario outcome: Applying this scenario and the mentioned assumptions will be acceptable and practical. All the irrigable and agricultural lands will be irrigated giving significant increase in the production. Beside the 42 MCM already exist, additional 136 MCM of water is needed and can be obtained from the new water resources (Palestinian water rights). The other remaining water can be saved for other purposes (domestic, industrial and tourism) which expected to have dramatic increase for their needs.

2nd: Optimal water use

This scenario assumed that more modern technology for saving water in all production chain will be adapted (irrigating at field capacity, new irrigation system, highly efficient convey system, practices to reduce evapotranspiration, covered agriculture, etc.).The expected changes are shown in table (29) below:

Table (29): Optimal water use, assumptions under full state.

Crop	% of saving	MCM needed	MCM saved	Area increase (dunums)	Increase in production (ton)
Greenhouse	12.5	2.37 + 25* =27.37	3.4	3400	42160
Tunnels	12.5	2.6 + 20* =22.6	2.8	5600	21280
Irrigated field vegetable	25	22.9+ 10* = 33.9	8.5	17000	41650
Irrigated field crops and potato	25	3.93 + 15* = 18.93	4.7	9400	22560
Irrigated Banana	25	2.31+ 5*=7.31	1.8	1200	4800
Irrigated Date	25	0.471 + 15* =15.5	0.09	80	80
Irrigated Grape	25	2.37 + 10* =12.37	3.9	7800	15600
Irrigated fruits	25	3 + 30* = 33	8.3	9765	14647
Irrigated field crops	20	6	1.2	4000	1200
TOTAL		**176.98 MCM**	**34.69 MCM**	**58245**	**163977**

**: New share of water (see table 29)*

Scenario outcome: The water use efficiency will be more optimal in terms of using the available water resource, so more water will be saved (around

35 MCM), this could be shifted to other water demand sectors or kept for farther expansion for the coming decades.

3rd supplementary water use

Due to prosperities and existence of funded and well- established infrastructure projects, suitable infrastructure and projects to have the capacity for treated wastewater and desalination of salt and brackish water and harvest water as well as reuse these resources will be possible. The saved water due to this scenario will be shared (table 30). It is estimated that additional amount of 45 MCM of water from both treated wastewater and desalination of brackish water will be available.

Table (30): Distribution of water in supplementary scenario, full state

Crop	Extra water	CM Water need \du	additional dunums	Increase in production (ton)
Greenhouse	4 MCM	1000	4000	49600
Tunnels	4MCM	500	8000	30400
Open irrigated potato	4 MCM	500	8000	26400
Grape	10 MCM	500	10000	20000
Date palm	9 MCM	1100	8200	8200
Other irrigated trees	10MCM	500	10000	15000
Open irrigated vegetables	4 MCM	500	8000	19600
TOTAL	**45 MCM**		**56200 dunums**	**169200**

Scenario outcome: applying this scenario will give a chance to invest and reuse the conventional and non- conventional water resources (Brackish, wastewater, harvesting), keeping the fresh water for other sectors and saving water from aquifers.

4^{th} scenario: virtual water scenario

Testing the virtual water scenario on WEAP for the SA is carried out. The assumption and changes are illustrated in table 31.

Table (31): Changes due to virtual water, full state scenario

Crop	Virtual water (m3/kg)	New share MCM	area dunums*	Additional change Full- state Area (dunum)	Total area Dunum	Increase in Production TON
Greenhouse (vegetables)	0.065	30	8288	30000	38288	372000
Tunnels (vegetables)	0.158	25	25566	50000	75566	190000
Irrigated field vegetable	0.2	20	13370	40000	53370	98000
Irrigated field crops	0.214	6	3486	20000	23486	6000
Irrigated Banana	0.75	0	0	0	0	0
Irrigated Date	0.73	10	0	9000	9000	9000
Irrigated Citrus	0.44	0	0	0	0	0
Irrigated Grape	0.25	5	3235	10000	13235	20000
Other Irrigated fruits	0.53	15	0	17650	17650	34241
Potato	0.15	25	22570	50000	72570	165000
Total increase in production due to applying the virtual scenario				**226650**	**303165**	**894241**

***: Represented the resulted area from applying virtual scenario on the current situation**

<u>Scenario outcome: </u>Although a positive results in production will be obtained, applying the virtual water scenario under the conditions of water availability will not be a priority cause. The virtual water is a concept that we refer to and try to apply under water scarcity.

5^th Poverty scenario

If an independent state is accomplished, it is possible to control all resources and have the ability to access and manage all aspects of life such as carry out, planning and developing of all sectors including agricultural.

This scenario assumed that under well- living condition, acceptable life standards and good economic situation, good technologies, more investments and highly efficient cultural practices will be used. It is suggested that 10 % of water use for agriculture sector will be saved (Table 32).

Table (32): Assumptions and their effects due to poverty, full state scenario

Crop	Area (dunum)	CM water /dunum	Additional water MCM	Area increased dunum	TOTAL area dunums	Increase in Production TON
Greenhouse	2369	1000	4	4000	6369	49600
Tunnels	5193	500	4	8000	13193	30400
Irrigated field vegetable	46745	500	2	4000	50745	9800
Irrigated field crops	13091	300	0	0	13091	0
Irrigated potato	4570	500	3	6000	10570	19800
Irrigated Banana	1540	1500	0	0	1540	0
Irrigated Date	428	1100	3	2730	3158	2730
Irrigated Citrus	4379	850	0	0	4379	0
Irrigated Grape	557	500	2.7	5400	5957	10800
Irrigated fruits	12154	500	2	0	12154	0
Rain fed crops	40994	0	0	0	40994	0
Rain fed vegetables	5320	0	0	0	5320	0
Rain fed trees	17561	0	0	0	17561	0
TOTAL			**20.7 MCM**	**30130 dunum**	**180652**	**123130**

Scenario outcome: Applying this scenario will cause an increase of more than 30 thousands dunums and around 123 thousand tons of productions. Its effect is close to other scenario (optimal water use, supplementary water use and virtual water) and more effective than poverty scenario under other political situation (intermediate and current situation).

6th : Food security

Under water availability condition, water will not be the limiting factor for food production and agricultural activities. Thus a higher level of food security is obtained. The gap in the suggested previous food security scenario (under current stage and intermediate stage) will be covered (27 MCM). The suggested changes in crop pattern are given in table (33).

Table (33): Changes in area due to food security scenario, full state

Crop	Tons needed 2025	SA production (ton)	% of SA from needed	Aimed % of sufficiency	% difference	Increased in production (ton)	Increase in Area(du)
Fruit	448931*	34253	7.7	20	12.3	55218	36800
Citrus	97705	8495.3	8.7	25	16.3	15926	8210
Dates	6544	428	6.5	80	73.5	4810	4810
Grape	35535	835.5	2.35	75	72.65	25816	12908
Banana	55233	6160	11.1	25	13.9	76773	23264
Other field crops	448931	13731	3	10	7	8979	31425
potato	163605	14718	10	75	65	106343	26586
							144003

*** Citrus, dates, banana, grapes all are not included (calculated separately below)**

Table (34): Water demand for food security scenario, full state

Crop	Increase in Area(du)	% of aimed sufficiency	Need water MCM	Change in production(tons)
Fruit	36800	20	31.3	55218
Citrus	8210	25	7	15926
Dates	4810	80	5.3	4810
Grape	12908	75	6.5	25816
Banana	23264	25	34.9	76773
Other field crops	31425	10	9.4	8979
Potato	26586	75	13.3	106343
TOTAL	**144003**		**107.7**	**293865**

Scenario outcome: an additional 107.7 MCM of water are needed to achieve good food security from some important crops such as potato, some fruits and vegetables (mainly tomato, cucumber, beans, eggplant, squash, cauliflower, cabbage, etc.). However, under water availability, agriculture area plays an important role as a limiting factor (table 34).

Main-Scenario full-state Outcome: under this scenario, more water supplies will be available for agricultural and other sectors which may affect the pattern of planted crops. In addition to that there is an opportunity for cultivating all the irrigable area. Data in table (35) summarize the water supply and the assumed production. Applying any scenario under this main scenario will be allow to utilize all the irrigable land in the study area.

Table (35): Input and outputs for different sub- scenarios, full-state main scenario

Developmental scenarios	Inputs full-state Scenario (MCM)	Output Increase in production (TON)
1. Optimal land use	191	736000
2. Optimal water use	225	899977
3. Supplemetry water use	236	905200
4. Virtual water	191	894241
5. Poverty	211.7	879130
6. Food security	191	293865

Water unmet demand for full-state scenario : All the sub scenarios under this main scenario will have more water supply than demands (table 36, figure 25). In some scenario there will around 30 MCM as an extra water that can be used for other purposes .

Table (36): Unmet demand for independent scenario

Developmental scenarios	Independent state (MCM)		
	Water supply	Unmet demand	% of unmet demand
Optimal land use	191	-9	-5%
Optimal water use	225	-43	-23.6%
Supplemetry water use	236	-54	-29.7%
Virtual water	191	-9	-5%
Poverty	211.7	-29.7	-16.3%
Food security	191	-9	-5

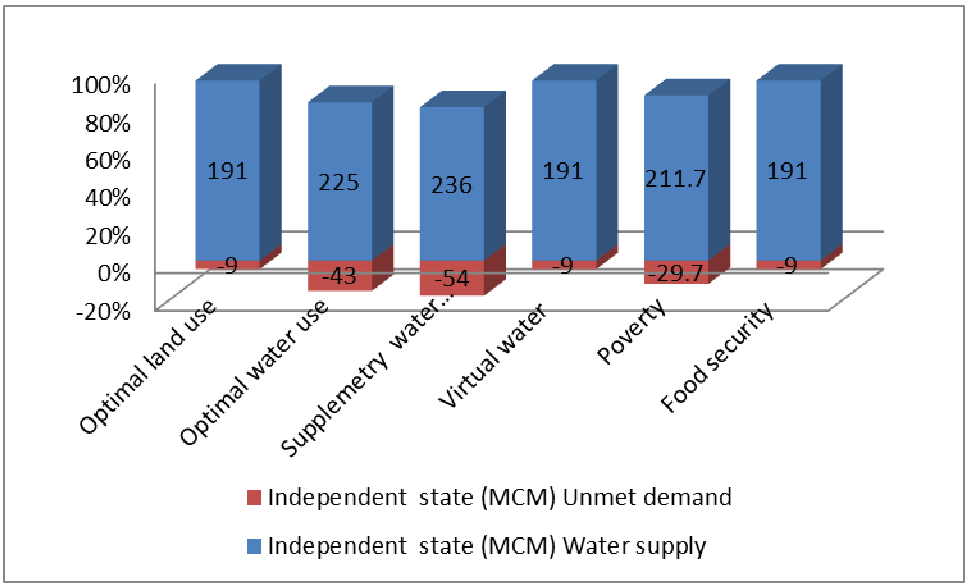


Figure (25): Unmet demand, water supply for intermediate scenario.

Chapter Five

5.1 Each Scenario comparison under main political scenarios

Comparison between each of the six scenarios under different main scenarios was carried and the following results were obtained:

1. Optimal land use scenario

As seen in figures (26 a,b), both intermediate and full state scenarios will have more water compared to current situation, and so more planted area.

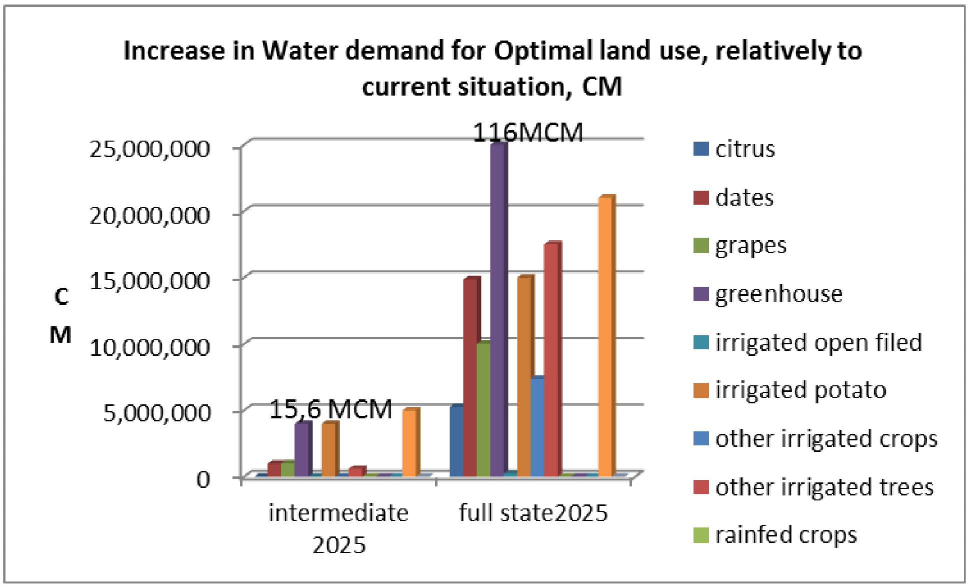


Figure (26a): Increase in water supply for optimal land use, relatively to current situation.

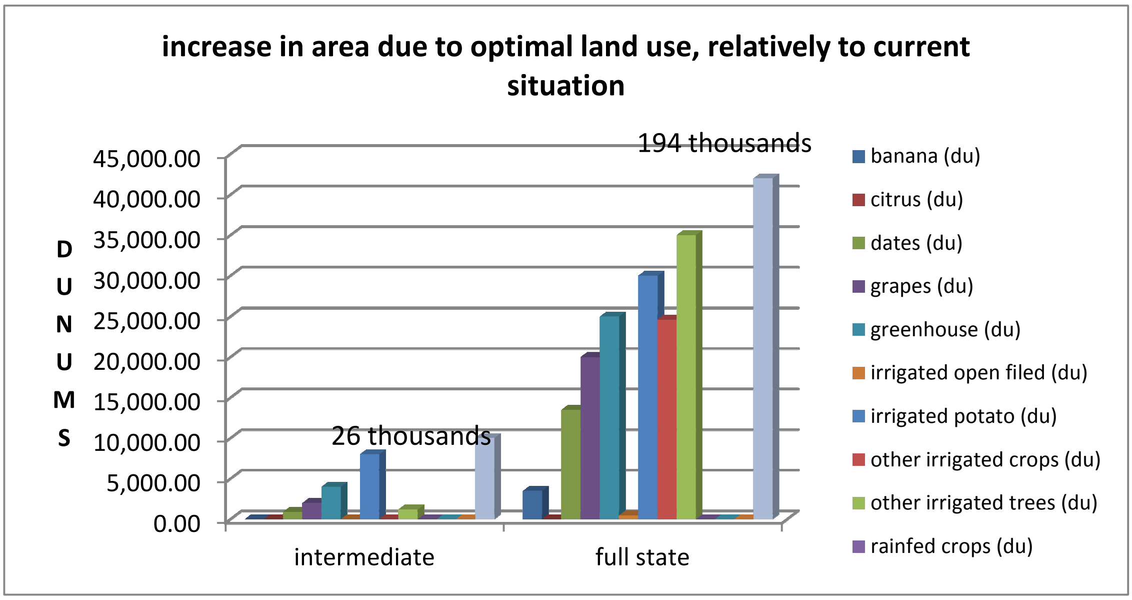


Figure (26b): Increase in area due to optimal land use, relatively to current situation.

2. Optimal water use

Running WEAP program and the optimal water use scenario in consideration of the three political scenarios revealed that the optimal water scenario under the full state scenario was the best performance while the intermediate scenario was slightly and positively different from the current situation. (Figures 27 a and b)

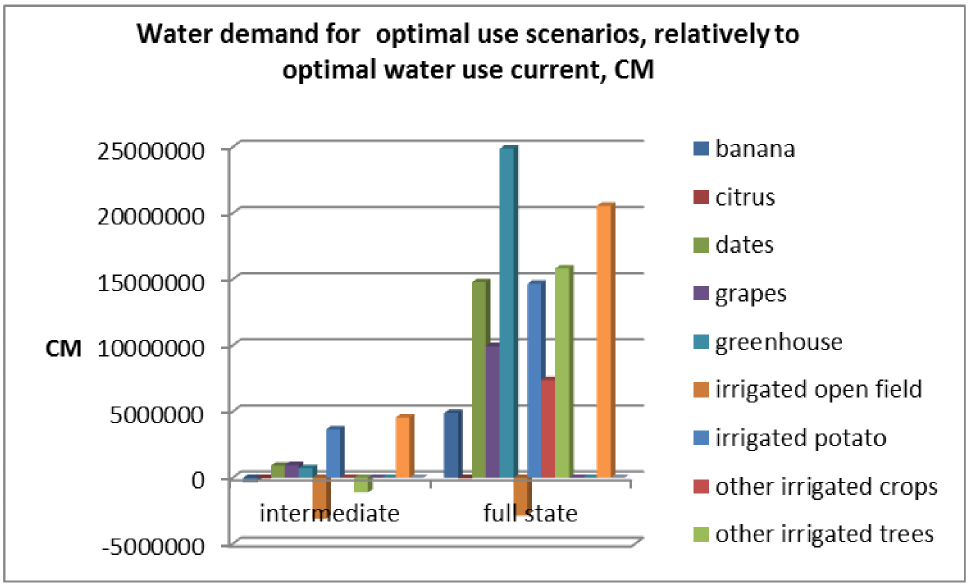


Figure (27a): Optimal water use sceanrio, reativley to optimal water current, CM

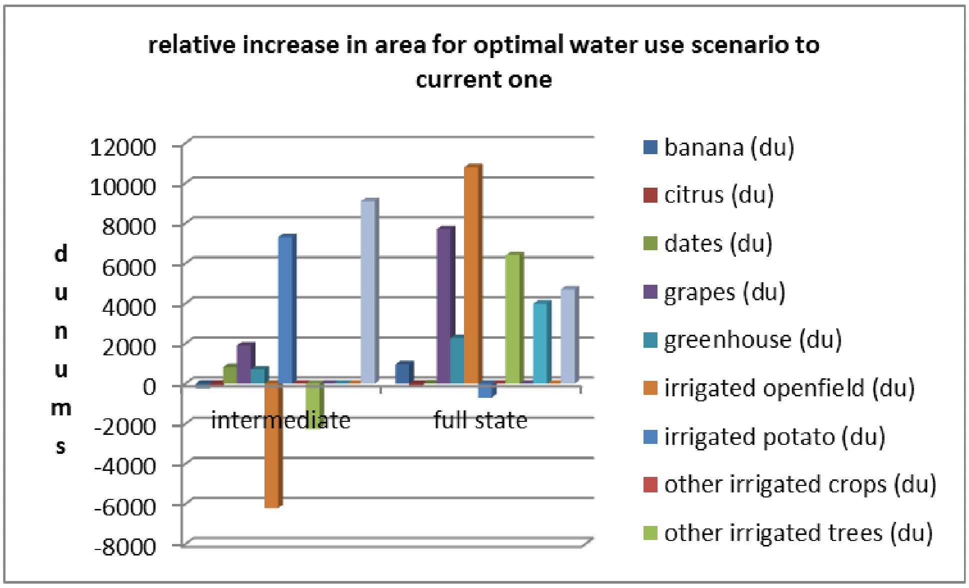


Figure (27b): Optimal water use scenarios, relatively to current optimal water scenario, AREA

3. <u>Supplementary water use:</u>

The same fact and trend obtained from the previous scenario was also obtained when evaluating the effect of the three political main scenarios on the supplementary water use scenarios, showing that valuable amount of water from conventional and non- conventional resources will be available under the full state. About 7, 30 and 45 MCM for the current, intermediate and full state scenarios, respectively can be gained. The additional amount of water saved from current and compromise situations more important than that of full state scenario(figures 28 a, b and c).

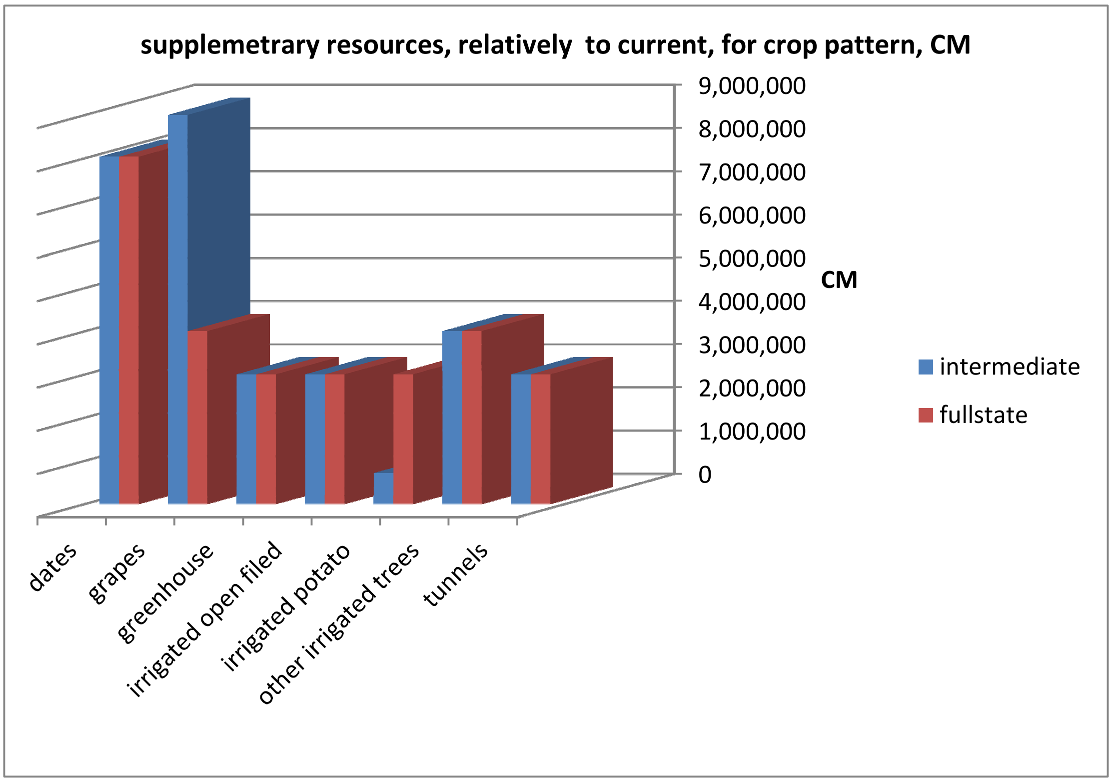


Figure (28a): Actual supplementary resources used in irrigation, relatively to current , for crop pattern, CM

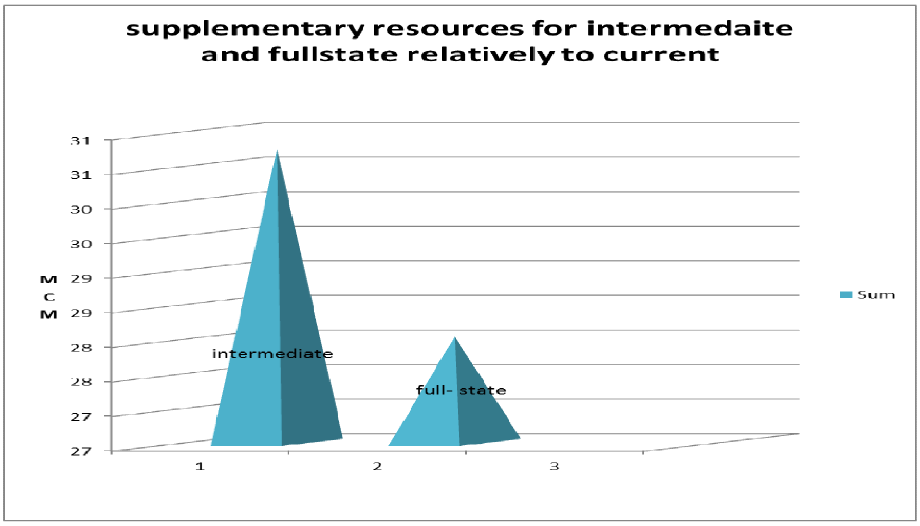


Figure (28b) :Supplementary resources used for intermediate and full state relatively to current

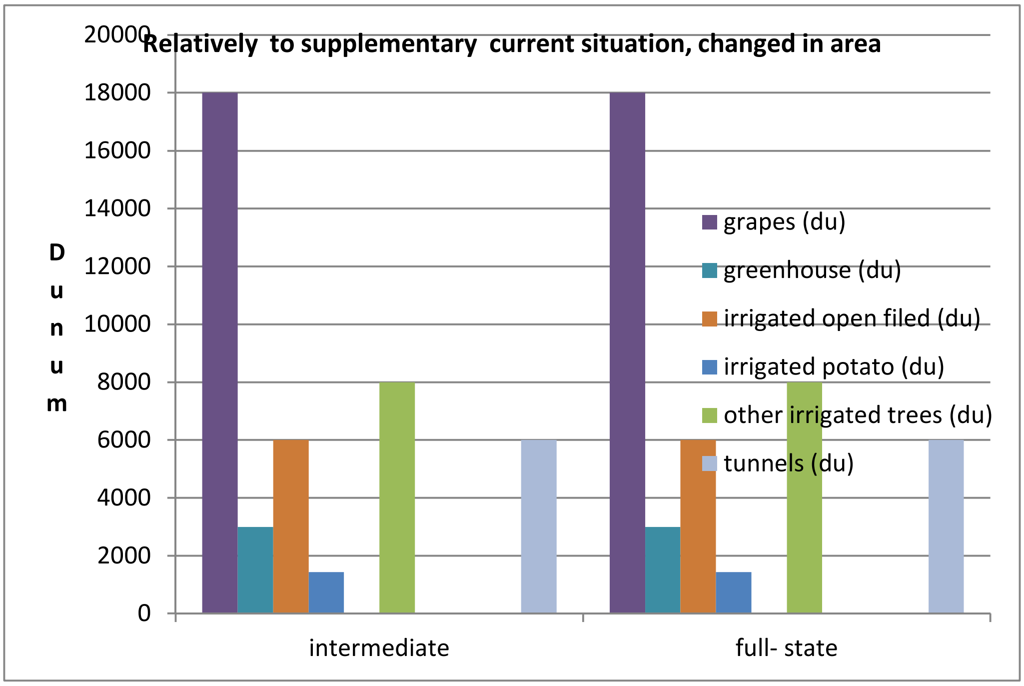


Figure (28c): Changes in area for supplementary water resources, relatively to current

4. Virtual water

Under the first two main scenarios (current and intermediate), the study area will suffer from water shortage. Using the concept of virtual water, water for all sectors will be saved. For this reason, the current situation virtual scenario was considered as basic for the three political scenarios, followed by applying the concept of virtual water for additional water supply for the second two scenarios. Figures (29a, b) show the importance of virtual water concept and its importance for the intermediate scenario.

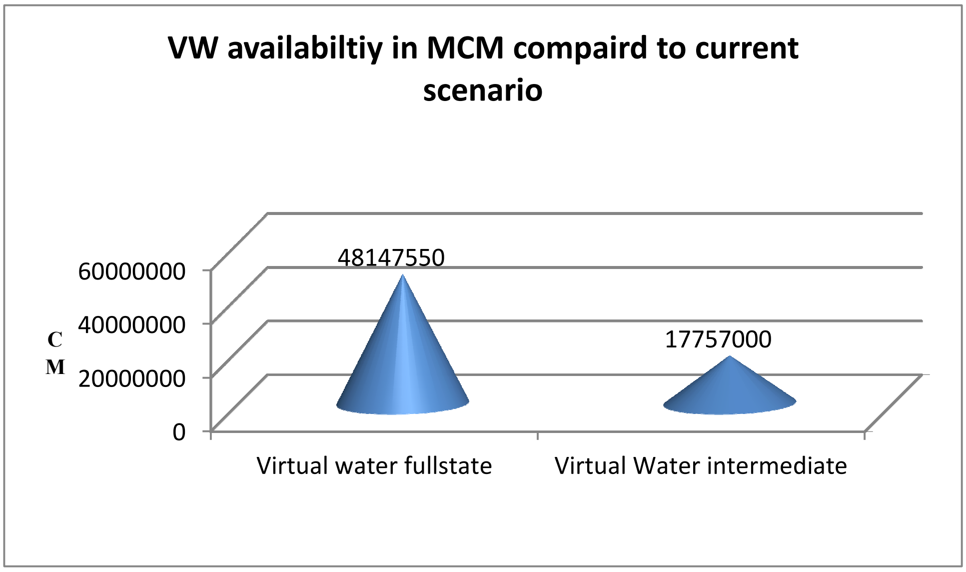


Figure (29a): Water available for virtual water scenarios relatively to current one (MCM)

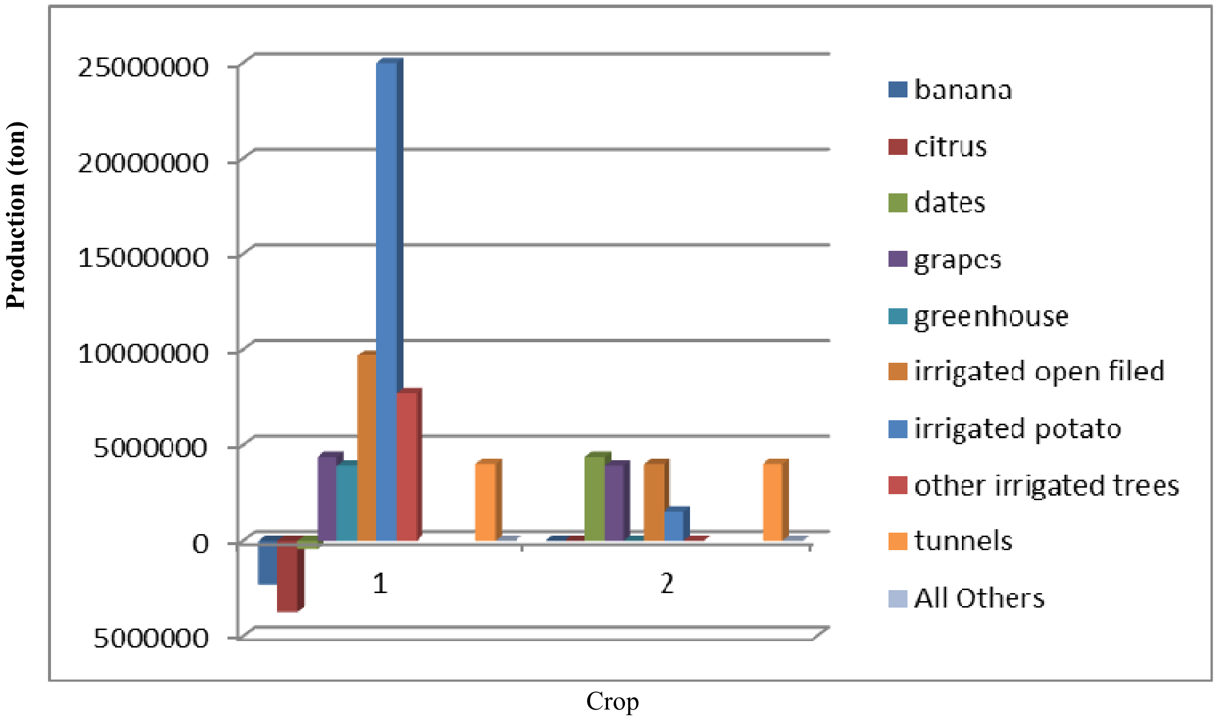


Figure (29b): Difference in production of crops types under VW scenarios relatively to current one

5. Poverty

The amount of water is directly proportional to the socioeconomic situation. Using advanced technique in agriculture, the percentage of water saving and improving water use efficiency increase by 5, 10 and 15% in political scenarios (current, intermediate, full state), respectively. The most positive change in production was recorded in the 3rd scenario (full-state) followed by the second (intermediate), and the 1st (current) scenarios. Figure (30) compare the share of water for crop pattern to the 2nd and 3rd scenarios. It indicates that the shared of water supply will be more for crop types under the 3rd scenario.

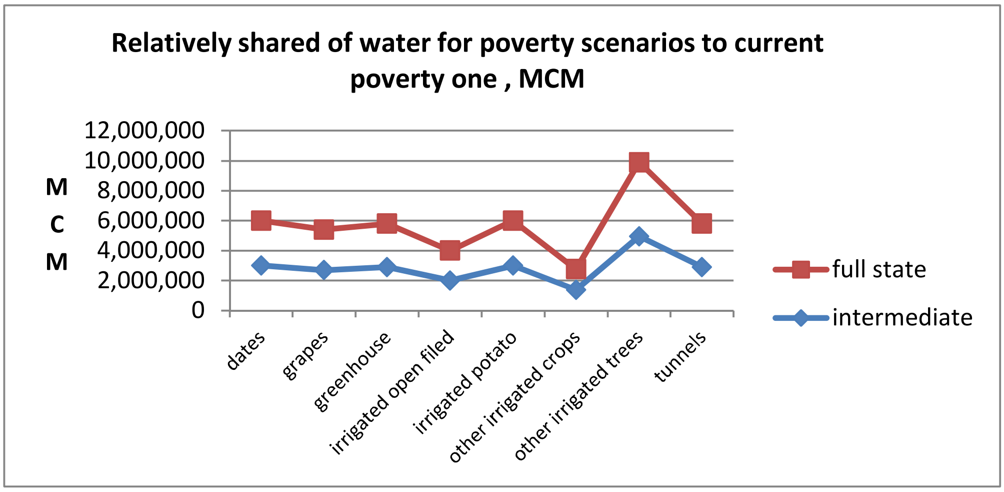


Figure (30): Relatively shared of water for poverty scenarios to current poverty one.

6. Food security

Data in tables (19 and 36) showed that one level of food security was proposed for the three main scenarios. The 3rd scenario was the only one that achieved this level of food security without any unmet water demands.

5.2. Comparison of the three main political scenarios:

Referring to running WEAP and implementations of its charts and tables, and referring to previous mentioned scenarios, tables (37 and 38) and figure (31) were carried out to summarize and concentrate the input water quantity will be available or saved and its effect on production for crop pattern in the SA. First main scenario (current) is the worst expected scenario, while the second scenario (intermediate) with integration of its assumed scenarios nearly will be able to plant the irrigable land for the SA, while the full-state scenario will be the best one leading to plant all the irrigable land and saving reasonable amount for other sectors and for future.

Table (37): Water supply and unmet demand for different scenarios under the main three scenarios.

Developmental scenarios	**Currnet politcal situation (MCM)**		**Copmromise state (MCM)**		**Independent state (MCM)**	
	Water supply	**Unmet demand**	**Water supply**	**Unmet demand**	**Water supply**	**Unmet demand**
Optimal land use	42	140	57	125	191	-9
Optimal water use	48.4	133.8	79.68	102.32	225	-43
Supplemetry water use	56	126	87	95	236	-54
Virtual water	42	140	57	125	191	-9
Poverty	44.2	137.8	62.7	119.3	211.7	-29.7
Food security	69 **(27 MCM as unmet demand)**	140	57 **(12 MCM as unmet demand)**	137	191	-9

Table (38): Changes in production for different scenarios under the main three scenarios.

Developmental scenarios	Current political situation Production changes (tons)	Compromise state Production changes (tons)	Full- state Production changes (tons)
Optimal land use	+ 45536(28% from rainfed)	113100	736000
Optimal water use	+ 25803	221093	899977
Supplemetry water use	+ 47800	302300	905200
Virtual water	+ 108327	335054	894241
Poverty	+ 22000	293752	879130
Food security	+ 120867	233967	293865

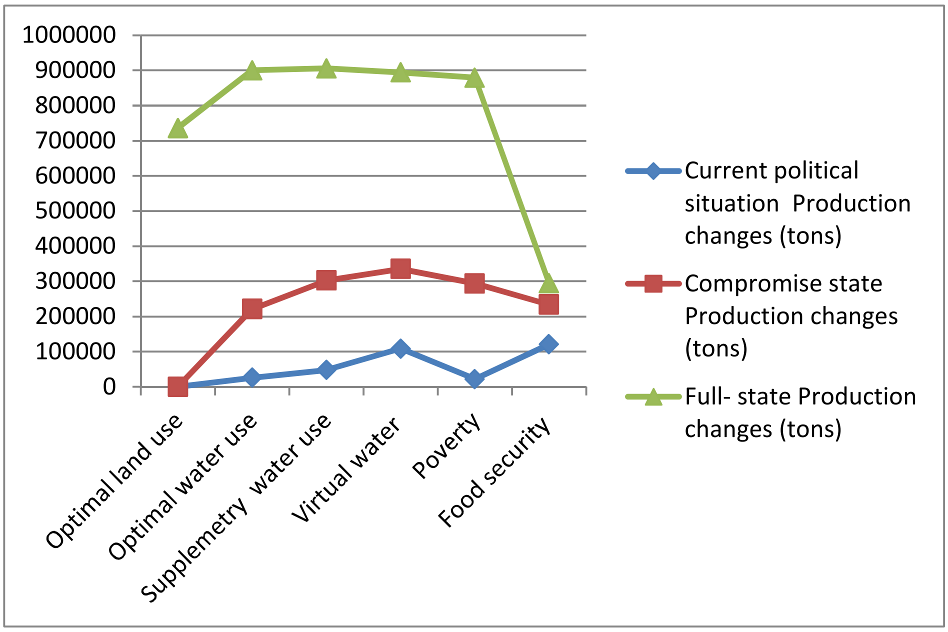


Figure (31): Changes in production for different scenarios under the main three scenarios.

5.3 Conclusions

In order to achieve the best suitable water management options for future agriculture in the LJV, the following specific conclusions were considered:

<u>1st Optimal Land Use Scenario</u>

For an optimal land use the following must be considered: (a) Shift from rain fed to irrigated agriculture. (b) Increase the area of protected agriculture such as greenhouses and tunnels, (c) Replace banana trees with palm dates for higher WUE, and (d) Use irrigable land that is not yet cultivated.

<u>2nd: Water use efficiency Scenario</u>

To save more water for agriculture development in the LJV, there is a need for (a) enhancing on farm water use efficiency and practices such as highly efficient irrigation system, (b) upgrading and rehabilitating water conveyance system from resource to farm, (c) constructing additional water storage reservoirs, and (d) improving and expanding extension services. WUE will increase when moving from current situation to intermediate and full state.

<u>3rd: Supplementary Water Scenario</u>

For the current situation, there is a potential for an increase of 8 % of the cultivated land due to an additional 7 MCM collected from water harvesting practices, treated wastewater and desalination of brackish water. Applying the political scenarios provides more potential to increase the cultivated land because more harvesting technique, treated wastewater and desalination of brackish water are carried out.

4th: Virtual Water Scenario

For both current and intermediate political scenarios, there is a need for combing and balancing agricultural production, reducing exporting products of high water requirement and focusing on agricultural production of low water requirement in the LJV. A shift to produce vegetables in greenhouse and protected tunnels must be used instead of using open field and trees production. Virtual water is less important than full-state scenario.

5th Poverty Scenario

There is a reversal relationship between poverty and water use efficiency: as economic growth being enhanced, farmer poverty level will decrease. Farmers will be able to buy and use better/higher technologies and materials and will move towards intensive agriculture. Consequently they will obtain better on farm WUE. Applying this assumption in the LJV would result in an additional increase in water use efficiency by 5, 10 and 20% of water for the three scenarios (current, intermediate and independency, respectively).

6th: Food Security Scenario

Based on the food security scenario and under current political conditions in the Palestinian Territory and the LJV, complete food security is not possible. About 37 MCM of water is needed per year to achieve partial food security. Testing the 3rd scenario which assumes that the secure of this additional water quantity and be obtained by sharing the Palestinian in the Jordan River basin. This might lead to Partial food security in several plant production areas such as vegetables, some fruits and field crops such as potato.

7th Main Political Scenario

The existing political situation, with limiting access and mobility to water and land and other constrains, affect negatively and extremely the agricultural sectors in the study area by limiting development of the study area, leading to unsustainable conditions in all economic activities including agriculture.

Comparison of Scenarios

Comparing the six scenarios under the current situation and their assumptions and outcomes, it was concluded that a single scenario will not lead to optimal water management in agriculture in the LJV. However, combination of several scenarios would better achieving this goal. Accordingly a combination of the first three scenarios (water and land use efficiency and supplementary water resources) is the best combination to achieve better water management in the LJV. The same trend was noticed for the intermediate political scenario with better production and more planted area. Integration of all of the six scenarios under this main intermediate scenario will lead to taking advantages from all the irrigable land.

Interestingly, considering the main political scenarios, applying the full- state scenario is the most suitable and applicable scenario in water and land management. It is clear that with full-state scenario there will be enough water supply for different agricultural activities and for other sectors at least for the near future.

Final Note

It is noteworthy that the findings of this study are general, local, and partial in nature and are considered as local water management solutions for Palestinian agriculture in the LJV suitable for the current political situation in Palestine and give an idea about the situation compared to other political situations (compromise and full state). These findings should help Palestinian decision makers either at the Ministry of Agriculture, Water Authority, or the Ministry of Planning under the prevailing conditions.

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Quran: Anbea "Sura21" ,"Ayah 30 " وجعلنا من الماء كل شيء حي----- سورة الأنبياء آية

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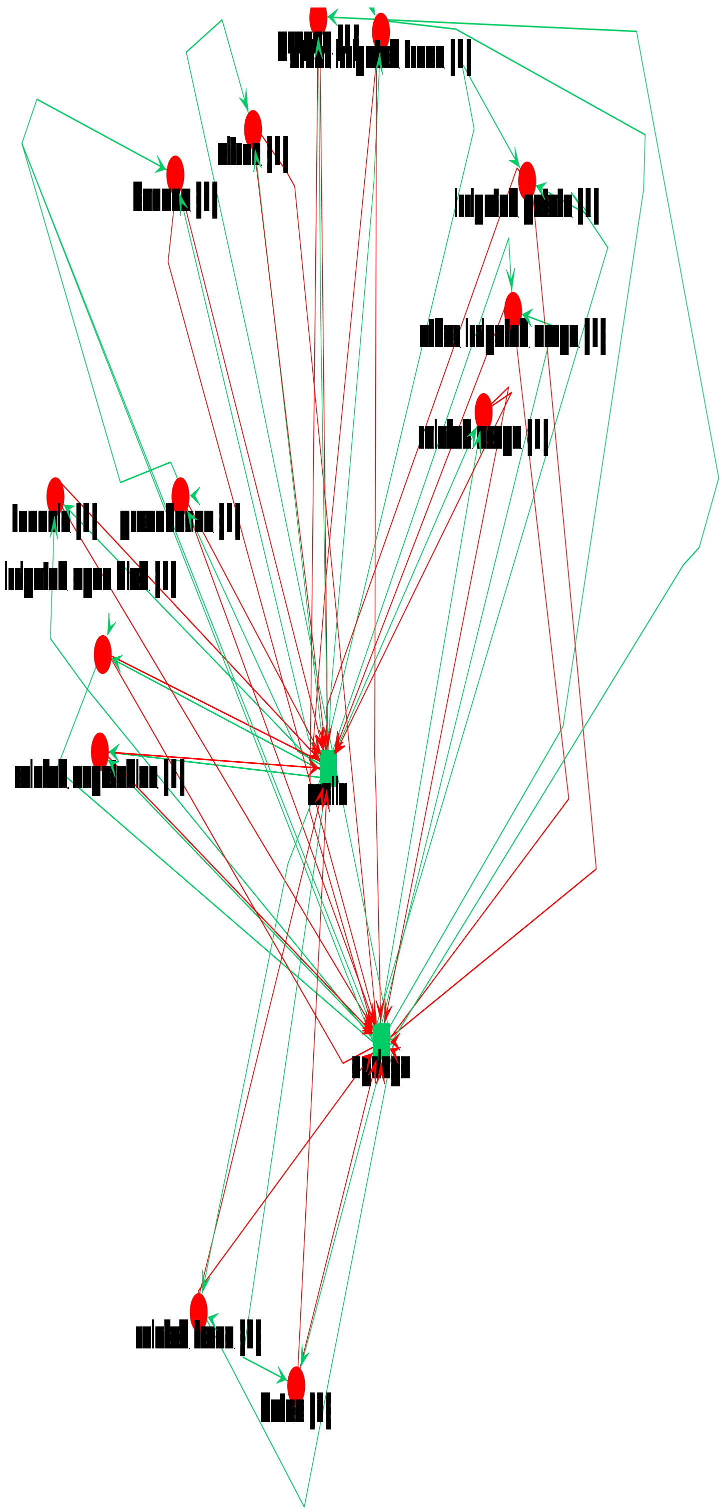
Appendix No. 1

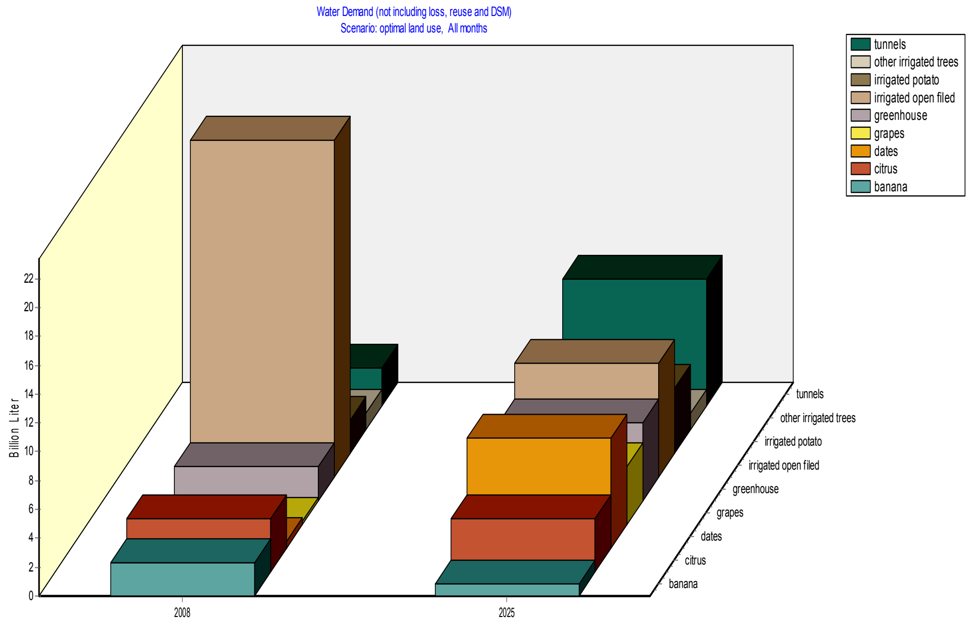
Charts

Selected figures from WEAP MODEL



WEAP Chart, supply and demand nodes

WEAP Charts for land use scenario



Changes of water demand for land use scenario

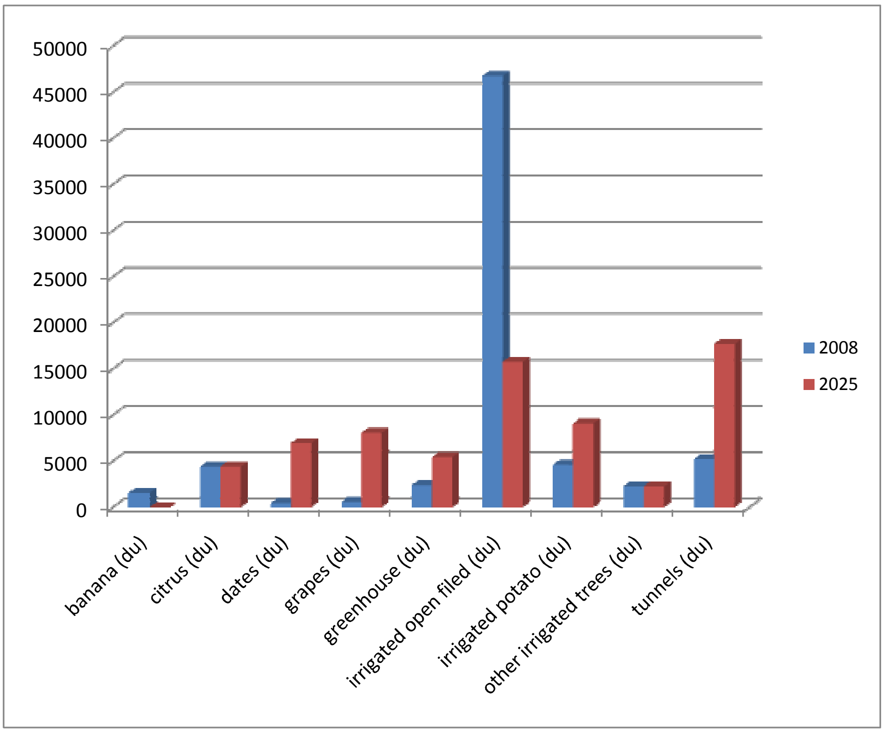


Figure: Comparison between crop pattern of the optimal land use with reference to current situation

❖ WEAP Charts for Optimal water use scenario

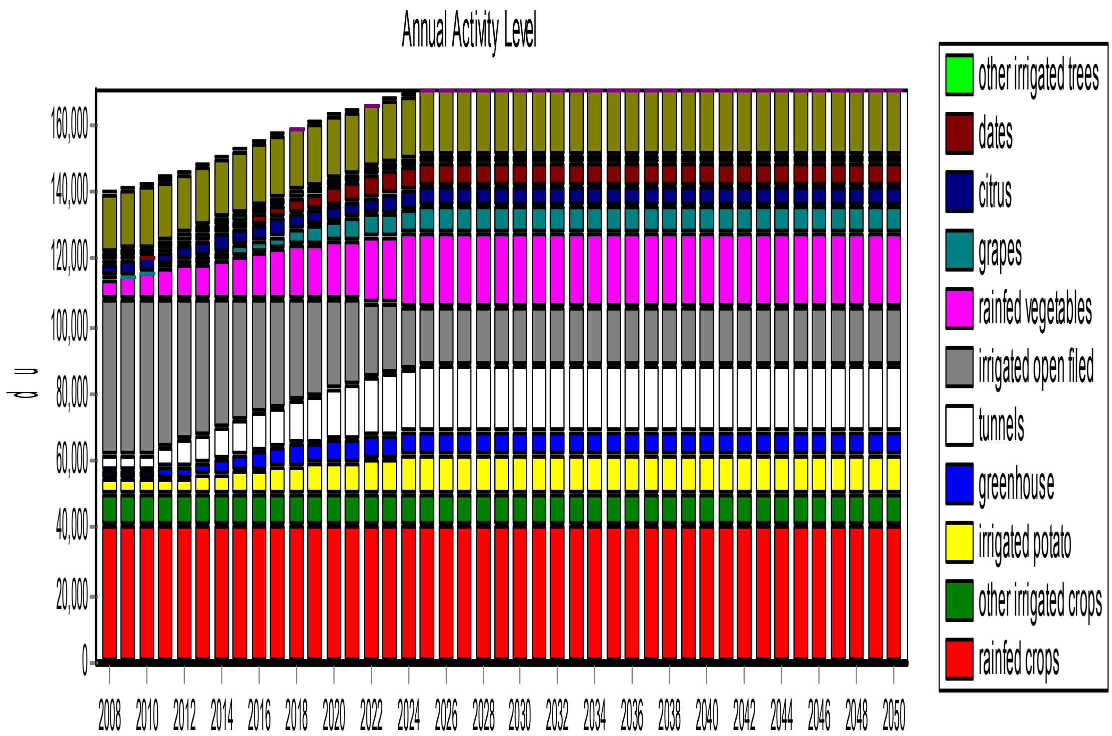
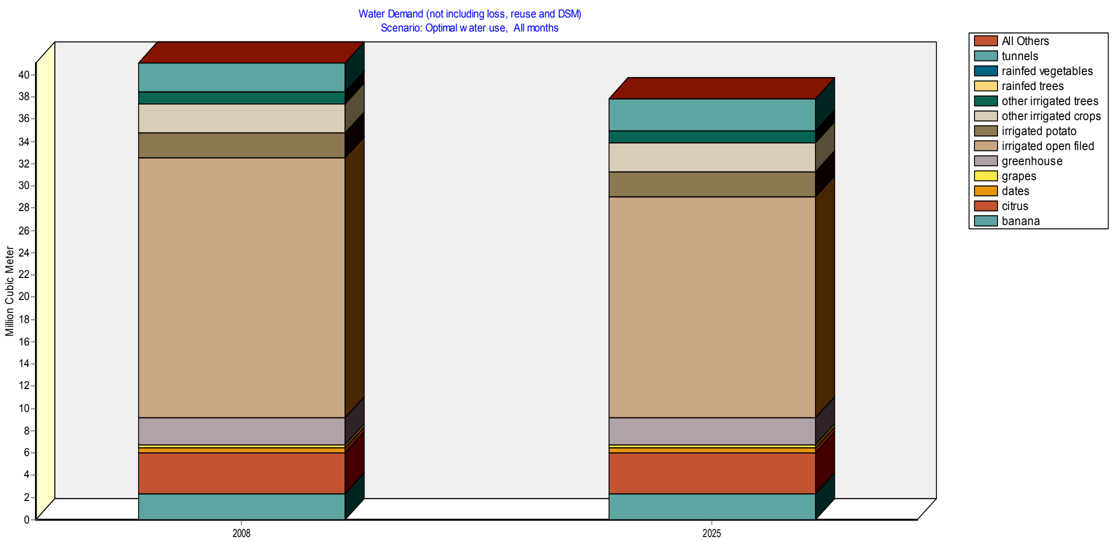
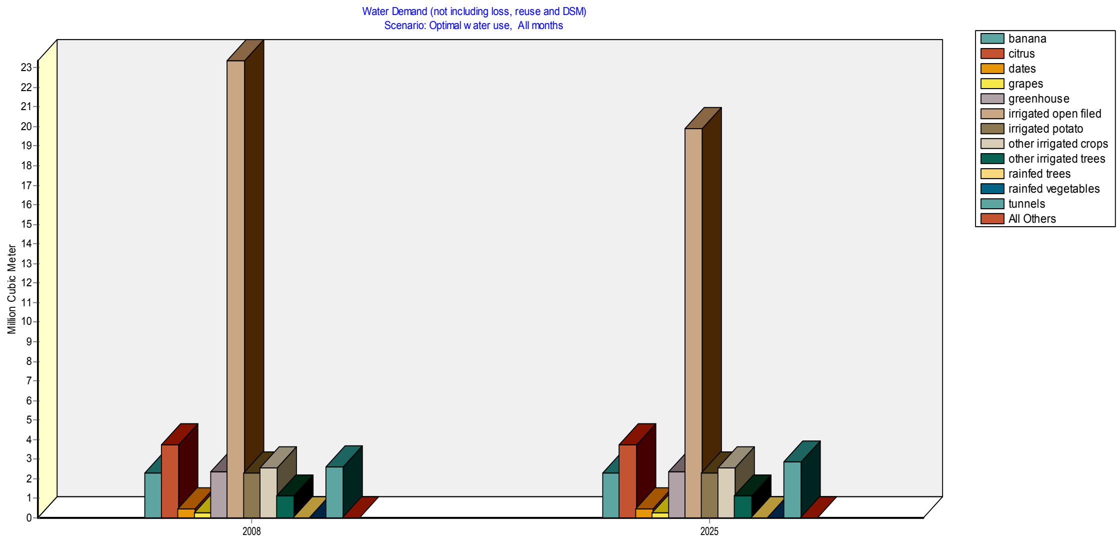


Figure: The Increase in Area Due to Optimal land Use Scenario





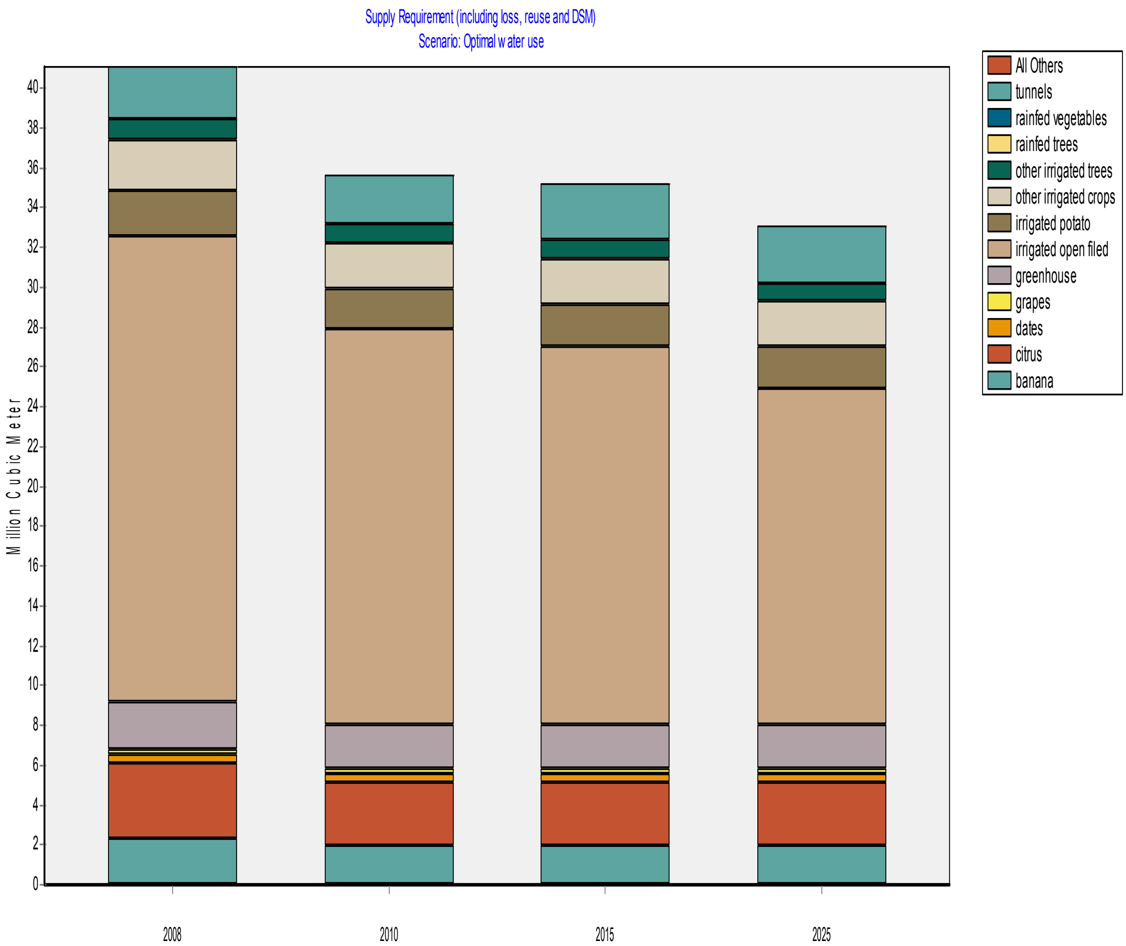
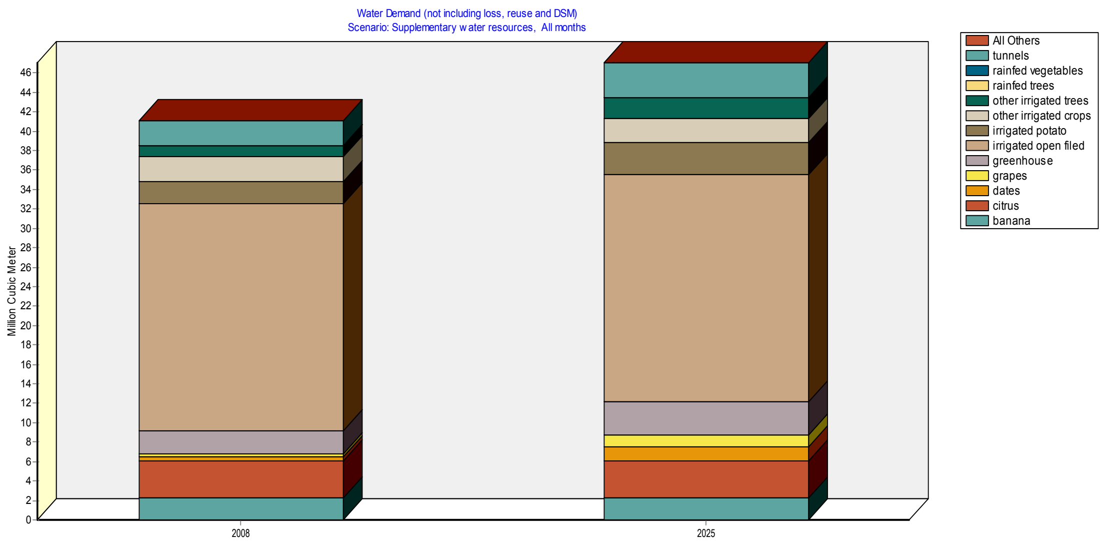
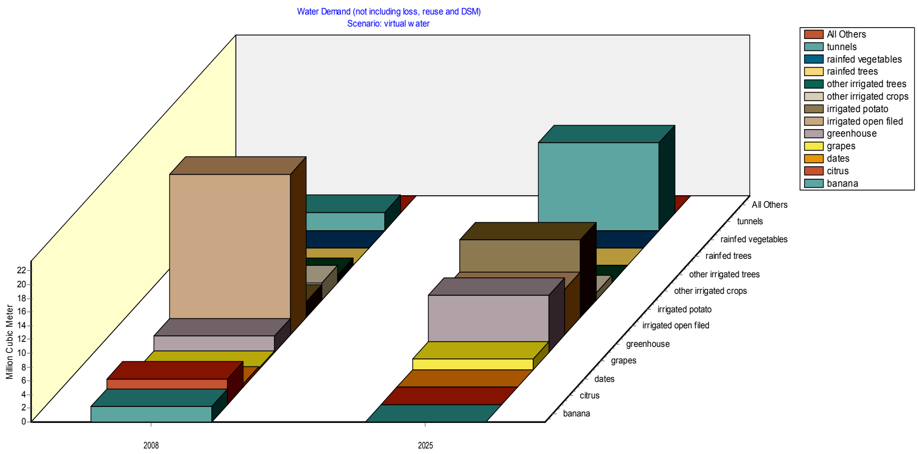


Figure: Water saving due to optimal water use scenario(same area and crop pattern)

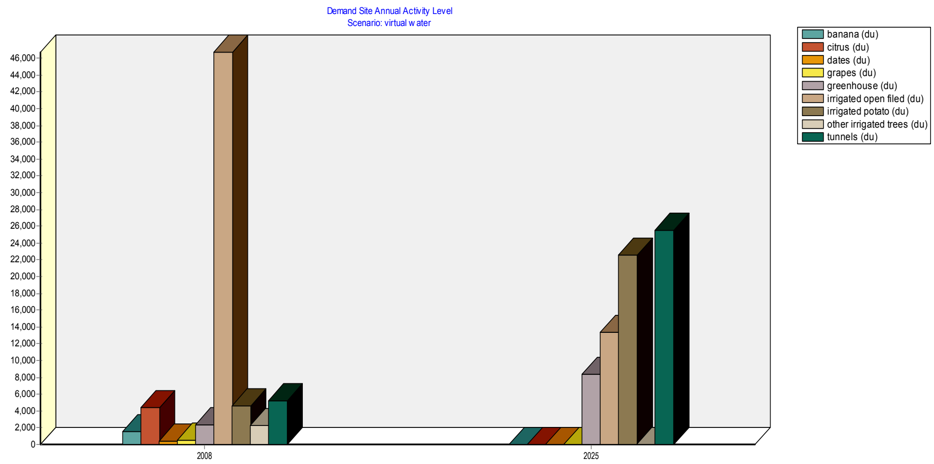
❖ WEAP Charts for supplementary water use scenario



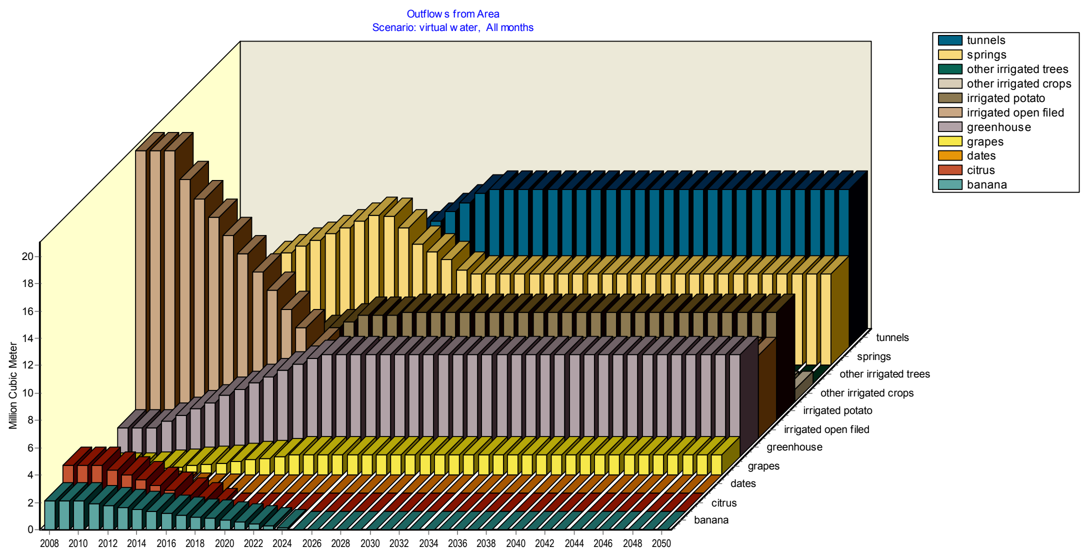
❖ WEAP Charts for virtual water scenario



Unmet demand for selected crops due to virtual water scenario

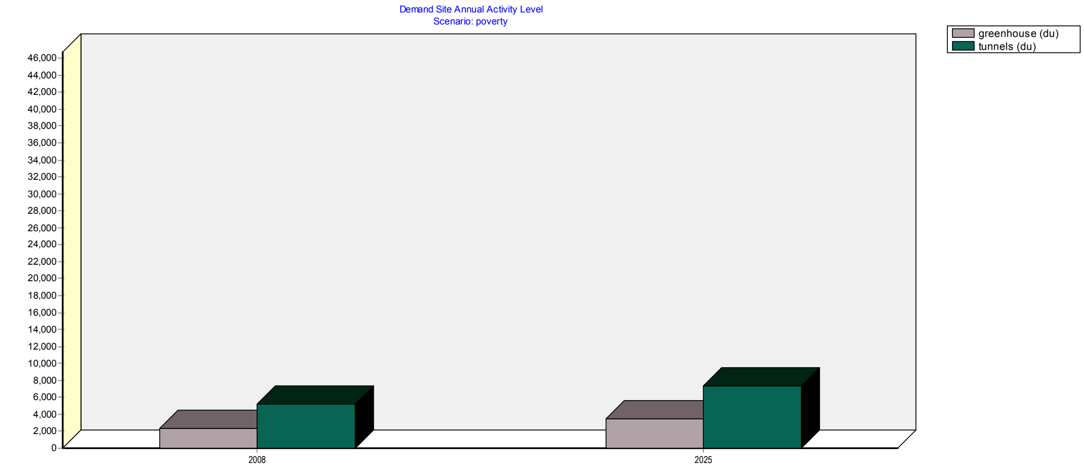


Demand site: Annual activity level (changes area in dunums)

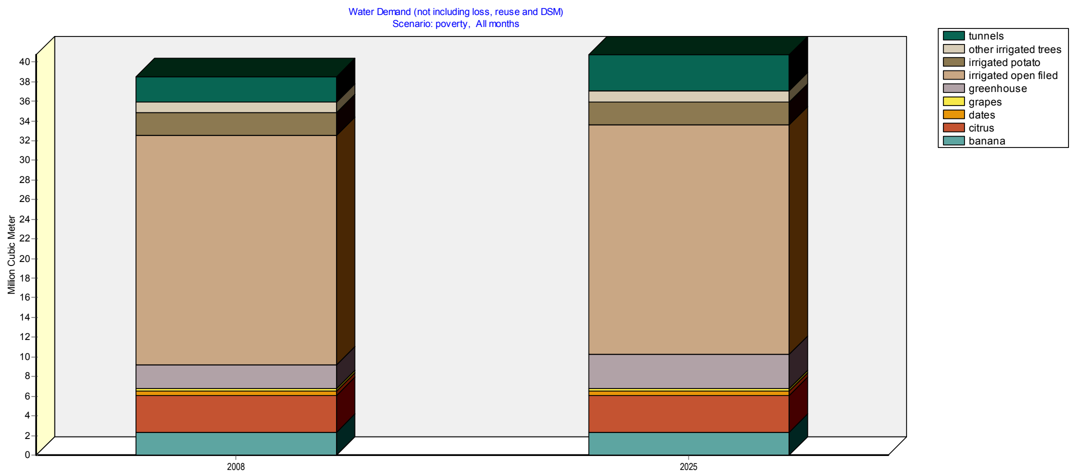


Distribution of available water as suggested by virtual water scenario

❖ WEAP Charts for poverty scenario



Annual activity level (slight increase in area of tunnels and greenhouses)



Water demand (slight decrease of water demand for the planted area, 2.2MCM)

Appendix No.2

“Oslo Agreement”

Oslo11 agreement, annex3, appendix 1, article 40

ARTICLE 40

Water and Sewage

On the basis of good-will both sides have reached the following agreement in the sphere of Water and Sewage:

Principles

1. Israel recognizes the Palestinian water rights in the West Bank. These will be negotiated in the permanent status negotiations and settled in the Permanent Status Agreement relating to the various water resources.

2. Both sides recognize the necessity to develop additional water for various uses.

3. While respecting each side's powers and responsibilities in the sphere of water and sewage in their respective areas, both sides agree to coordinate the management of water and sewage resources and systems in the West Bank during the interim period, in accordance with the following principles:

a. Maintaining existing quantities of utilization from the resources, taking into consideration the quantities of additional water for the Palestinians from the Eastern Aquifer and other agreed sources in the West Bank as detailed in this Article.

b. Preventing the deterioration of water quality in water resources.

c. Using the water resources in a manner which will ensure sustainable use in the future, in quantity and quality.

d. Adjusting the utilization of the resources according to variable climatological and hydrological conditions.

e. Taking all necessary measures to prevent any harm to water resources, including those utilized by the other side.

f. Treating, reusing or properly disposing of all domestic, urban, industrial, and agricultural sewage.

g. Existing water and sewage systems shall be operated, maintained and developed in a coordinated manner, as set out in this Article.

h. Each side shall take all necessary measures to prevent any harm to the water and sewage systems in their respective areas.

i. Each side shall ensure that the provisions of this Article are applied to all resources and systems, including those privately owned or operated, in their respective areas.

Transfer of Authority

4. The Israeli side shall transfer to the Palestinian side, and the Palestinian side shall assume, powers and responsibilities in the sphere of water and sewage in the West Bank related solely to Palestinians, that are currently held by the military government and its Civil Administration, except for the issues that will be negotiated in the permanent status negotiations, in accordance with the provisions of this Article.

5. The issue of ownership of water and sewage related infrastructure in the West Bank will be addressed in the permanent status negotiations.

Additional Water

6. Both sides have agreed that the future needs of the Palestinians in the West Bank are estimated to be between 70 - 80 mcm/year.

7. In this framework, and in order to meet the immediate needs of the Palestinians in fresh water for domestic use, both sides recognize the necessity to make available to the Palestinians during the interim period a total quantity of 28.6 mcm/year, as detailed below:

a. Israeli Commitment:

(1) Additional supply to Hebron and the Bethlehem area, including the construction of the required pipeline - 1 mcm/year.

2) Additional supply to Ramallah area - 0.5 mcm/year.

(3) Additional supply to an agreed take-off point in the Salfit area - 0.6 mcm/year.

(4) Additional supply to the Nablus area - 1 mcm/year.

(5) The drilling of an additional well in the Jenin area - 1.4 mcm/year.

(6) Additional supply to the Gaza Strip - 5 mcm/year.

(7) The capital cost of items (1) and (5) above shall be borne by Israel.

b. Palestinian Responsibility:

(1) An additional well in the Nablus area - 2.1 mcm/year.

(2) Additional supply to the Hebron, Bethlehem and Ramallah areas from the Eastern Aquifer or other agreed sources in the West Bank - 17 mcm/year.

(3) A new pipeline to convey the 5 mcm/year from the existing Israeli water system to the Gaza Strip. In the future, this quantity will come from desalination in Israel.

(4) The connecting pipeline from the Salfit take-off point to Salfit.

(5) The connection of the additional well in the Jenin area to the consumers.

(6) The remainder of the estimated quantity of the Palestinian needs mentioned in paragraph 6 above, over the quantities mentioned in this paragraph (41.4 - 51.4 mcm/year), shall be developed by the Palestinians from the Eastern Aquifer and other agreed sources in the West Bank. The Palestinians will have the right to utilize this amount for their needs (domestic and agricultural).

8. The provisions of paragraphs 6-7 above shall not prejudice the provisions of paragraph 1 to this Article.

9. Israel shall assist the Council in the implementation of the provisions of paragraph 7 above, including the following:

a. Making available all relevant data.

b. Determining the appropriate locations for drilling of wells.

10. In order to enable the implementation of paragraph 7 above, both sides shall negotiate and finalize as soon as possible a Protocol concerning the above projects, in accordance with paragraphs 18 - 19 below.

The Joint Water Committee

11. In order to implement their undertakings under this Article, the two sides will establish, upon the signing of this Agreement, a permanent Joint Water Committee (JWC) for the interim period, under the auspices of the CAC.

12. The function of the JWC shall be to deal with all water and sewage related issues in the West Bank including, inter alia:

a. Coordinated management of water resources.

b. Coordinated management of water and sewage systems.

c. Protection of water resources and water and sewage systems.

d. Exchange of information relating to water and sewage laws and regulations.

e. Overseeing the operation of the joint supervision and enforcement mechanism.

f. Resolution of water and sewage related disputes.

g. Cooperation in the field of water and sewage, as detailed in this Article.

h. Arrangements for water supply from one side to the other.

i. Monitoring systems. The existing regulations concerning measurement and monitoring shall remain in force until the JWC decides otherwise.

j. Other issues of mutual interest in the sphere of water and sewage.

13. The JWC shall be comprised of an equal number of representatives from each side.

14. All decisions of the JWC shall be reached by consensus, including the agenda, its procedures and other matters.

15. Detailed responsibilities and obligations of the JWC for the implementation of its functions are set out in **Schedule 8.**

Supervision and Enforcement Mechanism

16. Both sides recognize the necessity to establish a joint mechanism for supervision over and enforcement of their agreements in the field of water and sewage, in the West Bank.

17. For this purpose, both sides shall establish, upon the signing of this Agreement, Joint Supervision and Enforcement Teams (JSET), whose structure, role, and mode of operation is detailed in **Schedule 9.** Water Purchases

18. Both sides have agreed that in the case of purchase of water by one side from the other, the purchaser shall pay the full real cost incurred by the supplier, including the cost of production at the source and the conveyance all the way to the point of delivery. Relevant provisions will be included in the Protocol referred to in paragraph 19 below.

19. The JWC will develop a Protocol relating to all aspects of the supply of water from one side to the other, including, inter alia, reliability of supply, quality of supplied water, schedule of delivery and off-set of debts.

Mutual Cooperation

20. Both sides will cooperate in the field of water and sewage, including, inter alia:

a. Cooperation in the framework of the Israeli-Palestinian Continuing Committee for Economic Cooperation, in accordance with the provisions of Article XI and Annex III of the Declaration of Principles.

b. Cooperation concerning regional development programs, in accordance with the provisions of Article XI and Annex IV of the Declaration of Principles.

c. Cooperation, within the framework of the joint Israeli-Palestinian-American Committee, on water production and development related projects agreed upon by the JWC.

d. Cooperation in the promotion and development of other agreed water related and sewage-related joint projects, in existing or future multi-lateral forums.

e. Cooperation in water-related technology transfer, research and development, training, and setting of standards.

f. Cooperation in the development of mechanisms for dealing with water-related and sewage related natural and man-made emergencies and extreme conditions.

g. Cooperation in the exchange of available relevant water and sewage data, including:

(1) Measurements and maps related to water resources and uses.

(2) Reports, plans, studies, researches and project documents related to water and sewage.

(3) Data concerning the existing extractions, utilization and estimated potential of the Eastern, North-Eastern and Western Aquifers (attached as **Schedule 10**).

Protection of Water Resources and Water and Sewage Systems

21. Each side shall take all necessary measures to prevent any harm, pollution, or deterioration of water quality of the water resources.

22. Each side shall take all necessary measures for the physical protection of the water and sewage systems in their respective areas.

23. Each side shall take all necessary measures to prevent any pollution or contamination of the water and sewage systems, including those of the other side.

24. Each side shall reimburse the other for any unauthorized use of or sabotage to water and sewage systems situated in the areas under its responsibility which serve the other side.

The Gaza Strip

25. The existing agreements and arrangements between the sides concerning water resources and water and sewage systems in the Gaza Strip shall remain unchanged, as detailed **in Schedule 11**.

SCHEDULE 8

Joint Water Committee

Pursuant to Article 40, paragraph 15 of this Appendix, the obligations and responsibilities of the JWC shall include:

1. Coordinated management of the water resources as detailed hereunder, while maintaining the existing utilization from the aquifers as detailed in Schedule 10, and taking into consideration the quantities of additional water for the Palestinians as detailed in Article 40.

It is understood that the above-mentioned Schedule 10 contains average annual quantities, which shall constitute the basis and guidelines for the operation and decisions of the JWC:

a. All licensing and drilling of new wells and the increase of extraction from any water source, by either side, shall require the prior approval of the JWC.

b. All development of water resources and systems, by either side, shall require the prior approval of the JWC.

c. Notwithstanding the provisions of a. and b. above, it is understood that the projects for additional water detailed in paragraph 7 of Article

40, are agreed in principle between the two sides. Accordingly, only the geo-hydrological and technical details and specifications of these projects shall be brought before the JWC for approval prior to the commencement of the final design and implementation process.

d. When conditions, such as climatological or hydrological variability, dictate a reduction or enable an increase in the extraction from a resource, the JWC shall determine the changes in the extractions and in the resultant supply. These changes will be allocated between the two sides by the JWC in accordance with methods and procedures determined by it.

e. The JWC shall prepare, within three months of the signing of this Agreement, a Schedule to be attached to this Agreement, of extraction quotas from the water resources, based on the existing licenses and permits. The JWC shall update this Schedule on a yearly basis and as otherwise required.

2. Coordinated management of water and sewage systems in the West Bank, as follows:

a. Existing water and sewage systems, which serve the Palestinian population solely, shall be operated and maintained by the Palestinian side solely, without interference or obstructions, in accordance with the provisions of Article 40.

b. Existing water and sewage systems serving Israelis, shall continue to be operated and maintained by the Israeli side solely, without interference or obstructions, in accordance with the provisions of Article 40.

c. The systems referred to in a and b above shall be defined on Maps to be agreed upon by the JWC within three months from the signing of this Agreement.

d. Plans for construction of new water and sewage systems or modification of existing systems require the prior approval of the JWC.

SCHEDULE 9

Supervision and Enforcement Mechanism

Pursuant to Article 40, Paragraph 17 of this Appendix:

1. Both sides shall establish, upon the signing of this Agreement, no less than five Joint Supervision and Enforcement Teams (JSETs) for the West Bank, under the control and supervision of the JWC, which shall commence operation immediately.

2. Each JSET shall be comprised of no less than two representatives from each side, each side in its own vehicle, unless otherwise agreed. The JWC may agree on changes in the number of JSETs and their structure.

3. Each side will pay its own costs, as required to carry out all tasks detailed in this Schedule. Common costs will be shared equally.

4. The JSETs shall operate, in the field, to monitor, supervise and enforce the implementation of Article 40 and this Schedule, and to rectify the situation whenever an infringement has been detected, concerning the following:

a. Extraction from water resources in accordance with the decisions of the

JWC, and the Schedule to be prepared by it in accordance with sub paragraph l.e of Schedule 8.

b. Unauthorized connections to the supply systems and unauthorized water uses;

c. Drilling of wells and development of new projects for water supply from all sources;

d. Prevention of contamination and pollution of water resources and systems;

e. Ensuring the execution of the instructions of the JWC on the operation of monitoring and measurement systems;

f. Operation and maintenance of systems for collection, treatment, disposal and reuse, of domestic and industrial sewage, of urban and agricultural runoff, and of urban and agricultural drainage systems;

g. The electric and energy systems which provide power to all the above systems;

h. The Supervisory Control and Data Acquisition (SCADA) systems for all the above systems;

i. Water and sewage quality analyses carried out in approved laboratories, to ascertain that these laboratories operate according to accepted standards and practices, as agreed by the JWC. A list of the approved laboratories will be developed by the JWC;

j. Any other task, as instructed by the JWC.

5. Activities of the JSETs shall be in accordance with the following:

a. The JSETs shall be entitled, upon coordination with the relevant DCO, to free, unrestricted and secure access to all water and sewage facilities and systems, including those privately owned or operated, as required for the fulfilment of their function.

b. All members of the JSET shall be issued identification cards, in Arabic, Hebrew and English containing their full names and a photograph.

c. Each JSET will operate in accordance with a regular schedule of site visits, to wells, springs and other water sources, water works, and sewage systems, as developed by the JWC.

d. In addition, either side may require that a JSET visit a particular water or sewage facility or system, in order to ensure that no infringements have occurred. When such a requirement has been issued, the JSET shall visit the site in question as soon as possible, and no later than within 24 hours.

e. Upon arrival at a water or sewage facility or system, the JSET shall collect and record all relevant data, including photographs as required, and ascertain whether an infringement has occurred. In such cases, the JSET shall take all necessary measures to rectify it, and reinstate the status quo ante, in accordance with the provisions of this Agreement. If the JSET cannot agree on the actions to be taken, the matter will be referred immediately to the two Chairmen of the JWC for decision.

f. The JSET shall be assisted by the DCOs and other security mechanisms established under this Agreement, to enable the JSET to implement its functions.

g. The JSET shall report its findings and operations to the JWC, using forms which will be developed by the JWC.

SCHEDULE 10

Data Concerning Aquifers

Pursuant to Article 40, paragraph 20 and Schedule 8 paragraph 1 of this Appendix:

The existing extractions, utilization and estimated potential of the Eastern, North-Eastern, and Western Aquifers are as follows: Eastern Aquifer:

- In the Jordan Valley, 40 mcm to Israeli users, from wells;

- 24 mcm to Palestinians, from wells;

- 30 mcm to Palestinians, from springs;

- 78 mcm remaining quantities to be developed from the Eastern Aquifer;

- Total = 172 mcm.

North-Eastern Aquifer:

- 103 mcm to Israeli users, from the Gilboa and Beisan springs, including from wells; - 25 mcm to Palestinian users around Jenin; - 17 mcm to Palestinian users from East Nablus springs;

- Total = 145 mcm.

Western Aquifer:

- 340 mcm used within Israel;

- 20 mcm to Palestinians;

- 2 mcm to Palestinians, from springs near Nablus,

- Total= 362 mcm.

All figures are average annual estimates.

The total annual recharge is 679 mcm.

SCHEDULE 11

The Gaza Strip

Pursuant to Article 40, Paragraph 25:

1. All water and sewage (hereinafter referred to as "water") systems and resources in the Gaza Strip shall be operated, managed and developed (including drilling) by the Council, in a manner that shall prevent any harm to the water resources.

2. As an exception to paragraph 1., the existing water systems supplying water to the Settlements and the Military Installation Area, and the water systems and resources inside them shall continue to be operated and managed by Mekorot Water Co.

3. All pumping from water resources in the Settlements and the Military Installation Area shall be in accordance with existing quantities of drinking water and agricultural water. Without derogating from the powers and responsibilities of the Council, the Council shall not adversely affect these quantities.

Israel shall provide the Council with all data concerning the number of wells in the Settlements and the quantities and quality of the water pumped from each well, on a monthly basis.

4. Without derogating from the powers and responsibilities of the Council, the Council shall enable the supply of water to the Gush Katif settlement area and Kfar Darom settlement by Mekoroth, as well as the maintenance by Mekoroth of the water systems supplying these locations.

5. The Council shall pay Mekoroth for the cost of water supplied from Israel and for the real expenses incurred in supplying water to the Council.

6. All relations between the Council and Mekoroth shall be dealt with in a commercial agreement.

7. The Council shall take the necessary measures to ensure the protection of all water systems in the Gaza Strip.

8. The two sides shall establish a subcommittee to deal with all issues of mutual interest including the exchange of all relevant data to the management and operation of the water resources and systems and mutual prevention of harm to water resources.

9. The subcommittee shall agree upon its agenda and upon the procedures and manner of its meetings, and may invite experts or advisers as it sees fit.

Appendix No.3

Technical Regulations for treated wastewater irrigation

Palestinian National Authority
Palestine Standards Institution
President's Office

السلطـــة الوطنيـــة الفلسطينيـــة
مؤسسة المواصـــفات والمقاييـــس
مكتب الرئيس

نموذج مصادقة على تعليمات فنية إلزامية

أسم المادة / السلعة / الخدمة	المياه المعالجة للري الزراعي
رقم التعليمات الفنية الإلزامية	34 لسنة 2012
الوزارات ذات الاختصاص	وزارة الزراعة سلطة المياه

استنادا الى نص المادة (16) من قانون المواصفات والمقاييس رقم (6) لسنة (2000)، وبعد الاطلاع على المسودة النهائية للتعليمات الفنية الالزامية الخاصة بالمياه المعالجة للري الزراعي، فإننا نصادق على إقرارها كتعليمات فنية إلزامية تحت رقم 34 لسنة 2012.

التاريخ: 23\1\2012

الدكتور أحمد المجدلاني وزير الزراعة بالوكالة	الدكتور شداد العتيلي رئيس سلطة المياه

الدكتور حسن أبو لبده
رئيس مؤسسة المواصفات والمقاييس
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التعليمات الفنية الإلزامية 34-2012

المياه المعالجة للري الزراعي

(2012/1/23)

مقدمة

تهدف هذه التعليمات الفنية الإلزامية إلى ما يلي:

(1) وضع أسس لاستخدام المياه المعالجة للري الزراعي بشكل لا يضر بصحة الإنسان والحيوان وبالمزروعات.

(2) ضمان أن لا تشكل المياه المعالجة للري الزراعي ضررا على العناصر البيئية من تربة ومياه وهواء.

مادة (1)

المجال

تسري أحكام هذه التعليمات على المياه المعالجة الخارجة من محطات المعالجة بهدف استخدامها للري الزراعي.

مادة (2)

تعريفات

لغايات تطبيق أحكام هذه التعليمات يكون للكلمات والعبارات التالية المعاني المخصصة لها أدناه، ما لم تدل القرينة على خلاف ذلك:

2-1 الجهة المختصة: الجهة أو الجهات التي يحددها مجلس الوزراء لتنفيذ أحكام هذه التعليمات بموجب المادة (23) من قانون مؤسسة المواصفات والمقاييس والقوانين السارية الأخرى ذات الصلة.

2-2 المستخدم: شخص أو مقاول أو منشأة حكومية أو اهلية أو خاصة تستخدم أو تستفيد من المياه المعالجة للري الزراعي.

2-3 المياه العادمة: هي المياه الملوثة بمواد فيزيائية أو كيميائية أو بيولوجية أو إشعاعية ونتجت أو تخلفت عن استخدام المياه للأغراض المنزلية أو الصناعية أو التجارية أو الزراعية بحيث أصبحت تشكل خطورة عند إعادة استخدامها أو صرفها بشكل مخالف لأحكام القوانين السارية ذات الصلة.

2-4 الحدود القصوى: هو الحد الأقصى من تركيز المادة الملوثة المسموح بوجودها في المياه المعالجة وفقاً للحدود القصوى المذكورة في هذه التعليمات.

2-5 المياه المعالجة: هي المياه العادمة التي يتم التخلص من بعض أو جميع العوالق والرواسب والمواد المذابة فيها بالطرق الطبيعية أو الميكانيكية أو الكيميائية أو البيولوجية (الحيوية) سواء منفردة أو مجتمعة والتي لا تتجاوز مستوياتها الحدود القصوى المذكورة في هذه التعليمات.

2-6 محطة معالجة المياه العادمة: مجموعة المنشآت والأجهزة المعدة لمعالجة المياه العادمة بالطرق الطبيعية والميكانيكية والبيولوجية والكيميائية بهدف تحسين خواص المياه العادمة لإعادة استخدامها أو التخلص منها دون أيه أضرار صحية وبيئية.

مادة (3)

تصنف المياه المعالجة لأغراض الري الزراعي حسب جودتها إلى التصنيفات الواردة في ملحق (1).

مادة (4)

يشترط لاستخدام المياه المعالجة لأغراض الري الزراعي ما يلي:

(أ) مطابقتها لهذه التعليمات وخاصة الملحق (1).

(ب) موافقة الجهة المختصة بالري الزراعي على هذا الاستخدام وفق تعليمات صادرة عنها لهذه الغاية بما لا يتعارض مع اشتراطات هذه التعليمات.

مادة (5)

5-1 يجب أن تنقل المياه المعالجة لأغراض الري الزراعي بأنابيب ملائمة مغلقة ومميزة باللون البنفسجي ومطابقة للمواصفات الفلسطينية المعنية.

5-2 في حال نقل المياه المعالجة لأغراض الري الزراعي باستخدام مركبات الصهاريج، يجب أن تكون هذه الصهاريج مدهونة باللون البنفسجي ويكتب عليها عبارة "مياه معالجة للري الزراعي"، وذلك بخط مقروء وواضح من الجهتين.

مادة (6)

يجب على الجهة المختصة وضع تعليمات تشرح التدابير الوقائية الواجب اتخاذها داخل المزارع عند التعامل مع المياه المعالجة للري الزراعي.

مادة (7)

يجب على الجهة المختصة مراقبة جودة المياه المعالجة للري الزراعي من خلال تطبيق نظام المراقبة المذكور في المواصفة الفلسطينية رقم 742.

مادة (8)

يحظر استخدام المياه المعالجة للري الزراعي في:

(أ) سقاية المواشي والدواجن.

(ب) ري جميع أنواع الخضار.

(ت) تغذية المياه الجوفية عن طريق الحقن المباشر.

(ث) الاستزراع السمكي.

مادة (9)

لا يجوز للمستخدم التصرف في المياه المعالجة للري الزراعي في استخدامات غير تلك التي حددتها الجهة المختصة بالري الزراعي.

مادة (10)

عند وجود تعارض مع وثائق رسمية صادرة عن جهات أخرى، يجب تعديل تلك الوثائق بما ينسجم مع هذه التعليمات.

مادة (11)

تسري هذه التعليمات اعتباراً من تاريخ المصادقة عليها والإعلان عنها.

مادة (12)

في حال ظهور أي خلاف في تفسير أحد نصوص هذه التعليمات، فإنه يجب اعتماد التفسير الصادر عن لجنة التعليمات الفنية الإلزامية.

مادة (13)

على الجهة المختصة أن تضع خطة لتطبيق جميع احكام هذه التعليمات بحيث تتضمن مراحل التطبيق والموارد المطلوبة لتنفيذها على أن لا تتجاوز مدة هذه الخطة عن ثلاث سنوات من سريان هذه التعليمات.

ملحق (1)

تصنيف المياه المعالجة حسب جودتها

الحدود القصوى للخصائص الكيميائية والبيولوجية (ملغم/لتر) ما لم يذكر غير ذلك	جودة المياه المعالجة			
	جودة عالية (A)	جودة جيدة (B)	جودة متوسطة (C)	جودة متدنية (D)
الأوكسجين الممتص حيوياً BOD_5	20	20	40	60
المواد العالقة الكلية TSS	30	30	50	90
بكتيريا قولونية برازية FC (مستعمرة/100مل)	200	1000	1000	1000
الأوكسجين الممتص كيميائياً COD	50	50	100	150
الأكسجين المذاب DO	1<	1<	1<	1<
المواد الذائبة الكلية TDS	1200	1500	1500	1500
الرقم الهيدروجيني pH	9–6	9–6	9–6	9–6
الدهون والزيوت والشحوم Fat, Oil & Grease	5	5	5	5
الفينول Phenol	0.002	0.002	0.002	0.002
المنظفات الصناعية MBAS	15	15	15	25
النترات– نيتروجين NO_3-N	20	20	30	40
الأمونيوم– نيتروجين NH_4-N	5	5	10	15
النيتروجين الكلي Total-N	30	30	45	60
الكلوريد Cl	400	400	400	400
الكبريتات SO_4	300	300	300	300
الصوديوم Na	200	200	200	200
المغنيسيوم Mg	60	60	60	60
الكالسيوم Ca	300	300	300	300
نسبة ادمصاص الصوديوم SAR	5.83	5.83	5.83	5.83
الفوسفات – فسفور PO_4-P	30	30	30	30
الألمنيوم Al	5	5	5	5
الزرنيخ As	0.1	0.1	0.1	0.1
النحاس Cu	0.2	0.2	0.2	0.2

الحدود القصوى للخصائص الكيميائية والبيولوجية (ملغم/لتر) ما لم يذكر غير ذلك	جودة المياه المعالجة			
	جودة عالية (A)	جودة جيدة (B)	جودة متوسطة (C)	جودة متدنية (D)
الحديد Fe	5	5	5	5
المنغنيز Mn	0.2	0.2	0.2	0.2
النيكل Ni	0.2	0.2	0.2	0.2
الرصاص Pb	0.2	0.2	0.2	0.2
السيلينيوم Se	0.02	0.02	0.02	0.02
الكادميوم Cd	0.01	0.01	0.01	0.01
الزنك Zn	2	2	2	2
السيانيد CN	0.05	0.05	0.05	0.05
الكروم Cr	0.1	0.1	0.1	0.1
الزئبق Hg	0.001	0.001	0.001	0.001
كوبالت Co	0.05	0.05	0.05	0.05
البورون B	0.7	0.7	0.7	0.7
بكتيريا *E. coli* (مستعمرة/100مل)	100	1000	1000	1000
بيوض الديدان المعوية Nematodes (Eggs/L)	1≥	1≥	1≥	1≥

جامعة النجاح الوطنية
كلية الدراسات العليا

تقييم خيارات الإدارة المائية للقطاع الزراعي في غور الأردن- فلسطين باستخدام برنامج "WEAP"

إعداد
حازم شقير حسين عبد الجواد

إشراف
أ. د. مروان حداد

قدمت هذه الأطروحة استكمالاً لمتطلبات درجة الماجستير في الانتاج النباتي بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين

2012

تقييم خيارات الإدارة المائية للقطاع الزراعي في غور الأردن- فلسطين باستخدام برنامج "WEAP"

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أ. د. مروان حداد

الملخص

إن المياه هي عماد الحياة وهي أثمن المصادر الطبيعية على وجه البسيطة. القطاع الزراعي هو اكبر مستهلك للمياه العذبة. تزداد ندرة المياه في المناطق الجافة و شبه الجافة. تولى اهمية كبرى لتوزيع المصادر المائية و نوعيتها والسياسات المائية المتبعة. التخطيط لإدارة الموارد المائية يتطلب تكامل العديد من العلوم كعلم المياه و البيئة و الهندسة و الاقتصاد و التحليل وادارة المعلومات وغيرها. ان غور الأردن هو المنطقة الزراعية الأولى في الضفة الغربية. يهدف هذا البحث من خلال استخدامه برنامج الويب (WEAP) لإيجاد الإدارة المائية المستقبلية المثلى وبما يحقق الاستدامة لهذا المورد. مناخ حوض الأبيض المتوسط هو السائد في منطقة الدراسة (موسم صيف طويل وحار وجاف، وفصل شتاء قصير و دافئ و رطب). المياه الجوفية (الينابيع والآبار الارتوازية) هي مصدر المياه المتاح في هذه المنطقة. اختبرت الدراسة ست سيناريوهات (الاستخدام الأمثل للأراضي، الاستخدام الأمثل للمياه، وجود مصادر مياه اضافية، المياه الافتراضية، الفقر، الأمن الغذائي) تحت السيناريو الرئيس (السياسي). بمقارنة السيناريوهات المختلفة و فرضياتها و مدخلات و مخرجات كل منها وجد ان تكامل اكثر من سيناريو فرعي أفضل من تطبيق سيناريو لوحده .أن سيناريو الدولة الكاملة السيادة هو السيناريو الأفضل من بين السيناريوهات الرئيسية حيث توافر المصادر المائية للقطاع الزراعي والقطاعات الأخرى. إن نتائج هذه الدراسة من الممكن ان تساعد صانعي القرار الفلسطيني في المؤسسات المختلفة كوزارة الزراعة و التخطيط و سلطة المياه إن كان تحت الظروف السائدة او المتوقعة .