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

Irrigated agriculture in the West Bank constitutes less than 6% of the total Palestinian cultivated areas. There is a great potential to increase the areas under irrigation once Palestinians get their water rights from West Bank aquifer and the Jordan River. Israel has restricted Palestinian access to their water resources and is already exploiting more than 80% of the Palestinian water resources. Palestinians in the West Bank are being limited to use 125 MCM of their water resources per year for all purposes. Of these, 89 MCM are used for agriculture which is the backbone of the Palestinian economy.

It is estimated that, total water needs in Palestine for the three major types of use (municipal, industrial and agricultural) will be around 860 MCM by the year 2020. Current water supply is merely about one-third of that number. Based on the research estimates, Palestine should develop some 550 MCM/year in addition to water quantities available at present. To develop this quantity, it is necessary to design policies and strategies to, 1) increase the share of the Palestinians from surface and underground water sources available in the area between Jordan Valley and the Mediterranean, and 2) to develop unconventional sources of water, such as desalination of sea water and treatment of sewage water for irrigation purposes.

The aim of the conference on “Water Crisis and Agricultural Development in Palestine” was to provide the scientists and water experts with a platform to share their expertise in the diverse water and agriculture related fields. Peer reviewed papers presented essentially addressed the following themes: water and agricultural polices in Palestine, impact of climate changes on water and agriculture, management and use of conventional and non-conventional water resources in agriculture, and impact of agriculture practices on the environment and water resources.

The proceeding contains all full reviewed papers submitted to the conference and constitutes, therefore, an invaluable source of information reference for all who are involved in water and agriculture issues within the context of the four themes mentioned above.

My thanks and appreciation to all colleagues who participated in the preparation for this event, to Palestine Technical University administration. Thanks and appreciations are also extended to the partners and sponsors who have responded positively and generously by supporting and co-sponsoring the conference. Thanks are also due to the researchers who submitted quality papers.

Dr. Mahmoud Rahil

Conference Chairman

An Updated Water Budget for the Western Aquifer Basin and Potential for Agricultural Development in the West Bank, Palestine

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Abstract

This paper provides an update for the water budget for the Western Aquifer Basin (WAB) and highlights the potential for agricultural development in the West Bank. The Tulkarem and Qalqiliya governorates are used as a case study for agricultural development because of their dominance of irrigated agriculture. The WAB is a shared inter-boundary ground-water basin between the West Bank (in Palestine) and Israel. Two thirds of the Palestinians in the West Bank (1.5 million capita) are living within the upstream portion of the WAB, where 75 percent of its geologic aquifer outcrops (recharge area) are located. We used spatial modeling approach to create 10-meter cell-size grids showing the spatial distribution of precipitation, crop evapotranspiration (ETc), and runoff based on the 10-year (2001-2010) average available records of hydro-meteorological data. We used the general water budget equation to estimate rates and volumes of groundwater recharge by subtracting the spatial grids of ETc, runoff, and an assumed change in storage from precipitation grid. Change in storage, which includes minor losses by initial abstraction, subsurface flow, depression storage, soil's field capacity, and errors of measurement and estimation, was assumed at a lumped sum value of 5 percent of total precipitation. GIS geo-processing tools were used to clip the spatial grids of various water budget components for the WAB's aquifer outcrops and for the West Bank portion of the WAB. The 10-year average groundwater recharge for the entire WAB was estimated at 350 MCM/yr (million cubic meters per year). The 10-year average volumes of precipitation, ETc, runoff, and recharge were estimated for the West Bank portion of the WAB at 889 MCM/yr, 548 MCM/yr, 34 MCM/yr, and 263 MCM/yr, respectively, in addition to 44 MCM/yr of minor losses. In 2010, a total of 24.6 MCM/yr was extracted from 138 wells tapping the WAB's aquifers for various water use purposes in the Tulkarem and Qalqiliya governorates. Of which, 17.1 MCM/yr was consumed by irrigated agriculture from 119 agricultural wells and the remaining 7.5 MCM/yr was used for domestic purposes from the other 19 wells. Although there are 233,000 dunums of cultivated lands in the Tulkarem and Qalqiliya governorates, only 31,000 dunums (13 percent) are currently irrigated, due to restrictions on the Palestinian water use imposed by Israel. The 10-year average groundwater recharge for WAB's aquifers in the Tulkarem and Qalqiliya governorates was estimated at 81 MCM/yr. Assuming no Israeli restrictions on the Palestinian water use in those governorates, an extra 56 MCM/yr more aquifer recharge than current water use would potentially be enough to increase the current irrigated lands and significantly enhance the Palestinian economy.

Keywords: Water Budget, Watershed, Aquifer, GIS, Agriculture.

Disclaimer: This work represents the opinion of the authors and does not represent the views of the Utah Geological Survey and/or Brigham Young University.

1. Introduction

The objective of this paper is to develop an updated water budget for the Western Aquifer Basin (WAB) and to use its results to highlight the potential for water and agricultural development in the West Bank with special focus on the Tulkarem and Qalqiliya governorates.

Figure 1 shows the location map of the study area which includes the WAB's boundary, the western surface watershed boundary, the geologic aquifer outcrops (recharge areas), the political boundaries, and the boundaries of the Tulkarem and Qalqiliya governorates.

The WAB is a shared inter-boundary ground-water basin between the West Bank (in Palestine) and Israel (Figure 1). The WAB has a vital importance to the Palestinians due to the fact that two thirds of the Palestinians in the West Bank (~1.5 million capita) are living within the upstream portion of the WAB, where 75 percent of its geologic aquifer outcrops (recharge area) are located.

The WAB emerges from the mountains of the West Bank in the east and extends westward crossing the Palestinian/Israeli border to finally drain its extra water into two historical natural spring outlets, the Auja (Yarkon in Hebrew) and Tamaseeh (Taninim in Hebrew) springs, located entirely within the boundary of Israel. The WAB is normally referred to as the "Yarkon-Taninim Aquifer" in the Israeli literature after the Yarkon and Taninim springs. Figure 2 shows the location of wells and springs in the study area (PWA, 2011 and HSI (Hydrological Services of Israel), 1999).

Although, the WAB has an area of more than 9000 square kilometers that extends further south to the Negev desert (HSI, 1999), only the northern and central parts of the WAB with an approximate area of 6236 square kilometers were included in this study (report cells 210, 211, 212, and 220 in (Figure 2). About 98 percent of the total extracted groundwater from the WAB occurs in those report cells, of which 90 percent is extracted from cells 210 and 211 (HSI, 1999; figure 2).

Geologically, the WAB consists of two main aquifers; the Upper Cenomanian-Turonian Aquifer (upper aquifer; 200-250 meters of average thickness) and the Lower Cenomanian Aquifer (lower aquifer; 300-400 meters of average thickness). Both aquifers are outcropped in the West Bank portion (zero thicknesses) of the WAB and are mainly composed of karstic permeable limestone and dolomite inter-bedded with argillaceous formations of low permeability to form an aquitard (intermediate layer; the upper 100-150 meters of the Lower Cenomanian) separating the upper aquifer from the lower aquifer (Sabbah, 2004). However, in some places both aquifers are hydraulically connected to form one combined aquifer known as the Cenomanian-Turonian Aquifer. The Upper Cenomanian-Turonian Aquifer is overlain by a series of aquitards with a total combined thickness of 500-600 meters with geologic ages ranging from the Senonian to the Eocene. Those aquitards confine the Upper Cenomanian-Turonian Aquifer and separates it from the Quaternary Coastal Aquifer on the Mediterranean Sea (HSI, 1999). In some places, the Coastal Aquifer is in direct hydraulic connection with the Upper Cenomanian-Turonian Aquifer (HSI, 1999).

The total groundwater recharge for the WAB's aquifers (as of year 1997) was estimated at 366 MCM/yr which was fully pumped out through 510 wells tapping its aquifers both in Israel and the West Bank (HSI, 1999 and PWA, 2011). A total of 341 MCM/yr was pumped from 372 Israeli wells and 25 MCM/yr (7% of total pumping and recharge) was pumped from 138 Palestinian wells in the West Bank. In addition, 57 MCM/yr were naturally discharged by springs, of which 55 MCM/yr was discharged from the Auja and Tamaseeh springs (Yarkon and Taninim springs) inside Israel and 2 MCM/yr was discharged from another 28 low scale springs in the West Bank (HSI, 1999 and PWA, 2011). Of the total 366 MCM/yr of the pumped water from the WAB's aquifers in 1997, only 30 MCM/yr (8 percent of total extraction) were pumped from the Lower Cenomanian Aquifer (lower aquifer) (HSI, 1999).

The 2010 total water used by the Palestinians from the West Bank portion of the WAB's aquifers is about 29.45 MCM/yr (PWA, 2011) for all purposes which constitute less than 8 percent of the overall WAB's recharge and/or pumping. In addition to the Palestinian wells and springs, the Israeli Mekorot water company has 5 operating wells in the West Bank portion of the WAB which roughly pump a total water volume of 3 MCM/yr (PWA, 2011).

The 2010 total water used in the Tulkarem and Qalqiliya governorates was 24.6 MCM/yr from 138 wells tapping the WAB's aquifers, of which 17.1 MCM/yr was consumed by irrigated agriculture pumped from 119 wells, and another 7.5 MCM/yr was extracted from the other 19 wells for domestic water use (PWA, 2011). In the potential for agricultural development in the West Bank, the Tulkarem and Qalqiliya governorates were considered as a case study because of their dominance of irrigated agriculture. Although there are 233,000 dunums of current cultivated land in the Tulkarem and Qalqiliya governorates, only 31,000 dunums (13 percent) are currently irrigated (PCBS (Palestinian Central Bureau of Statistics), 2012).

2. Literature review

Although recharge of WAB's aquifers is generally known in literature to range from 300 MCM/yr to 400 MCM/yr, very limited technical water studies, if any, have been conducted by the Palestinian researchers due to Israeli political restrictions from 1967 to 1993. However, there are some Israeli studies that report the overall water budget for the entire WAB. Neither of these studies did identify the spatial distribution and flow rates of various water budget components nor classify them by governorates or aquifers of the WAB. Also those Israeli studies focus on the downstream portion of the WAB located entirely within Israel boundaries where most groundwater pumping occurs.

The Palestine Consultancy Group (PCG) and the Hebrew University of Jerusalem (HUJ) (1994a, 1994b) organized three joint Israeli-Palestinian workshops entitled "Joint Management of Shared Aquifers" and published their proceedings in three publication volumes (I, II, and III). The aim of the workshops was to propose the best way to maintain the sustainability of various shared Israeli-Palestinian aquifers and the ways to protect them from deterioration and over pumping. Those studies assumed a known water budget from Israeli sources and they didn't include any technical study to evaluate spatial distribution of recharge along with other water budget components. In other words, none of these studies have estimated the WAB's water budget volumes for the upstream and downstream portions of the WAB in the West Bank and Israel, respectively.

Gvirtzman (1994) published a paper entitled "Groundwater Allocation in Judea and Samaria" in which he tried to analyze the rights of Palestinians and Israelis in the West Bank Aquifer System based on zones of natural recharge as well as discharge zones within a historical perspective rather than natural and hydrological aspects. His final conclusion was that the actual water needs of the communities that depend on shared waters take precedence over the natural properties of that shared basin. His paper also emphasized that the priority of water use should base on the past and existing water use.

Isaac and Sabbah (1998) submitted their research outcome report on "Water Resources and Irrigated Agriculture in the West Bank" which evaluated the available water resources and their use in various governorates, aquifers, and groundwater basins. ET_c and crop water requirements were also estimated in that study for various governorates of the West Bank.

The Hydrological Services of Israel (HSI, 1999) submitted a state water report (translated from Hebrew), which subdivided the WAB area into 6 report cells of hydrologic meaning based on sources of recharge. That report published the lump sum annual average values of groundwater recharge, well pumping, spring flow discharge, water level, and nitrate and chloride concentrations for each report cell for the period 1968-1997.

Palestine Consultancy Group and Truman Institute of The Hebrew University (2000) submitted a research report entitled "Environmental Protection of the Shared Israeli-Palestinian Mountain

Aquifer". That study reported sources of pollution and simple coarse-grid cells pollution transport model and suggested ways to protect the WAB's aquifers from human related activities.

Sabbah (2004) estimated the 10-year (1991-2000) average recharge for the West Bank portion of the WAB at 336 MCM/yr. That recharge volume was high due to the almost double precipitation/recharge occurred in 1991/1992 hydrologic year. Sabbah (2004) also estimated recharge for the entire WAB's area by using a 1-year (year 2000) steady state groundwater flow model at 366 MCM/yr.

This study provides an update for the WAB's water budget, based on the most recent available hydro-meteorological data for the 10-year (2001-2010) period (HSI, 2000-2010), and integrates the spatial distribution of the various water budget components for both the Israeli and the West Bank portions of the WAB. This study took into consideration the western surface watershed boundary, the WAB's boundary, the entire WAB's aquifer outcrops, the West Bank portion of the WAB's aquifer outcrops, and Israel portion of the WAB's aquifer outcrops.

3. Methodology of study

In this study, we used the spatial modeling approach and ArcGIS Spatial Analyst (ESRI, 2010) to estimate an updated water budget for the WAB for the 10-year period (2001-2010). The 10-year period is used to make sure that the time span includes at least one drought cycle and one wet cycle. Spatial modeling techniques emerged recently after major development in vector and raster GIS formats which enables the evaluation of the target parameters both spatially and temporally based on a user defined cell-size gridding the entire study area. The spatial modeling approach used in this study took into consideration various parameters ranging from physical fixed data that does not change with time for the same area to dynamic data which changes with time. Fixed data used in this model includes elevation, geology, geographic boundaries, groundwater boundary, watershed basin boundary, and the WAB's aquifer boundaries (recharge areas). Dynamic data used in this model includes values of weather and meteorological parameters such as precipitation, evapotranspiration, and runoff. Figure 3 shows the location map of western watershed boundaries and their drainage patterns along with 90 locations with the hydrometric stations, rain gages, climate, and weather stations used in this study to integrate the various water budget components (HSI, 1999; PWA, 2011; PCBS, 2012; IMS (Israel Meteorological Service), 2012; and PMD (Palestinian Meteorological Department, 2012). Figure 4 shows the flowchart of the spatial modeling approach used in this study.

We have digitized the boundaries of the WAB and the western surface watersheds from the 1999 hydrologic state report (translated from Hebrew) (HSI, 1999). We have also digitized the geologic outcrops of the principal aquifers, which represent the recharge areas of the WAB's aquifers, from the 200,000 scale geologic map of Israel (Geological Survey of Israel, 1998). Other boundaries and base maps were integrated from previous study done by Sabbah (2004). We have converted all previously mentioned maps into GIS format shape files and all areas of the WAB, surface watersheds, aquifer outcrops (recharge areas), and other base maps were estimated using the ESRI ArcGIS 10 Software and the embedded Spatial Analyst tool (ESRI, 2011). Based on that area estimate, 1582 square kilometers of the WAB's study area (26 percent) are located upstream within the entire boundary of the West Bank. The estimated recharge area of the WAB is about 1703 square kilometers which constitutes about 29 percent of WAB's study area. About 1249 square kilometers of overall WAB's recharge area is located within the entire West Bank boundary (75 percent of the overall WAB's recharge area).

The 10-year (2001-2010) average hydro-meteorological data were used to derive precipitation, ET_c, and runoff spatial grids, along with an assumed minor losses were integrated by GIS spatial interpolation from measuring and/or estimated values at station points. All these grids were then converted from raster into vector contour maps within the western watershed boundaries, the western aquifer basin boundary, and finally within the WAB's recharge area.

We estimated the reference evapotranspiration (ET_0) from the 10-year average annual temperature, solar radiation, relative humidity, and wind speed using the Modified Penman-Montieth equation embedded in CropWat 8.0 for Windows Software released by the FAO (United Nations Food and Agriculture Organization) (FAO, 2010). Modified Penman-Montieth method also uses crop properties and estimated ET_0 to estimate the crop evapotranspiration using the following equation:

$$ET_c = K_c * ET_0 \quad \textit{Equation (1)}$$

where K_c is the crop coefficient which ranges in this study from 0.4 to 1.33 based on the average K_c values for the 20 most dominant crops (Isaac and Sabbah, 1998). Since this method is used for estimating water budget from natural precipitation, the estimated monthly ET_c was finally adjusted in such a way that it doesn't exceed precipitation in any single month ($ET_c <= P$) which means the maximum value of ET equals the monthly value of precipitation.

Then runoff was integrated from measurements at 31 Israeli hydrometric stations (HSI, 2010). The spatial distribution of runoff rate was estimated by first estimating the runoff coefficient for all sub-watersheds of the study area by dividing the measured stream flow volume by the estimated precipitation volume for each sub-watershed and those coefficients were then multiplied by precipitation rates in each cell spatial model. In this case runoff works as a function of precipitation grid.

From the authors' own experience, change in storage and minor losses due to initial abstraction, subsurface flow, depression storage, soil's field capacity, and estimation errors was assumed at 5 percent of precipitation grid.

Finally, the spatial recharge coverage was derived using the simple math grid algebra using the ArcGIS Spatial Analyst (ESRI, 2011) by subtracting the spatial grids of ET_C, runoff, and change in storage and minor losses from precipitation grid coverage (figure 4) as shown in following general mass balance equation:

$$P - ET_c - Ru - Re = \text{Change in storage and minor losses} \quad \textit{Equation (2)}$$

where, P Precipitation/Rainfall grid

ET_c Crop evapotranspiration grid

Ru Runoff grid (Rainfall Excess)

Re Recharge grid

Running the spatial modeling approach (figure 4) produced a spatial grid for each water budget component which shows the cell-by-cell distribution of estimated precipitation, ET_c, runoff, and groundwater recharge rates for the entire western watershed boundary, the entire WAB's boundary, and the WAB's recharge area boundary. We converted all estimated water budget grids into vector GIS contours and we calculated areas between contours of the created contour maps using the ArcGIS Spatial Analyst (ESRI, 2011). Volumes and weighted average rates were estimated using the following equation:

$$V = \sum_{i=0}^{n} Pi * AiV = \sum_{i=0}^{n} Pi * Ai \quad \textit{Equation (3)}$$

where, V is the total volume

Pi is the average value of parameter for each contour region (precipitation, ET_c, runoff, and recharge)

Ai is the area between every two contours i is the contour region number.

n is the total number of contour regions

The ArcGIS geo-processing tools (ESRI, 2011) were used to estimate volumes and weighted average rates for the various water budget components for the entire western surface watershed boundary, WAB's boundary, and the entire WAB's aquifer outcrops (recharge area), the West Bank portion of the WAB's aquifer outcrops, and Israel's portion of the WAB's aquifer outcrops.

4. Results and Discussion

Table (1) shows the various estimated components of the water budget both for the aquifer and non-aquifer outcrops of the WAB subdivided by the upstream (WAB's West Bank recharge portion) and downstream (WAB's Israeli recharge portion) portions. Table 2 shows the various estimated components of the water budget both in Israel and the West Bank governorates tapping the WAB.

The 10-year (2001-2010) average estimated precipitation, ET_C, runoff, and final adjusted recharge were estimated in the West Bank portion of the WAB's outcrops at 889 MCM/yr, 548 MCM/yr, 34 MCM/yr, 263 MCM/yr, respectively, in addition to about 44 MCM/yr in the form of minor losses and change in storage (Table 1).

The 10-year (2001-2010) average estimated precipitation, ET_C, runoff, and final adjusted recharge were estimated in the Israeli portion of the WAB's outcrops at 254 MCM/yr, 142 MCM/yr, 13 MCM/yr, 87 MCM/yr, respectively, in addition to about 12 MCM/yr in the form of minor losses and change in storage (Table 1).

The overall 10-year (2001-2010) average estimated precipitation, ET_C, runoff, and final adjusted recharge were estimated for the WAB's outcrops at 1143 MCM/yr, 690 MCM/yr, 47 MCM/yr, 350 MCM/yr, respectively, in addition to about 56 MCM/yr in the form of change in storage and minor losses(Table 1).

The adjusted recharge is about 68 MCM/yr less than the overall recharge because only aquifer outcrops are considered to have recoverable recharge (Table 1). This 68 MCM/yr is stored in aquitards which is mostly non-recoverable unless they leak into aquifers upper or lower aquifers.

The WAB's aquifer recharge areas and volumes were estimated for the upper and lower aquifers (Table 1) as follows:

- The upper aquifer referred to as the Upper Cenomanian-Turonian Aquifer has a total outcropped recharge area of 1314 square kilometers (975 km^2 in the West Bank and 339 km^2 in Israel) and receives a 10-year (2001-2010) average groundwater recharge of 271 MCM/yr (208 MCM/yr in the West Bank and 63 MCM/yr in Israel).
- The lower aquifer referred to as the Lower Cenomanian Aquifer has a total outcropped recharge area of 389 square kilometers (274 km^2 in the West Bank and 115 km^2 in Israel) and receives a 10-year (2001-2010) average recharge of 79 MCM/yr (55 MCM/yr in the West Bank and 24 MCM/yr in Israel).

In summary, the WAB's Upper Cenomanian-Turonian Aquifer receives about 77 percent of total aquifer's recharge, while the Lower Cenomanian Aquifer receives 23 percent (Table 1). As of 1997, a total of 366 MCM/yr was pumped from both the upper and lower WAB's aquifers, of which about 341 MCM/yr was pumped by Israel and 25 MCM/yr was pumped by the Palestinians of the West Bank (HSI, 1999). Only 5 percent (18 MCM/yr) of that total extracted water was pumped from 39 wells tapping the Lower Cenomanian Aquifer (HSI, 1999) which indicates that the Cenomanian-Turonian

Aquifer is fully- or even over-utilized, while there is still a potential to develop more water from the lower aquifer.

Although only 25 percent of the WAB's area is located entirely within the West Bank boundary, it receives 75 percent of the WAB's average annual recharge volume, while the rest are received in the downstream portion within the Israeli boundaries (Table 1).

Figures 5 through 8 show the spatial distribution, lump sum volumes, and the weighted average rates of the 10-year average precipitation, ET_c, runoff, and recharge for the western surface watershed, the WAB's boundary, the WAB's overall recharge area, the Israeli portion of the WAB's aquifer outcrops, and the West Bank portions of the WAB's aquifer outcrops using the ArcGIS Geo-processing clip and grid calculator tools (ESRI, 2011).

The 10-year (2001-2010) average volumes of precipitation were estimated at 3984 MCM/yr, 2817 MCM/yr, 1143 MCM/yr, 254 MCM/yr, and 889 MCM/yr for the western surface watersheds, the overall WAB's boundary, the WAB's overall aquifer outcrops (recharge area), the Israeli portion of the WAB's aquifer outcrops, and the West Bank portions of the WAB's aquifer outcrops, respectively (Figure 5). The 10-year (2001-2010) average weighted rates of precipitation were estimated at 441 mm/yr, 473 mm/yr, 558 mm/yr, 547 mm/yr, and 562 mm/yr for the western surface watersheds, the overall WAB's boundary, the WAB's overall recharge area, the Israeli portion of the WAB's aquifer outcrops, and the West Bank portions of the WAB's aquifer outcrops, respectively (Figure 5).

The 10-year (2001-2010) average volumes of ET_c were estimated at 2354 MCM/yr, 1638 MCM/yr, 690 MCM/yr, 142 MCM/yr, and 548 MCM/yr for the western surface watersheds, the overall WAB's boundary, the WAB's overall recharge area, the Israeli portion of the WAB's aquifer outcrops, and the West Bank portions of the WAB's aquifer outcrops, respectively (figure 6). The 10-year (2001-2010) average weighted rates of ET_c were estimated at 260 mm/yr, 275 mm/yr, 337 mm/yr, 305 mm/yr, and 346 mm/yr for the western surface watersheds, the overall WAB's boundary, the WAB's overall recharge area, the Israeli portion of the WAB's aquifer outcrops, and the West Bank portions of the WAB's aquifer outcrops, respectively (Figure 6).

The 10-year (2001-2010) average volumes of runoff were estimated at 224 MCM/yr, 164 MCM/yr, 47 MCM/yr, 13 MCM/yr, and 34 MCM/yr for the western surface watersheds, the overall WAB's boundary, the WAB's overall recharge area, the Israeli portion of the WAB's aquifer outcrops, and the West Bank portions of the WAB's aquifer outcrops, respectively (Figure 7). The 10-year (2001-2010) average weighted rates of runoff were estimated at 25 mm/yr, 27 mm/yr, 23 mm/yr, 28 mm/yr, and 21 mm/yr for the western surface watersheds, the overall WAB's boundary, the WAB's overall recharge area, the Israeli portion of the WAB's aquifer outcrops, and the West Bank portions of the WAB's aquifer outcrops, respectively (Figure 7).

The 10-year (2001-2010) average volumes of recharge were estimated at 1207 MCM/yr, 875 MCM/yr, 350 MCM/yr, 87 MCM/yr, and 263 MCM/yr for the western surface watersheds, the overall WAB's boundary, the WAB's overall recharge area, the Israeli portion of the WAB's aquifer outcrops, and the West Bank portions of the WAB's aquifer outcrops, respectively (Figure 8). The 10-year (2001-2010) average weighted rates of recharge were estimated at 134 mm/yr, 147 mm/yr, 206 mm/yr, 192 mm/yr, and 211 mm/yr for the western surface watersheds, the overall WAB's boundary, the WAB's overall recharge area, the Israeli portion of the WAB's aquifer outcrops, and the West Bank portions of the WAB's aquifer outcrops, respectively (Figure 8).

On the potential for agricultural development in the West Bank, the Tulkarem and Qalqiliya governorates were considered as a case study because of the dominance of irrigated agriculture using 119 wells tapping the WAB's aquifers. The total cultivated lands in those two governorates is about 233,000 dunums, of which only 31,000 dunums (PCBS, 2012) are currently under irrigation which only consumes about 17.1 MCM/yr (PWA, 2010), while the rest (202,000 dunums) of lands are rain-fed.

5. Conclusions and recommendations

The 10-year (2001-2010) average precipitation, ET_c, runoff, and recharge were estimated for the West Bank portion of the WAB at 888 MCM/yr, 528 MCM/yr, 53 MCM/yr, and 263 MCM/yr, respectively, in addition to 44 MCM/yr of minor losses.

The overall 10-year (2001-2010) average estimated precipitation, ET_C, runoff, and final adjusted recharge were estimated for the WAB's outcrops at 1143 MCM/yr, 690 MCM/yr, 47 MCM/yr, 350 MCM/yr, respectively, in addition to about 56 MCM/yr in the form of minor losses and change in storage.

The Upper Cenomanian-Turonian Aquifer which has a total outcropped area of 1314 square kilometers receives a 10-year (2001-2010) average recharge of 271 MCM/yr, of which 208 MCM/yr (77 percent) is received within the entire West Bank boundary.

The Lower Cenomanian Aquifer which has a total outcropped area of 389 square kilometers receives a 10-year (2001-2010) average recharge of 79 MCM/yr, of which 55 MCM/yr (70 percent) is received within the entire West Bank boundary.

In 2010, irrigated agriculture consumed about 17.1 MCM/yr from 119 agricultural wells in the Tulkarem and Qalqiliya governorates, while 7.5 MCM/yr was extracted from the other 19 wells for domestic water use. There is a potential for agricultural development in the Tulkarem and Qalqiliya governorates because of their dominance of irrigated agriculture. For example, the current 31,000 dunums of irrigated lands could be expanded greatly since there is 202,000 other dunums of rainfed cultivated lands (PCBS, 2012). Such expansion of irrigated land could be achieved using the extra 56 MCM/yr more aquifer recharge than current water use, assuming no Israeli restrictions on the Palestinian water use.

Salfit, Nablus, Ramallah, Jerusalem, Bethlehem, and Hebron governorates partially overlie the WAB's aquifers and receive a total recharge of 182 MCM/yr, while the total water pumping from the WAB's aquifers in these governorates is only 3 MCM/yr for all purposes (PWA, 2010). Again assuming no Israeli restrictions, there is a potential to develop and irrigate more lands there.

Although 75 percent of total annual natural recharge (263 MCM/yr out of 350 MCM/yr) occurs in the West Bank portion of the WAB's aquifer outcrops, Israel is utilizing 92 percent (341 MCM/yr as of 1997; HSI (1999)) of the WAB's aquifers yield while the other 8 percent (30 MCM/yr as of 2010; PWA (2010)) is being pumped and used by the Palestinian communities in the West Bank. In addition to pumping 341 MCM/yr from 367 wells inside Israel, Israel has 5 other wells run by Mekorot in the West Bank portion of the WAB which pump about 3 MCM/yr (PWA, 2011). Of the 510 Palestinian and Israeli wells pumping the WAB's aquifers, only 39 wells are pumping from the Lower Cenomanian Aquifer that pump a total quantity of 18 MCM/yr (HSI, 1999).

This study shows that all hydrometric stations, used in this study, measuring stream and flood flows are located in the entire boundary of Israel. Thus there is an urgent need to install hydrometric stations at the stream outlets right before they cross the West Bank/Israel border to measure the stream and flood flow runoff generated within the West Bank boundary along with other meteorological data on an hourly or daily basis (Figure 3). These stations should be able to measure the hydro-meteorological data every 5, 30, 60, 120, 180 minutes, respectively, in order to conduct more detailed hydrological research modeling studies in the West Bank potion of the WAB. The detailed measurements could be used to create the Intensity-Duration-Frequency (IDF) curves of rainfall that have many valuable applications in hydrological research.

Assuming no Israeli restrictions, the Palestinians could also use certain amount of water from the 53 MCM/yr of runoff water by constructing low and large scale water harvesting tools.

The Israeli official water policy on the WAB's aquifers is focused on the assumption that it is fully utilized historically by Israel (340-360 MCM/yr) and that they are doing great favor to the Palestinians of the West Bank by letting them use about 30 MCM/yr of its aquifers. They base their policy on the historical water use by claiming the international water law gives them the right to maintain such share in its water. That might be right in normal conditions between two independent states sharing the same water sources. However, that rule is not applicable in the Palestinian-Israeli water conflict due to the abnormal occupation of the Palestinian land by Israel. Even if Israel was using such water before 1967 when the West Bank was under the Jordanian administration from 1948-1967, the Palestinians did never had an independent state to deal with their natural resources properly. Thus any Palestinian official body entitled to negotiate with Israel in the future over the Palestinian water rights should focus on the importance of this water body (WAB) so that a just and fair water share is fulfilled from this basin, taking into consideration that 75 percent of recharge of the WAB's aquifers occurs within the entire West Bank boundary. The worst case scenario (the bottom ceiling) of the Palestinian water share in the WAB's aquifers should be 50 percent.

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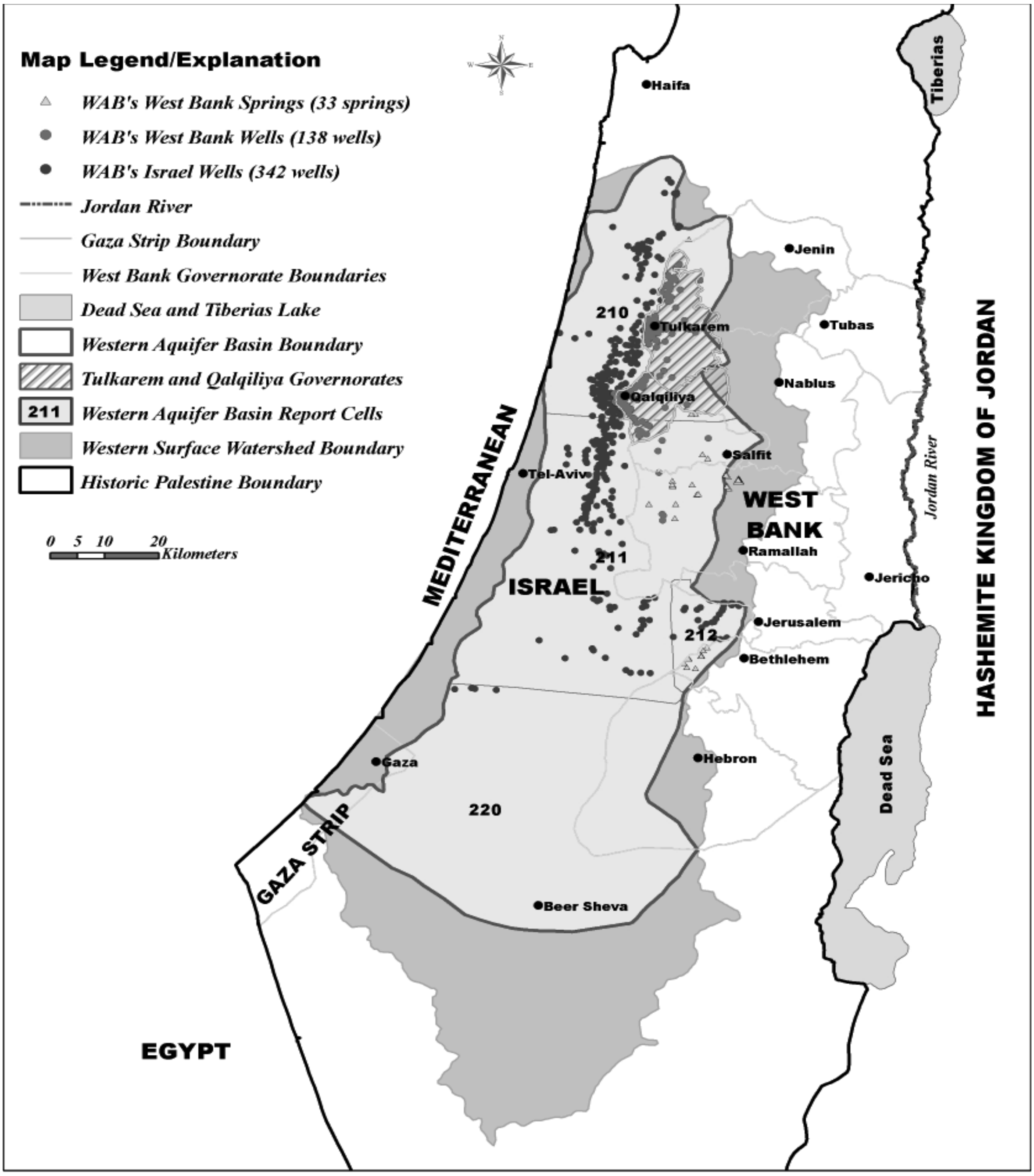
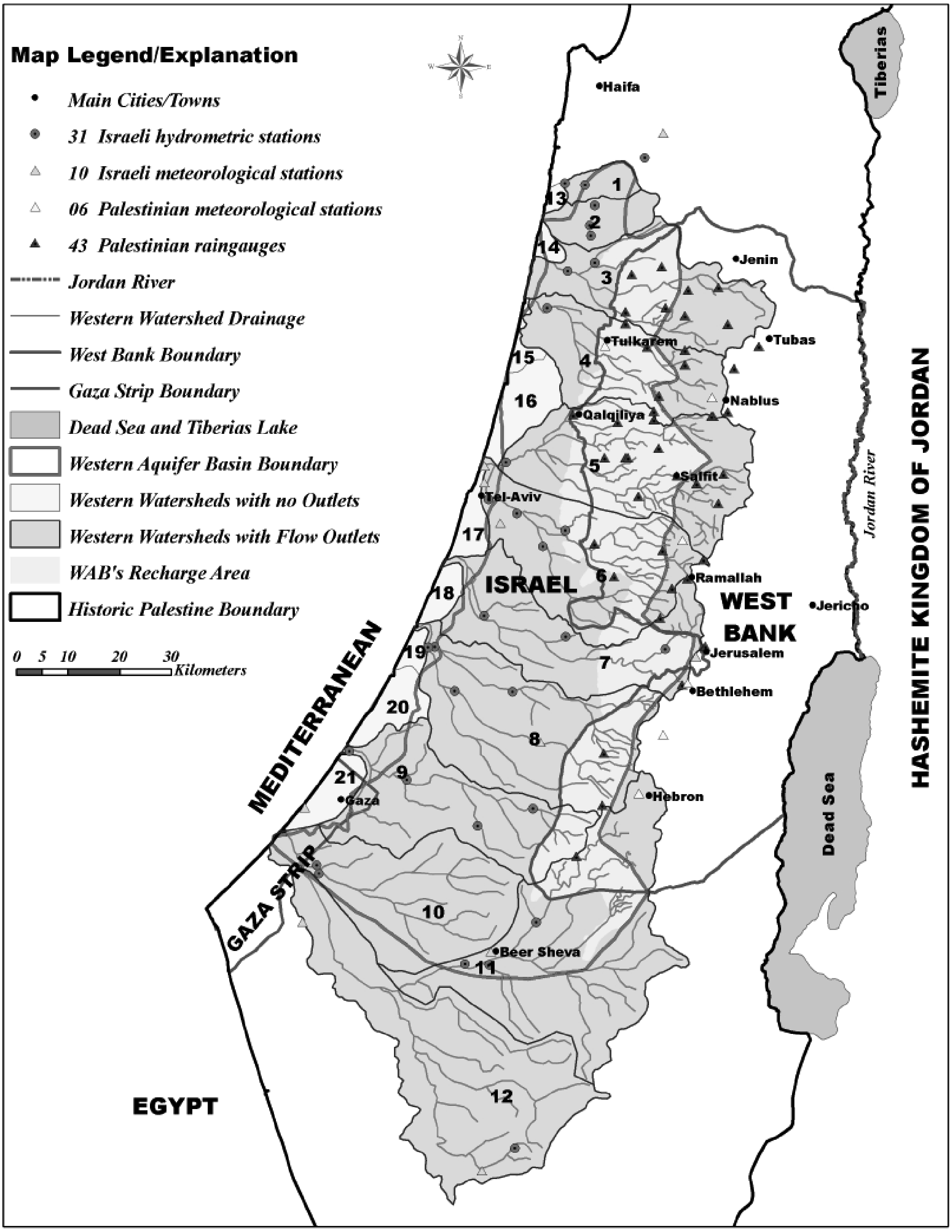


Sources: Basemaps from Palestinian Geographic Center. Surface watersheds, WAB's boundary, and hydrologic report cells were digitized from 1999 Hydrological Service of Israel state report (HSI, 1999). Wells and springs were integrated from Palestinian Water Authority (PWA, 2012) and Hydrological Service of Israel (HSI, 1999).

Figure 1. Location of wells and springs in the study area.



Sources: Surface watersheds, WAB's boundary, and drainage patterns were digitized from 1999 HSI report (HSI, 1999). Weather, hydrometric, meteorological, and raingage stations were integrated from the websites of Palestinian Meteorological Department (PMD), Palestinian Water Authority (PWA), Israeli Meteorological Service (IMS), and Hydrological Service of Israel (HSI).

Figure 2. Western watersheds, drainage pattern, and hydro-meteorological stations in the study area.

Table 1. Estimated water budget parameters for the WAB's geologic outcrops.

Geologic outcrops in the Israeli portion of the WAB	Rainfall	ETc	Runoff	Minor Losses	Total Recharge Volume	Aquifer/ Non-aquifer outcrop	Total Recharge Area	Adjusted Recharge Area	Adjusted Recharge Volume
	units in million cubic meters per year (MCM/yr)						km2	km2	MCM/yr
Quaternary	2.41	1.35	0.18	0.12	0.81	Non-aquifer	4.03	0.00	0.00
Eocene	0.00	0.00	0.00	0.00	0.00	Non-aquifer	0.00	0.00	0.00
Senonian	3.54	2.17	0.20	0.18	1.03	Non-aquifer	7.20	0.00	0.00
Turonian	107.15	62.99	6.49	5.36	34.19	UC-T Aquifer	207.90	338.87	62.78
Upper Cenomanian	75.98	40.25	3.89	3.80	28.59		130.96		
U. Lower Cenomanian	17.76	9.64	0.64	0.89	6.72	LC Aquifer	31.40	115.14	24.59
L. Lower Cenomanian	47.57	25.63	1.71	2.38	17.87		83.74		
Lower Cretaceous	0.04	0.02	0.00	0.00	0.02	Non-aquifer	0.077	0.00	0.00
Sub-total	254.45	142.05	13.11	12.72	89.23		465.31	454.00	87.37
Geologic outcrops in the West Bank portion of the WAB	**Rainfall**	**ETc**	**Runoff**	**Minor Losses**	**Total Recharge Volume**	**Aquifer/ Non-aquifer outcrop**	**Total Recharge Area**	**Adjusted Recharge Area**	**Adjusted Recharge Volume**
	units in million cubic meters per year (MCM/yr)						km2	km2	MCM/yr
Quaternary	37.59	31.65	3.86	1.88	12.71	Non-aquifer	73.34	0.00	0.00
Eocene	34.42	31.08	1.63	1.72	11.02	Non-aquifer	72.20	0.00	0.00
Senonian	104.30	92.87	6.22	5.21	40.18	Non-aquifer	180.59	0.00	0.00
Turonian	235.50	135.97	0.24	11.78	87.51	UC-T Aquifer	428.62	975.21	208.07
Upper Cenomanian	320.52	181.60	1.98	16.03	120.56		546.60		
U. Lower Cenomanian	69.73	27.44	14.56	3.49	24.79	LC Aquifer	126.76	273.79	54.93
L. Lower Cenomanian	82.13	43.74	4.14	4.11	30.14		147.03		
Lower Cretaceous	4.82	3.20	1.38	0.24	1.75	Non-aquifer	7.75	0.00	0.00
Sub-total	889.00	547.54	34.00	44.45	328.65		1582.88	1249.00	263.00
Geologic outcrops in the WAB's recharge areas	**Rainfall**	**ETc**	**Runoff**	**Minor Losses**	**Total Recharge Volume**	**Aquifer/ Non-aquifer outcrop**	**Total Recharge Area**	**Adjusted Recharge Area**	**Adjusted Recharge Volume**
	units in million cubic meters per year (MCM/yr)						km2	km2	MCM/yr
Quaternary	40.00	33.00	4.04	2.00	13.52	Non-aquifer	77.37	0.00	0.00
Eocene	34.42	31.08	1.63	1.72	11.02	Non-aquifer	72.20	0.00	0.00
Senonian	107.83	95.03	6.42	5.39	41.22	Non-aquifer	187.79	0.00	0.00
Turonian	342.65	198.95	6.73	17.13	121.70	UC-T Aquifer	636.52	1314.08	270.85
Upper Cenomanian	396.50	221.86	5.87	19.82	149.14		677.56		
U. Lower Cenomanian	87.49	37.08	15.20	4.37	31.51	LC Aquifer	158.16	388.92	79.52
L. Lower Cenomanian	129.69	69.36	5.85	6.48	48.01		230.76		
Lower Cretaceous	4.86	3.22	1.38	0.24	1.76	Non-aquifer	7.83	0.00	0.00
Grand total	1502.59	893.26	66.53	75.13	540.48		2048.18	1703.00	350.37

U.= Upper; L.= Lower; UC-T Aquifer= Upper Cenomanian-Turonial Aquifer; LC Aquifer= Lower Cenomanian Aquifer.

Table 2. Estimated water budget parameters for the WAB's recharge area, subdivided by the West Bank governorates tapping it.

Region	WAB recharge area	Rainfall Volume	ETC Volume	Runoff Volume	Minor Losses Volume	Adjusted WAB Recharge Volume
	km2	Volume units are in million cubic meters per year (MCM/yr)				
Israel	454.00	254.45	153.00	13.11	12.72	87.37
Jenin	78.46	66.45	36.87	3.24	3.32	19.42
Tulkarem	164.2	151.7	84.1	6.4	7.58	46.1
Qalqiliya	141.1	95.4	53.3	4.3	4.77	35.3
Salfit	189.29	119.15	66.29	5.31	5.96	46.41
Nablus	18.47	13.45	7.22	0.58	0.67	4.72
Ramallah	286.46	216.26	138.69	8.31	10.81	61.75
Jerusalem	14.29	8.53	5.17	0.25	0.43	3.14
Bethlehem	39.40	21.50	12.78	0.46	1.08	8.01
Hebron	317.28	196.60	143.13	5.15	9.83	38.22
WB Governorates	1249.00	889.00	547.54	34.00	44.45	263.00
Overall Total	1703.00	1143.44	700.54	47.11	57.18	350.37

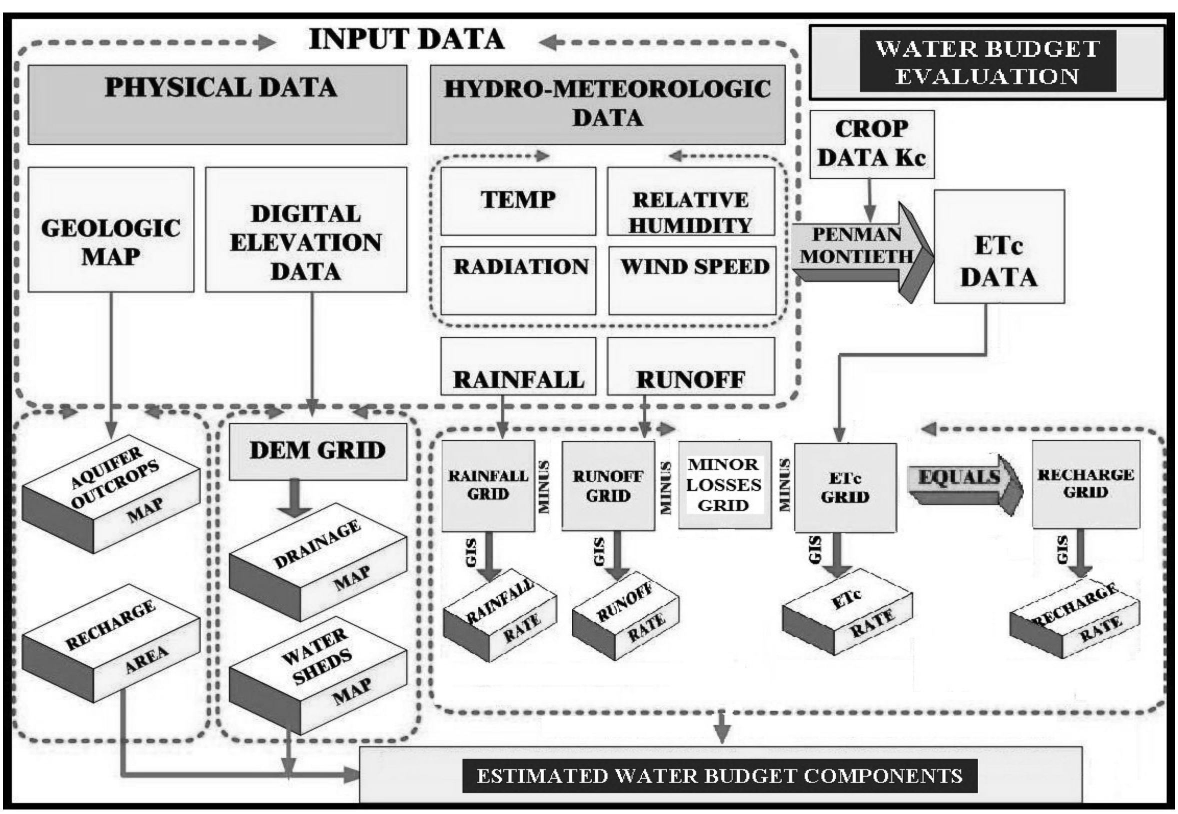


Figure 3. Flowchart for Water Budget estimation.

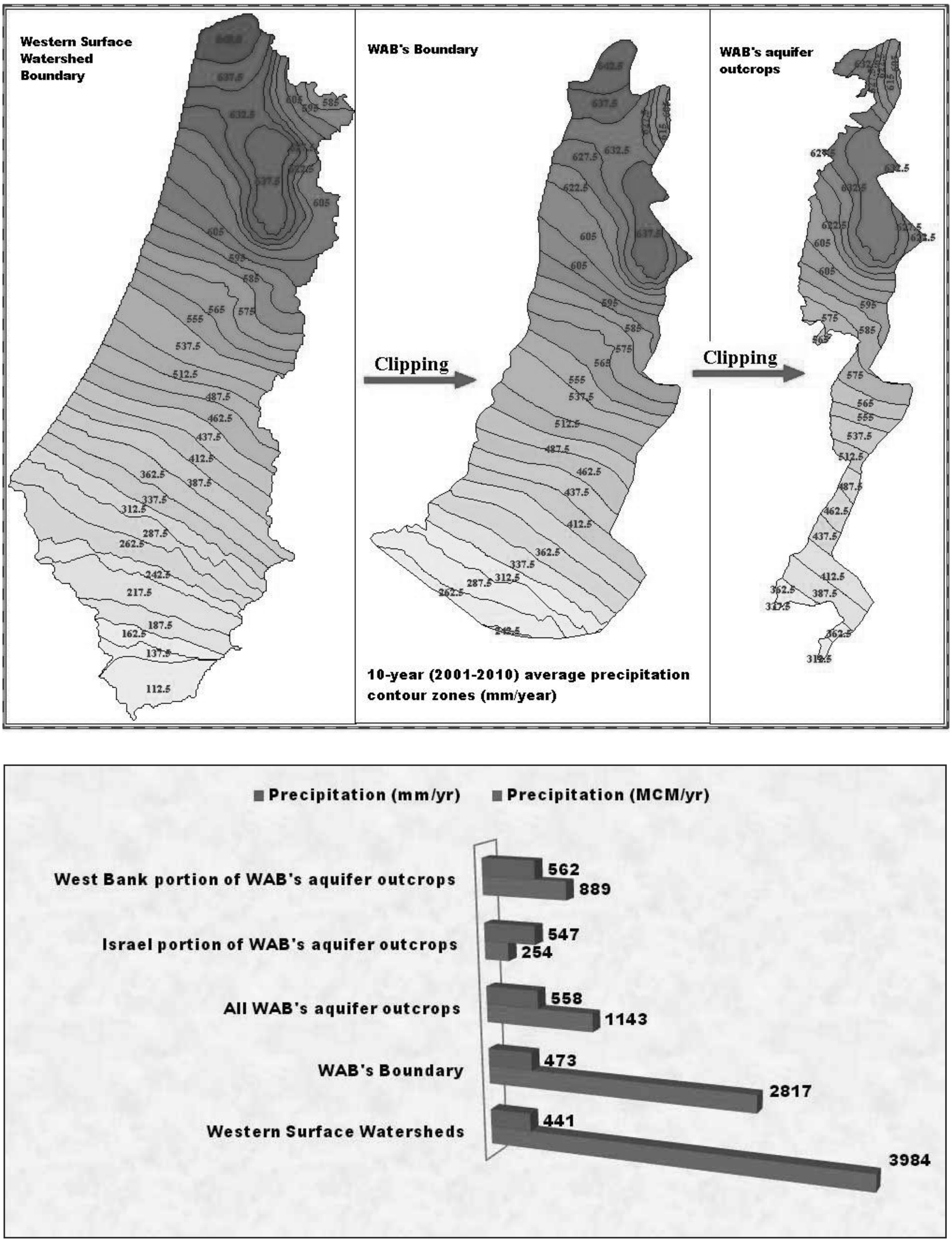


Figure 4. Ten-year (2001-2010) average precipitation contours and estimated rates and volumes for the Western Aquifer Basin.

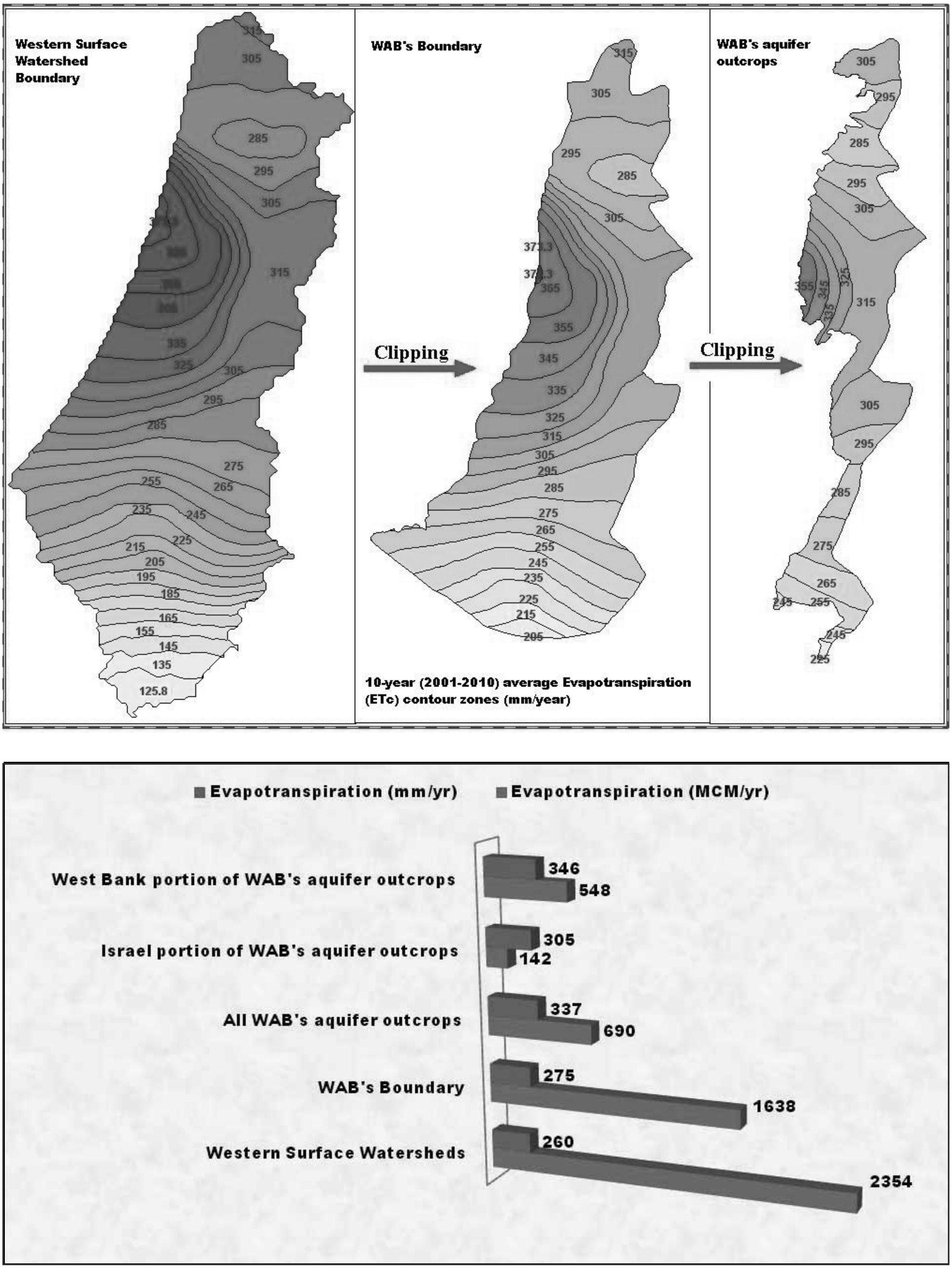
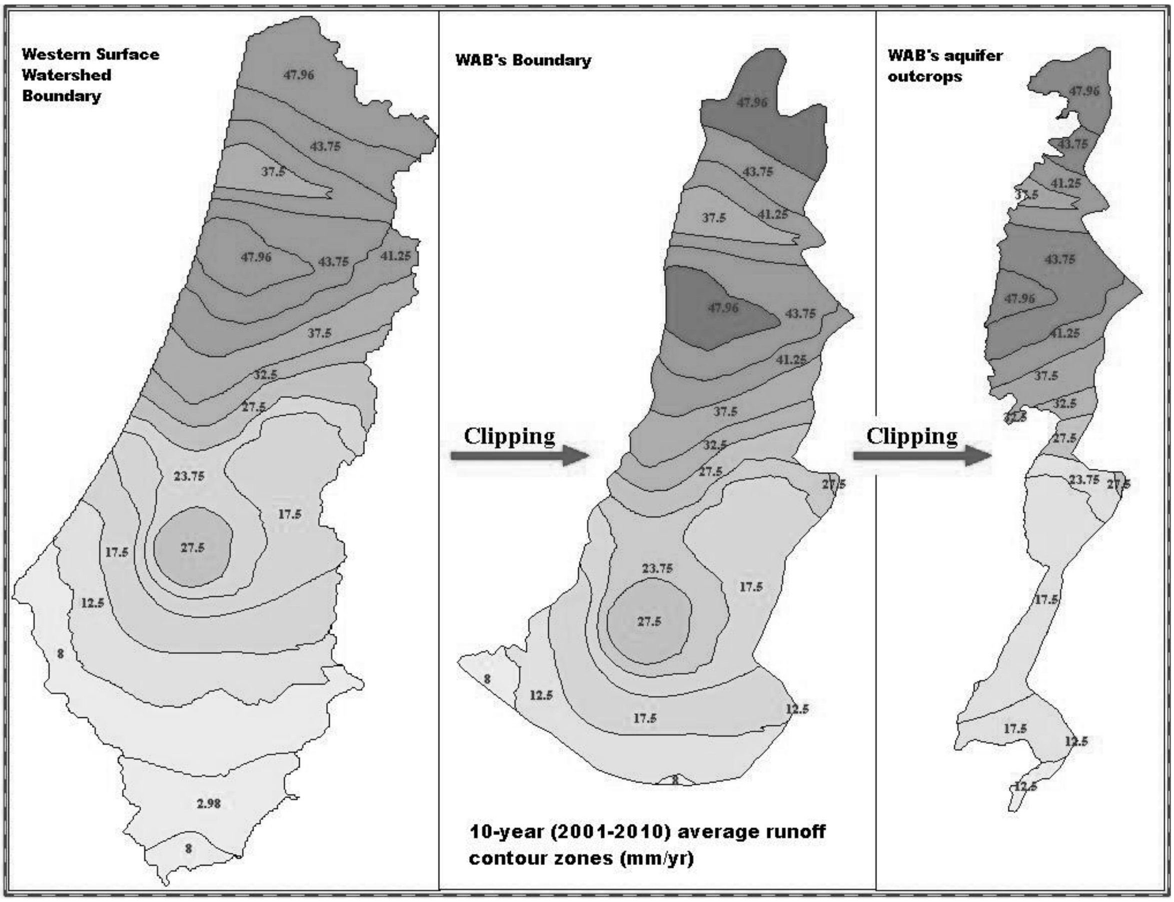


Figure 5. Ten-year (2001-2010) average evapotranspiration contours and estimated rates for the Western Aquifer Basin.



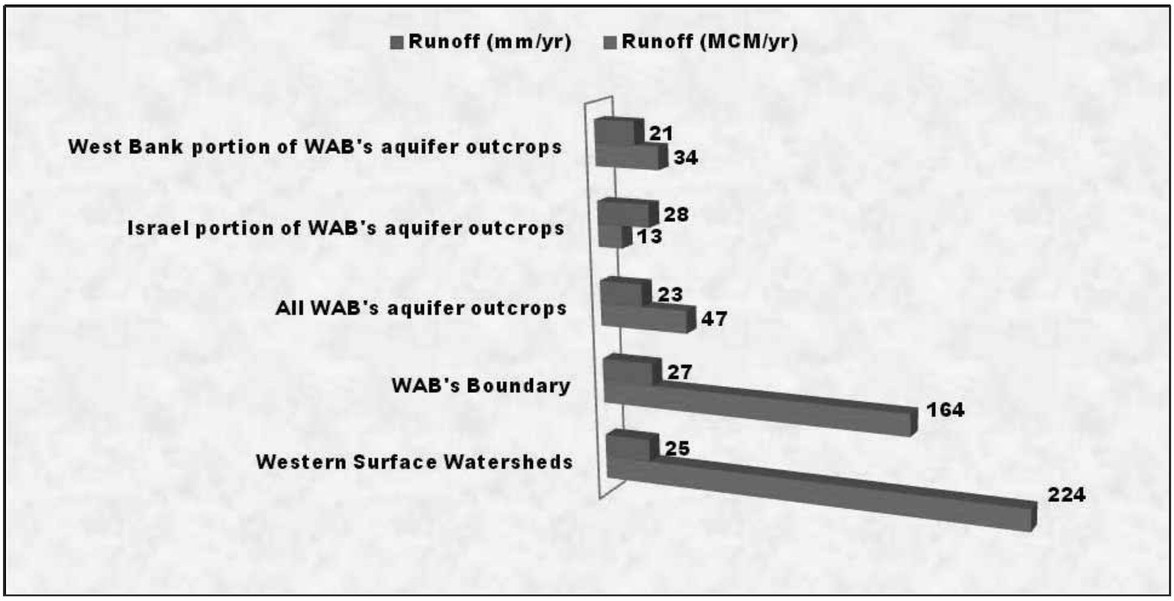
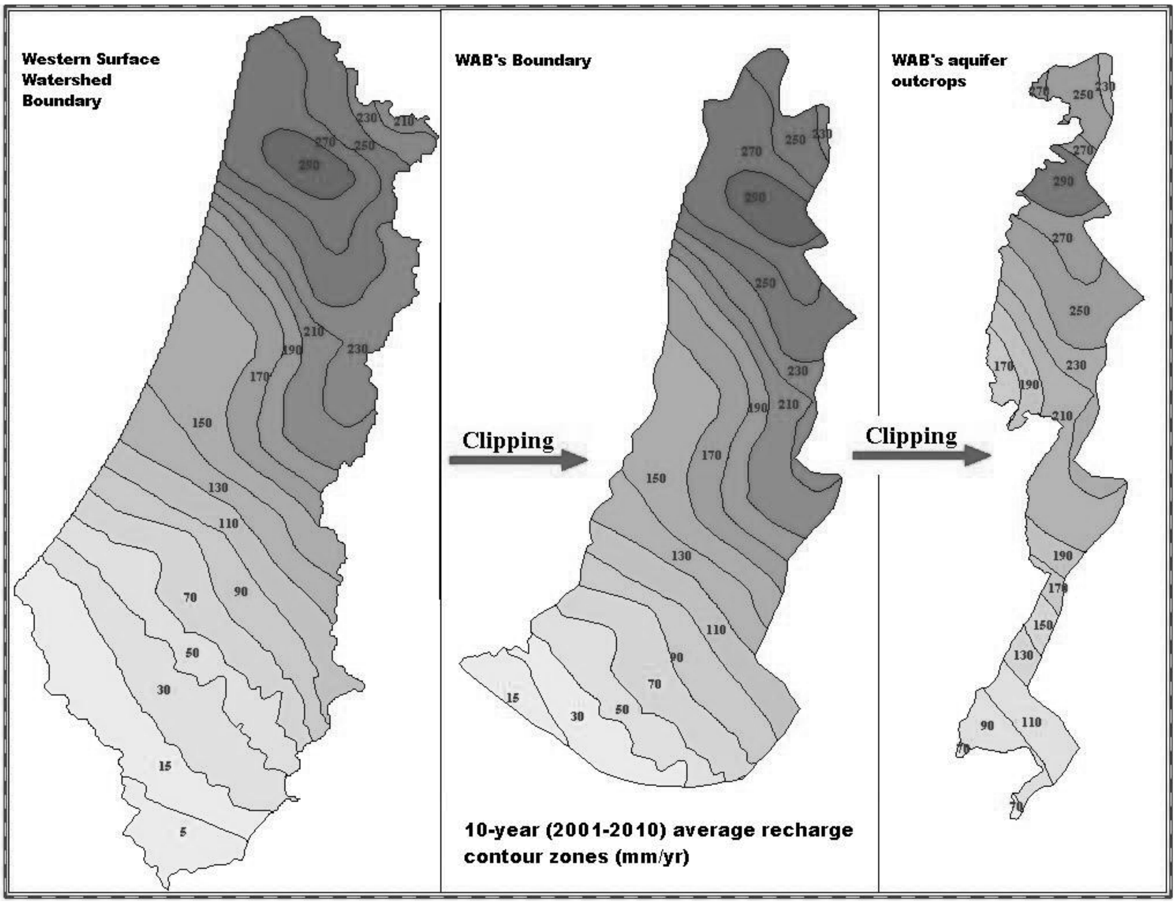


Figure 6. Ten-year (2001-2010) average runoff contours and estimated runoff rates and volumes for the Western Aquifer Basin.



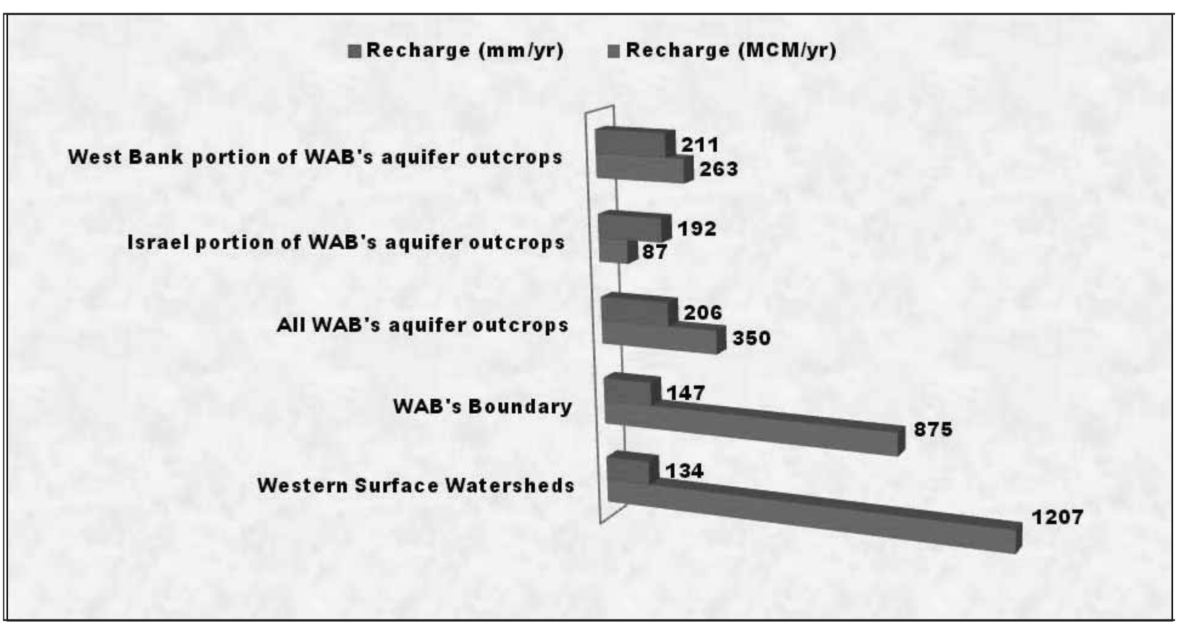


Figure 7. Ten-year (2001-2010) average recharge contours and estimated recharge and volumes for the Western Aquifer Basin.

Agriculture and the Need for A Water Strategy in Palestine

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Abstract

Palestinians face a water crisis that has been severe for decades and that, without serious action toward a strategic vision, will become much worse. Demand for municipal and domestic supplies continues to grow, yet hundreds of villages in the West Bank are without piped water. The Coastal Aquifer in the Gaza Strip has been devastatingly polluted for many years, and now some West Bank aquifers are beginning to show alarming signs of contamination. There has been only limited success at implementing technologies that would allow for significant reuse of treated wastewater, even for agricultural purposes. The future effects of climate change are very uncertain, yet they could be serious for Palestinian agriculture and other uses. There are many reasons for these problems. Water demand is high relative to accessible supplies, but there are few effective market-based tools to balance demand and supply. Importantly, a struggling Palestinian economy dependent on agriculture creates a high demand for fresh water, so water management policies that affect Palestinian agriculture must address economic impacts. The most serious reason for these difficulties is that Palestinians control little water, and so are limited in the types of water management mechanisms they can implement. It is therefore critical that Palestine develop a strategic policy for water use. Such a policy must address the realities of the economic importance of water in Palestine, unsatisfied water demand across all water sectors, future uncertainties in climate and water supply, and the lack of control that Palestinians have over their own water. These problems must be addressed strategically across all water sectors, especially agriculture, in light of where Palestinians want their future economic development to lead. This paper presents ideas with regard to developing a strategic vision for dealing with these factors and speculates on the likely constraints that will be encountered in implementing such a vision.

1. Introduction

Agriculture has long been an important part of the Palestinian economy, both in the West Bank and the Gaza Strip, in terms of the number of people it employs and, to a lesser extent, its contribution to the gross domestic product (GDP) of Palestine. Agriculture in Palestine uses a great deal of fresh water relative to the total available supply. In light of growing demand for water across all sectors, the limited availability of water in Palestine, the future uncertainty in supply quantities that is implied by the possibility of climate change, it is important that the future allocation of limited water supplies be made in a way that will best support the economic and social aspirations of the Palestinian people. This allocation of water in the future can be informed through the development of a Palestinian national water policy that carefully examines the range of possible future supply conditions and the economic and social desires of Palestinians and the resulting water demands that might be expected, and then postulates a series of options for achieving a desired economic future that best fits within the very real constraints on water resources, land, access to markets, etc., that Palestine will always face.

Much has already been written about the conditions under which Palestinian access to water resources can be improved. Much of this literature in the past two decades has focused on how co-operation between Palestinians and Israelis in the management of jointly claimed water resources could improve access to water for Palestinians and, at the same time, provide an example for the peace process of the benefits of how collaboration in the region could benefit everyone (for example, see Assaf et al., 1993; Elmusa, 1994; Shuval, 1992; Kally, 1990; and many of the papers in the volume edited by Issac and Shuval, 1994). In fact, the failure of Oslo II to significantly alleviate Palestinian water problems shows that the early optimism about the potential benefits of equitable and shared management of the water resources jointly claimed by Palestinians and Israelis was unjustified.

Many others have also written about the need for strategic planning in relation to Palestinian and the jointly held water resources (see Layonnaise Des Eaux, Khateeb and Alami, 1998; McKee, 2005;), and much real work has been done with respect to strategic water sector planning for Palestine (see CDM/Morganti, 1997a and 1997b; PECDAR, 2002). However, these efforts have been largely confined to a limited set of assumptions about future water demands that have not been well informed by any knowledge of future Palestinian economic conditions or development policies that Palestine will adopt. This is a potentially serious shortcoming of these earlier studies and will translate into greater uncertainties about Palestinian agriculture and its future demand for water.

This paper will summarize a few of the most critical facts that will constrain the development of a Palestinian water policy and the position within it that agriculture will have to take.

2. Palestinian Agriculture: Economics and Water

2.1 The Reality of Palestinian Water Resources

Planning studies done by CDM/Morganti (1997a and 1997b) and subsequently refined by others indicate that by the middle of the century Palestine will need nearly one cubic kilometer of water per year above what is currently available. The precise quantity of water that will be needed can be debated, but the fact will remain that Palestine will require much more water than the quantities presently available or even that would have been available if Oslo II had been fully implemented if economic development and population growth are to be accommodated.

Added to the future need for significant amounts of new water, the political climate shows little likelihood that Palestinians and Israelis will be able to resolve the many issues that separate them and that resolution of Palestinian claims for water will continue to go unaddressed. However, resolution of water claims might be possible if it could be separated from the many others that keep the two sides apart in a final status solution.

A major source of uncertainty about future water supply quantities is the issue of climate change. Palestine lies at a latitude wherein most global climate circulation models predict significant changes in future temperature and precipitation patterns. Many researchers are studying the implications of this now, but the state of the art of these predictive models is still primitive, especially for relatively small areas such as the West Bank and Gaza Strip. This condition leaves much uncertainty in any forecasts of future water availability.

Pollution of Palestine’s water sources has become a growing concern. The Gaza Coastal Aquifer has been contaminated for many years by a variety of pollutants, but historically the West Bank aquifers have been largely considered of good quality. However, studies are showing nitrate levels in many locations that should give alarm. For example, see Ammar et al. (2008). Increased pollution levels will threaten water availability for at least some types of uses. This is a trend that should not be allowed to continue.

2.2 Realities of Agriculture in the Palestinian Economy

In terms of employment, agriculture is an important component of the Palestinian economy. Recent statistics show that at one time or another during the year, between 10 and 40 percent of Palestinian workers are employed in the agricultural sector, depending on the season and location (West Bank or Gaza) (see Table 14, Palestinian Central Bureau of Statistics, 2009). However, the full-time equivalent number of jobs in the agricultural sector is not large. Further, daily wages are low, averaging approximately between US$10 and US$30 per day in 2008 (table 13, Palestinian Central Bureau of Statistics, 2009).

The CIA Factbook (2012) provides a few telling statistics about the Palestinian economy and the economic role played by agriculture. For example, per capita GDP in 2008 was estimated to be US$2,900, which placed Palestine at number 169 in the world. Clearly, Palestinian education levels and aspirations are higher than this. By sector, agriculture provides only 3.7 percent of the Palestinian GDP (as estimated for 2010 by the CIA Factbook, 2012), as opposed to 13.6 percent from industrial activity and 82.6 percent from services. The CIA Factbook (2012) estimates that the 2008 Palestinian labor force was distributed among these sectors at 12, 23, and 65 percent, respectively, in agriculture, industry, and services. One must conclude that, while agriculture provides jobs, it does not provide much income, nor does it represent a high fraction of the Palestinian economy.

Water use in agriculture is significant. The Palestinian Central Bureau of Statistics (2009) estimates in 2008, agriculture in the West Bank and Gaza strip, respectively, used 105 and 75 million cubic meters (mcm) of water. By comparison, Jayyousi and Srouji (2009) report total estimated water use in 2006 in the domestic and municipal sectors in the West Bank and Gaza Strip was, respectively, approximately 75 and 55 mcm.

The present reality of water is that Palestinian agriculture uses very large quantities of high quality fresh water, yet contributes little to the economy. This begs the question of whether it makes economic sense to continue to allocate fresh water to low-valued uses in agriculture when high-values uses, such as domestic supply, are seriously rationed. In the future, the Palestinian economy must be made to grow in order to support the economic aspirations of Palestinians. This growth will not be possible if the economy is based largely on irrigated agriculture. As and if future economic growth happens, agriculture must become a relatively smaller fraction of the national economy. Economic growth in other sectors will have to be accompanied by increased water allocation of fresh water to those sectors.

The agricultural and economic facts are these: water is scarce in Palestine, especially water controlled by Palestinians, and future water availability is uncertain; Palestinian agriculture uses a great deal of fresh water yet contributes in only limited ways to the Palestinian economy; Article 40 in Oslo II has been only partially fulfilled, leaving severe water shortage conditions throughout the West Bank and Gaza Strip, especially for domestic and municipal users; groundwater quality conditions are deteriorating and, in the case of the Gaza Strip, groundwater resources are very seriously polluted; most administrative action in the water sector since Oslo II has, by necessity, gone into responding to crisis and not into identification and implementation of long-range plans for water development and management; in particular, no implementable water plans have been seriously coordinated with strategic economic development plans at the national level.

3. A Possible Future: Palestinian Water and Economics

To reach the approximately one additional cubic kilometer of new water per year that a viable Palestinian economy will require by the middle of the century (as estimated by CDM/Morganti, 1997a and 1997b), some combination of several things must happen. First, consumption of fresh water in agriculture must be gradually reduced; this reduction can be accomplished without diminished economic output from the agricultural sector by implementation of an aggressive policy of wastewater treatment and reuse and improvements in water use efficiency in agriculture. For a variety of reasons, reuse of treated wastewater is not widespread in Palestine, even though the technology available for this is well known. Lack of adoption of reuse options is largely due to political and not technical issues. Greater efficiencies in irrigated agriculture can be achieved through adoption of better on-farm technologies and management practices as well as better administrative and regulatory policies. All of these things are being done somewhere in the world, but only some are implemented in Palestine.

Next, even if very large quantities of treated wastewater are used to reduce future agricultural demand for fresh water, Palestine will still require access to additional water sources beyond those currently available. While the nearly unsolvable political problems of Palestinians and Israelis make acquisition of new water very difficult, it will be an easy thing to do from an economic and technical perspective. Regardless of the outcome of any final-status Palestinian-Israeli peace negotiations, the Palestinian water supply and wastewater situation can be resolved by the middle of this century for a total cost no more than approximately US$10 billion (CDM/Morganti, 1997a and 1997b). While this is a great deal of money, it is exceedingly small when compared to monthly expenditures the US has made in each of two Middle East wars over the past decade. Economically and technologically, the problem of greater Palestinian access to water can be solved.

In the future, the Palestinian economy will have to diversify and grow if the economic conditions for residents of the West Bank and Gaza Strip are to significantly improve. An end of the Occupation is probably a necessary precursor to improved economic conditions, but it will not be a sufficient condition. Ultimately, a viable Palestinian economy must be based on productive stocks of land, labor, capital, and other resources such as water. In the long run, say over the next 50 years, the limited irrigable area of the West Bank and Gaza Strip and the very limited quantities of available fresh water will constrain the role that agriculture can play in economic development. If it is to grow in significant ways, the future Palestinian economy must be based principally on other, non-agricultural industries and services. If this new economy is to materialize, its structure and its required production inputs must be consistent with the resource limitations especially water that will continue to exist, even if a favorable political resolution of the Palestinian-Israeli conflict is reached and even if advances in technology continue to reduce the cost of water supply.

4. Recommendations for a Strategic Vision

Creation of a strategic plan for water development is not easy because of the uncertainties in future water supply and demand; however, a framework for assembling such a plan exists (and is embodied in the stance that Palestine has taken in its water portfolio for final status negotiations). The heart of this framework was laid down in the CDM/Morganti planning documents (CDM/M 1997a and 1997b). The following list of recommendations for the formulation of a strategic vision of Palestinian water development is offered from the observations given in the foregoing discussions:

1. Begin to treat water as an economic good and not an entitlement or component of state security. Work with Israelis, and perhaps other Jordan River riparians, to allow water and money to pay for it to move between sectors and across borders. Fisher et al. (2002) have shown that all parties, Palestinians and Israelis alike, would benefit economically if water could be seen as an economic, rather than a political, good.

2. Conduct national discussions to identify the direction and means to move the Palestinian economy over time toward non-water intensive, minimally polluting industries for which access to markets can be obtained. Examples of the types of economic sectors that could be considered might be found in the economies of Singapore, Taiwan, or others.

3. Include in this discussion the role that education must play. Palestine is blessed with a high literacy rate and many well educated citizens. Unfortunately, the Palestinian economy will not currently support all of them, and many of the best and brightest have found employment in other countries. In the future, Palestine would do well to commit to more strategic directions with respect to economic development and then support this commitment with a strategic investment in the education of people who can enter a labor force in a growing economy.

4. Move as much fresh water out of agricultural use as possible, and substitute treated wastewater to replace it. This will require large investments in new infrastructure and training. It will also require very difficult solutions to the political road blocks that have prevented this from happening to date.

5. Begin to implement strategic institutional and management tools in the water sector in a serious way. This includes tariffs, revenue collection, monitoring, enforcement, and training activities, and it should encompass all water uses and users including agriculture. Tariffs and revenue collections should, at a minimum, initially cover the costs of operation and maintenance, and in the future should be increased to also cover capital costs of system upgrade and replacement.

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Future Trends in Agricultural Water Management and Institutional Innovations in Palestine

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Abstract

To meet the increasing present and future demand for food and water, alleviate poverty and hunger, and sustain the environment and its resources in Palestine under various political scenarios, there is a high need for improving and/or reforming agricultural water management and water institutions in Palestine. It was found that the Palestinian agricultural sector developmental challenges are becoming numerous and more complex. Accordingly special attention, more governmental involvement, and non-traditional dynamic policies and strategies approaches need to be adapted and implemented to ensure sector productivity increase and sustainability. A balanced interrelated tripod of resources, uses, and impacts management was proposed and detailed to achieve better, more equilibrated management of Palestinian agriculture.

1. Introduction

Agricultural sector plays a crucial role in the social well being of the Palestinian people. The agricultural sector, which utilizes anywhere between 50-80% of total water resources in each country, has a very low rate of efficiency. As a result, the agricultural sector consumes more than half of the water resources and contributes to a fraction of the total GDP outcome each year. Agriculture however, still provides sustenance and employment for a sizeable portion of the population in the Middle East. Therefore, it is important that (1) Palestinian agriculture need to be looked at from cultural heritage angle and point of view and (2) new irrigation methods like drip irrigation are installed in order to reduce wastage of water in the agricultural sector. Also instead of using freshwater for irrigation, infrastructure should be set in place that would utilize treated wastewater (Haddad 2010).

Although, the West Bank economy continued to grow in the first half of 2010 and the real growth rate, combined with Gaza, is likely to reach the projected 8 percent for the year, Sustainable economic growth in the West Bank and Gaza, however, remains absent. Some of the increase in economic activity can be attributed to improved investor confidence. The main driver of growth, however, remains external financial assistance (World Bank, 2010).

Total current water use in the West Bank and Gaza Strip (WBGS) is estimated to be about 331 million cubic meters (MCM) per year. Agriculture continues to be the largest consumer of water accounting for about 60 percent of total use (167 MCM, about half each in the West Bank and in the Gaza Strip (WASAMED, 2004; PWA, 2009; PWA 2011; and PWA, 2012).

FAO (2003) found that the OPT is not self sufficient in food and relies upon commercial imports to supply domestic demand. It was also found that with rising poverty and unemployment, the food security situation has considerably deteriorated over the past three years, with four out of ten Palestinians food insecure. Food insecurity is a reality for 1.4 million people (40 percent of the population) and a near constant worry for an additional 1.1 million people (30 percent) who are under threat of becoming food insecure should current conditions persist. People's physical access to food and farmers physical access to the inputs and assets to produce food have been severely affected by restrictions on the movement of people and goods and the damages to personal property.

Economic access to food in terms of the ability to purchase food rather than lack of food is the main constraint to securing a healthy nutritious diet. The numbers of meals, the portion size and the frequency by which certain foods are consumed have all been reduced. Many meals consist solely of bread and tea. Cereals and increasingly potatoes, pulses, the cheaper vegetables and fruits form the core of their diet. Though nutrition surveys are not conclusive, they do indicate that childhood malnutrition is a major concern for some groups and that some more widespread nutritional problems are emerging. Micronutrient deficiencies are also a concern, especially in iron, foliate, vitamin A, zinc and iodine (FAO, 2003).

The scarcity of conventional renewable fresh water sources in arid and semi-arid regions in many parts of the world like South Africa, the Middle East including Palestine, Southern Europe and South America has prompted the search for additional supplementary conventional and non-conventional water sources (Haddad and Mizyed, 2011).

This paper will evaluate and discuss the main issues related to agricultural water management and institutional innovation in Palestine and consequently suggest future improvements and reforms needed in both agricultural water management and water institutions in Palestine and define the drivers responsible for or needed to achieve such improvements and reforms.

2. The Study Area

2.1. Location

Palestine, Palestinian Territory, or the Occupied Palestinian Territory (OPT) as presented in this paper consists of the West Bank including East Jerusalem and the Gaza Strip. The West Bank and the Gaza Strip are those parts of Historic Palestine which were occupied by the Israeli army during the 1967 war between Israel and Egypt, Syria, and Jordan. The land area of the West Bank is estimated at 5572 km^2 extending for about 155 km in length and about 60 km in width. The Gaza Strip, with an area of 367 km^2 extending for approximately 41 kilometers in length and approximately 7 to 9 kilometers in width (see Figure 1, Abdel Salam 1990, and Haddad 1998).

Figure 1. General location Map

Source: UNEP 2003.

2.2. Population

Palestinian population projections reveal that mid year population in 2008 totaled 4.048 millions, of whom 2.513 in the West Bank and 1.535 in Gaza Strip (PCBS, 2010, see Figure 2). According to the official list of local authorities added by the Palestinian Central Bureau of Statistics (PCBS, 2003) and the ministry of local governments, there are 686 localities in Palestine. The localities are distributed by type as 54 urban, 603 rural, and 29 refugee camps. These localities distributed by type of authority as 107 municipalities, 11 local councils, 374 village council or project committee, and 29 director of refugee camp (additional 76 rural localities are either not inhibited or joined to larger locality).

2.3. Available Water Resources

The estimated average annual ground water recharge in Palestine is 698 to 708 mcm/yr (648 mcm/yr in the West Bank and 50 to 60 mcm/yr in the Gaza Strip). As listed in Table 1, the estimated average annual ground water recharge in Palestine is 703 mcm/yr (648 mcm/yr in the West Bank and 55 mcm/yr in the Gaza Strip). This groundwater is laying in four major aquifers: The western, northern, north-eastern, and the coastal aquifer basin (SFG 2010, Haddad 1993, see Figure 3).

Table 1. Groundwater Balance in Palestine

Hydrologic	Contribution to Water Balance				
Parameter	**West Bank**		**Gaza Strip**		**Palestine**
	Percentage	mcm/yr	Percentage	mcm/yr	mcm/yr
Annual Rainfall	100	2248	100	101	2349
Evapotranspiration	-68	-1529	-52.5	-53	-1582
Surface Runoff	- 3.2	-71	-1.98	-2	-72
Groundwater Recharge	28.8	648	45.5	46	694
Return Flow (RF)	-----	RF	8.9	9	9 + RF
Overall Balance		648 + RF		55	703 + RF

RF = Return Flow
Source: Haddad 1993

The only surface water source in the West Bank is the Jordan River and its tributaries. In the Johnston plan, the Palestinian share in the Jordan River of 257 mcm/yr was considered as part of the Jordanian share of 774 mcm/yr as the West Bank was under the Jordanian rule. Since 1967 war and until present, Palestinians were prohibited by the Israeli army from using the Jordan River water and their lands and farms located along the western side of the river were confiscated and the area was declared as a restricted military security zone (Haddad, 1993).

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2.4. Land Use

In 2005, the distribution of land use in the occupied Palestinian territory was 25.5% agricultural land, 1.6% forests and wooded land, 10.0% build-up areas, 3.2% Jewish colonies, and 62.9% bare land and other uses (PCBS, 2008). The build-up area was distributed by urban, rural and camps were 63.7%, 5.1% and 31.2% respectively. The trend 2000-2005 shows that the annual increase in the built-up area in the Gaza Strip was 19.1% (ARIJ, 2006).

2.5. Agriculture

Agricultural land was estimated at 1.854 million dunums or about 31% of the total area of west bank (91%) and Gaza Strip (9%). of which 86% are rain fed and 14%is irrigated (WASAMED, 2004). A listing of irrigable land distribution among land systems in the West Bank is given in Table 2 below.

2.6. Water and Food Supply and Demand

According to PWA (2012), the total Palestinian water supply was 331.1 mcm/yr of which 73.7% pumped from wells, 8.1% from springs and 16.9% through the Israeli company commissioned by the Israeli occupational authorities (Table 3). The total water supply for domestic purposes was 185.5 mcm/yr distributed by mean of supply as follows: 86.7% piped networks, 3.4% tankers, 6.7% rain water harvesting, and 3.2 % by other means (PCBS 2008). The variation in total water supply available for Palestinians (Table 2) is due to the variability in spring discharge and not in water pumped from wells or that obtained through the Israeli company. For example, the spring discharge in the year 2007 was 44.8 mcm/yr while it is 25.2 mcm/yr in 2008.

As shown in Table 3, there is an annual decrease trend 2002-2008 in agricultural water use from 55.3% of total water supplied in 2002 to 40 % in 2008. If this trend continues agriculture in Palestine will diminish drastically in the next 20-40 years. Accordingly, water availability for agriculture is and will be one of the most critical issue for Palestine.

The low income and the limited and restricted economic growth of Palestine restrict people from buying more and better quality food. For example at present and because of very high fresh meat prices, more people buy frozen meat and fish with low and/or questionable quality for protein.

Table 2. Irrigable land distribution among Land Systems in the West Bank

System's Name	Average Rainfall (mm)	Agricul. Well Extract. (M^3/Year)	System Area (km^2)	Irrigable Area (km^2)	Irrigable Area (%)
Plain of Jenin	300-500	1,877,257	71	51.5	72.5
Qalqilya Hills	500-650	6,350,547	544	102.5	18.8
Tulkarm Hills	500-600	9,953,466	484	89.5	18.5
Nablus Heights	350-600	1,974,280	385	69.8	18.1
Jerusalem – Hebron Foothills	300-600	-	195	16.3	8.0
Hebron Heights	350-700	-	601	19.3	3.2
Jerusalem-Ramallah Heights	100-500	-	623	32.1	5.2
Aldahiriya Hills	100-500	-	277	30.0	10.8
Jerusalem Desert	<100-400	-	910	101.7	11.2
Jordan Valley	<100-300	11,101,566	434	87.9	20.2
Far Norheastern Heights	150-250	-	295	7.3	2.0
Mid Northeastern Heights	100-400	3,026,589	855	188.6	22.0
Total		**34,283,705**	**5498**	**756.5**	**14.5**

Source: WASAMED 2004

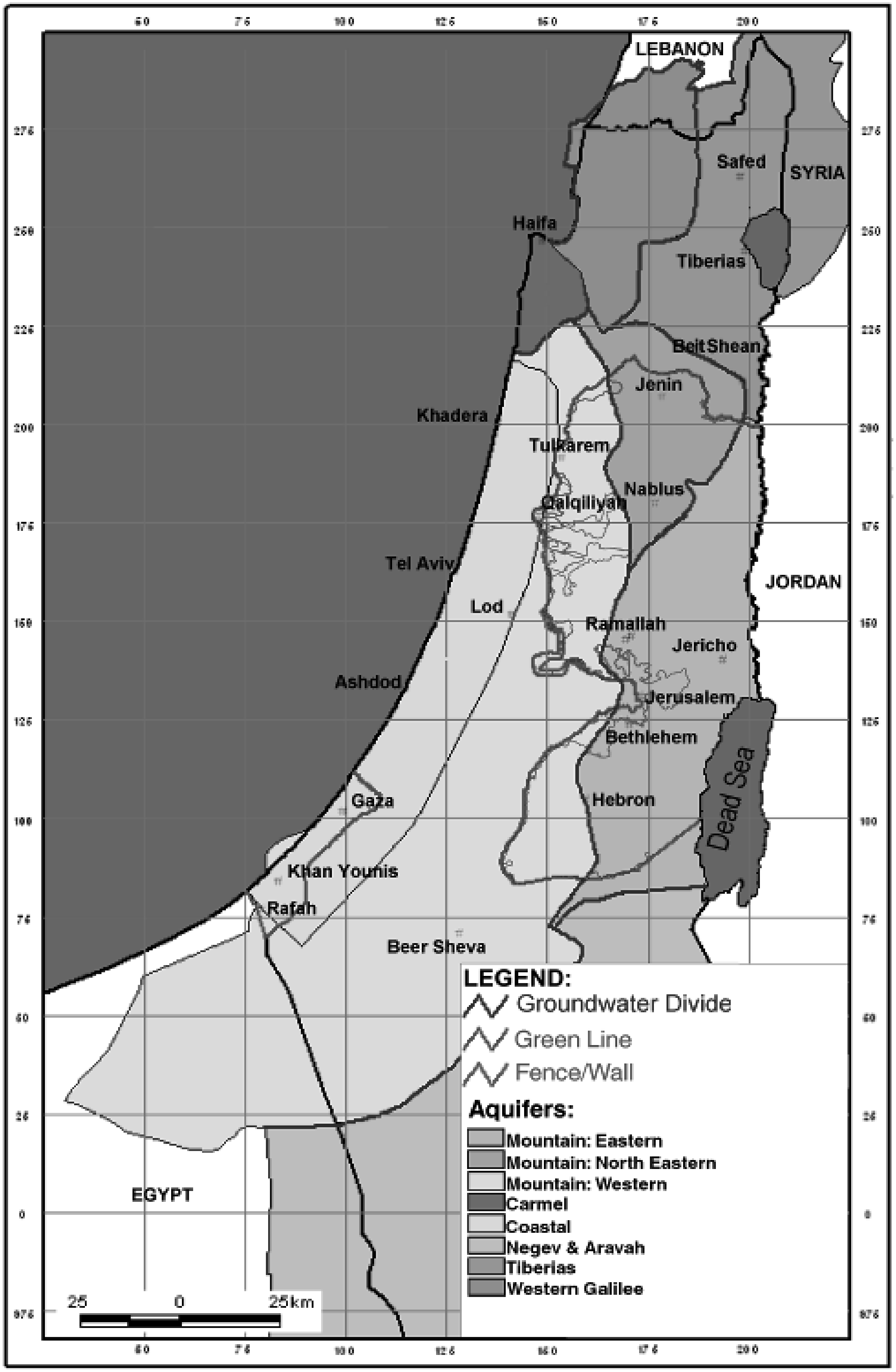

Figure 3. Palestinian Ground Water Resources

Source: Amnesty International 2009

Table 3. Available Water Supply in Palestine by Year and Source

Indicator	Year								
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Annual Available Water Quantity (million m3/year)	279.9	..	295.8	315.2	319.1	335.4	308.7	316	331.1
Annual Pumped Quantity from Groundwater Wells (million m3/year)	203.4	..	196.1	214.7	223.5	241.2	225.7	227.2	244
Annual Discharge of Springs Water (million m3/ year)	38.1	60.5	52.7	53.6	51.7	44.8	25.2	30.6	26.8
Annual Quantity of Water Purchased from Israeli Water Company (Mekorot) for Domestic Use (million m3/year)	38.4	43.1	42.6	42.2	43.9	49.4	52.8	53.5	56
Annual Quantity of Water Supply for Domestic Sector (million m3/year)	125.2	..	142.9	153.2	160.2	175.6	185.5	185.2	185.2
Annual Quantity of Water Supply for Agricultural Sector (million m3/year)	154.7	--	152.9	162	158.9	159.8	123.2	130.8	145.9
Percent of Agricultural water to Total Water Used (million m3/year)	55.3	--	51.7	51.4	49.8	47.6	40	41.4	44.1

Source: PWA (2009); PWA (2011); and PWA (2012).

3. Agricultural and Water Management Problems and Prospects

In reviewing the current status of Palestinian agricultural and water management as well as institutional performance of the sector, the following problems were observed:

Agricultural Management

- The declining quality and efficiency of agricultural resources use.
- The attacks on agricultural land and its conversion to non-agricultural purposes.
- Reliance on import through Israel and Israeli agents for fulfilling agricultural production needs (seeds, fertilizers, pesticides, herbicides, insecticides, irrigation equipment, and other).
- Ineffective marketing services for farmers.
- Lack of insurance policy for disaster and natural risks.
- Weak agricultural infrastructure.
- Helpless or inexistence of incentives.
- Weak extension and training services.
- Unsuccessful financial support to farmers.
- Inadequate agricultural capacities and education system.
- Low agricultural production and consequently low agricultural profit or economic feasibility.
- Absence of a national umbrella for planning and overall supervision on the agricultural sector.
- Insubstantial agricultural research, knowledge generation and dissemination,
- Fragile rain fed agriculture.
- Weak Palestinian public and private investment in the sector.

Water Management

- The over-pumping of groundwater.
- The increase in un- licensed wells and reliance on rain variability and the impacts of climate change.
- Lack of water storage of surface runoff and storage related to various levels and types of water harvesting.
- Lack of wastewater treatment and reuse in agriculture.
- Lack of master-strategic water network and infrastructures.

Institutional Performance

- Overlapping and conflicting authority and responsibilities.
- Weak institutional framework.
- Incomplete legal framework.
- Weak enforcement of laws and legislation.
- Weak capacities for agricultural planning including policy setting, monitoring, and implementation.

The above listed problems facing the sector of agricultural water management clearly indicate that the Palestinian agricultural sector developmental challenges are becoming numerous and more complex. Accordingly special attention, more governmental involvement, and non-traditional dynamic policies and strategies approaches need to be adapted and implemented to ensure sector productivity increase and sustainability.

The available and potential prospects related to agricultural water management including institutional framework can be summarized as follows:

Human Capacities: there are sufficient and capable human capacities available, however, the right person is not in the right place and/or have no power and authority to develop neither agricultural resources or production and uses.

Private Sector Involvement: The private sector is eager to support and invest in the sector, however, this needs assurances by the legal system which does not exist yet.

International Community Investment and Support: The international community is willing to support the water and agricultural sector development, but within the Israeli limits which make the long-term efficiency of such support is limited.

Political Situation: the prospects of peace would encourage and support the development of reform and upgrade of the water and agricultural sector and vice versa.

Institutional Capacities: There are much of the institutional setup and arrangement of the agricultural and water management sector, but these still in the establishment phase and need much support to really fully be able to serve the sector.

Awareness and Education: there is acceptable level of public awareness of the problems faced by the secto0r. This level needs to be continuously upgraded and supported with new detailed data and information with friendly access.

Regional and International Trade: the recent trade agreements allow the Palestinian authority to be open in trade with regional and neighboring international countries. In this regard the institutional setup to arrange and follow-up on such trading process is lacking.

4. Proposed Future Improvements and Reforms

For the future of the agricultural water management and institutional innovation in Palestine, equilibrium between natural resources development, its uses, and the resulting impacts of the uses is maintained. Accordingly, it is proposed that a balanced interrelated tripod of resources, uses, and impacts management be placed in effect and in practice as follows (Figure 4):

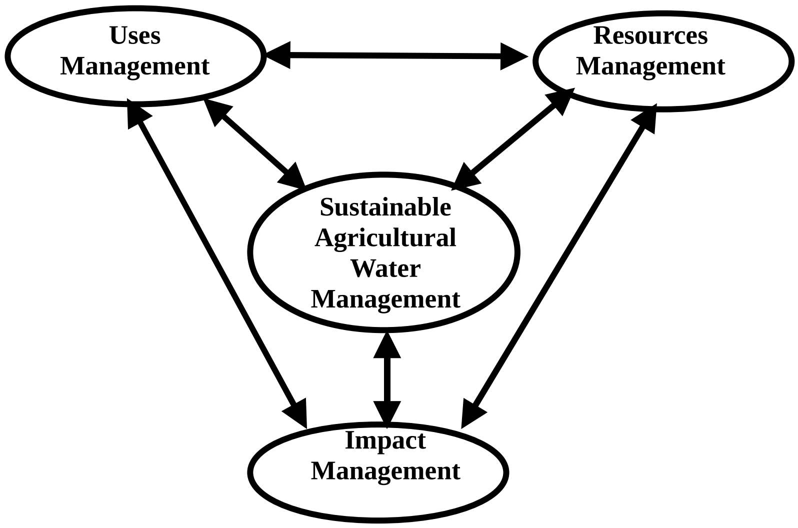

Figure 3. Schematic of Sustainable Agricultural Water Management Tripod

Resource Management: Within resource management including water, land, food, the following management activities are proposed:

- Increase irrigable land area.
- Re-consideration and affirmation of irrigation water rights.
- Increase water availability/allocation to agriculture.
- Re-distribute irrigation areas (support Jordan Valley agriculture) for better performance and efficiency of the sector.
- Enhance water storage and harvesting facilities.
- Enhance wastewater treatment and reuse in agriculture.

Uses Management:

- Rehabilitate/upgrade existing irrigation water conveyance system and schemes.
- Improve irrigation management practices.
- Arrange and optimize spatial and temporal cropping system.
- Increase green house areas.

Impacts Management:

- Increase public awareness about sector management.
- Balance the resource and use to maintain food supply and cultural aspects of local agriculture.
- Enhance extension and training to minimize impacts.
- Stop any over pumping of aquifers.

For the institutional aspects of the sector, and taking in consideration the existing setup of the Ministry of Agriculture, the following measures, activities, or developmental pathways are proposed:

- Unify water and agricultural policies and strategies on the governmental level.
- Involve farmers and/or agricultural associations in sector management .
- Enhance existing institutions in spatial distribution and with appropriate power, authority, and funding.
- Enhance existing institutions by conducting proper training of potential staff and eliminating incapable one.
- Enhance existing institutions in monitoring the quality and quantity of agricultural production and production inputs.
- Create proper agricultural marketing institutions and allow its support
- Create farmers investment and credit institutions and banks to help in financial funding and investment in the sector.
- Involve local academic institutions in sector management and development.
- Integrate efforts between various stakeholders to optimize the process.
- Create an active, comprehensive and friendly accessed agricultural and water data base and newsletter.
- Create a system of incentives for good and innovative farmers and farming.

5. Drivers for Achieving Future Improvements and Reforms

There were four main drivers observed for achieving future improvements and reforms in the agricultural water management and institutional innovation of the sector: the Israeli military occupation of Palestinian land and resources, the international financial support, the Palestinian government performance and efficiency, and the role of academic and research institutions.

Israeli military occupation:

- Limited access and mobility to natural resources and their development and exploitation.
- Constraints on import and export of food and agricultural goods and production inputs.
- Limited access and mobility to local market through apartheid wall, check points, and closures affecting production flow scheduling.
- Total discontinuity, separation between West Bank and Gaza Strip.

International financial support

- Funders and donor identify funding priorities in water and agricultural issues in coordination with the Israeli side/agenda.
- Funders and donors support is associated with political developments/status.

Palestinian Government

- Rules and regulation development with regard to food production and handling, food trading, and food safety and monitoring.
- Provide proper control of cropping and marketing mechanisms and patterns.
- Providing proper extension services to farmers.
- Provide sufficient financial support to farmers.
- Limit un-necessary food imports and/or exports.
- Support research and development of the sector.

- Generate and provide precise information on all agricultural and water management aspects and make it available to public through friendly means.
- Generate and provide detailed inventory on new and appropriate technology used in water and agricultural production and management and make it available to public through friendly means.
- Provide guidelines for managing water and agricultural inventories and supplies.
- Provide clear vision of appropriate and needed agricultural technology and know-how.
- Provide trade-offs between agricultural sector development (securing sufficient and safe food) and agricultural trade (food import/export).
- Better mechanisms for food price setting and market control.
- Spatial and temporal decision making on the cropping system and patterns.
- Deciding on agricultural area expansion – where and when.
- Develop leadership, technical capacities, and institutions of the sector.

Palestinian Universities and Research Centers

- Communicate, meet, and interact with sector policy and decision makers deciding their role in how the sector be productive and sustainable.
- Conduct research and demonstration projects that allow and help sector policy and decision makers as well as other stakeholders including farmers to develop and upgrade the physical-technical-technological, socio-economic, governance and policy perspectives and others aspects of the sector.
- Develop upgrade academic educational programs that generate capable human, technical, and technological capacities for the sector.

6. Concluding Remarks

Based on the findings of this study, the following concluding remarks were observed:

- A balance equilibrium between natural resources exploitation and development, there uses for various social and economic activities including agricultural food production, and the resulting impacts represent the best way to achieve better agricultural production and sustainable sector.
- Water availability for agriculture will be the most critical issue for Palestine to overcome in this 21st century and beyond. There should be a clear vision of how much water we will allocate for the sector with time.
- Population growth is a key driver with respect to agricultural water management
- Agricultural sector developmental challenges are becoming numerous and more complex
- Palestinian agriculture need to be looked at from cultural heritage angle and point of view.
- Governments role and focus need to be well identified within a clear national priorities and implemented in real practice not only in reports.
- Policies and policy responses for sector productivity increase within sustainability limits need to be more adaptive and flexible and developed in coordination and collaboration of all sector stakeholders

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Climate Change and Opportunities to Reduce its Impacts on Agriculture and Water, and Conflict Risks in Palestine.

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Abstract

Palestine faces many challenges, of which climate change is the newest one. Climate change, in Palestine, is likely to alter patterns of water availability, thus adding to the existing restrictions on Palestinian water access imposed by the Israeli side. The following contribution discusses, in its first part, the impacts of climate change on water availability and security, and on agricultural production and food security, based on existing empirical data on precipitation amounts and crop cultivation. In addition, potential implications of climate change in the context of the Israeli-Palestinian conflict are discussed. In its second part, the contribution gives an overview of adaptation measures at the Palestinian level that have been suggested. In particular, waste water re-use and changes in the crops cultivated are discussed.

Keywords: Climate change, Water, Agriculture, Socio-economic, Conflict, Palestine, Israel.

1. Introduction

Climate change refers to shifts in the mean state of the climate or in its variability, persisting for an extended period (decades or longer) (Ziervogel and Zermoglio, 2009). It presents a new and real threat of severe environmental, economic, political, and security impacts (Elasha, 2010). Climate change is expected to intensify existing problems and create new combinations of risks, particularly in regions, where there is widely spread poverty and dependence on the natural environment (Ziervogel and Zermoglio, 2009).

Climate change will lead to an intensification of the global hydrological cycle and can have major impacts on water resources including availability and quality. It will likely make drought longer and rainfall events more variable and intense, raising probabilities of flooding and desertification. Moreover, it will act as a multiplier of existing threats for food security by making natural disaster more frequent and intense, land and water more scarce and difficult to access, and increases in productivity even harder to achieve (Mimi et al., 2009; WFP et al, 2009; Sowers et al. 2011). The Middle East is one of the regions of the world potentially most vulnerable to climate change (Iglesias et al, 2010). For a region that is already exposed to many non-climate stresses, climate change and its potential physical and socio-economic impacts constitute additional stressors (Elasha, 2010).

This contribution discusses the impacts of climate change on Palestine, along the dimensions of water scarcity, agriculture, food security and conflict (Section 2). This discussion is based on existing data, such as from the Palestinian ministry of agriculture subsequently, it discusses adaptation option, in particular the re-use of wastewater and saline water (Section 3).

2. Climate change in Palestine

The climate of Palestine is traditionally described as Mediterranean; it is characterized by rainy winter and dry summer. However, there is a great climatic diversity (Mimi et al., 2009). This is due to the great variation in the topography and altitude of Palestine, especially in the West Bank where altitudes range between 1020 meters above sea level and 375 meters below sea level (Ministry of Agriculture, 2004). The annual rainfall in the West Bank (Figure 1) is higher in the North (up to 700 mm) and lowest in the Dead Sea area of the South (80 - 100 mm). In addition to this altitudinal variation, there is an orographic one – the western slopes receive 500 - 600 mm, while the Eastern slopes receive 150 - 450 mm (Ministry of Agriculture, 2008).

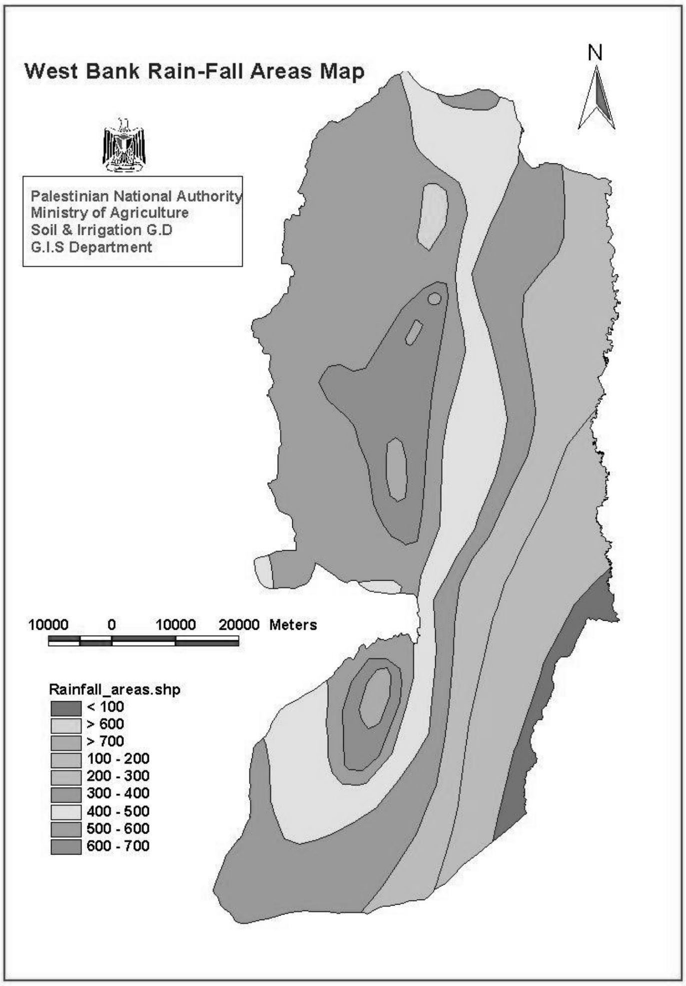

Figure 1. Isohyetal contour map of average rainfall of the West Bank, source: GIS department – Ministry of Agriculture, Ramallah – Palestine.

The most important impacts of climate change in Palestine are likely to be in the form of water scarcity, and resulting from this, impacts on agriculture and food security. Moreover, given the Israeli-Palestinian conflict and the situation of occupation in Palestine, it is also an interesting question what impact climate change will have with regard to this conflict. These issues are discussed in the next section.

2.1. The present situation: politically induced water scarcity

Most countries in the Middle East suffer from an ongoing shortage of water. The situation is felt acutely in Palestine, and is worsening due to the decrease in useable water reserves as a result of pollution and climatic changes, as well as population growth and the rising demand for water (Water Authority, 2009). However, the Palestinian situation is specific in that its water resources are not only influenced by natural factors, but also subject to political restrictions. This situation needs to be understood when assessing the (additional) impact that climate change may have.

Most of the West Bank's natural water resources lie beneath its soil in three shared aquifers. These aquifers are the Western, the North Eastern, and the Eastern aquifer. All three of these aquifers derive most of their recharge from rainfall and snowmelt on the Palestinian side. Two of the three aquifers (the Western and North Eastern) also underlie Israel territory; their flow follows the surface topography, from the West Bank toward Israel. The third aquifer – the Eastern – lies almost completely within the West Bank and discharges towards the Dead Sea (The World Bank, 2009). Water resources in the Palestinian Territory are restricted mainly to ground water and springs (71.7% and 13.7% respectively), and water purchased from the Israeli Water Company (Mekorot). The quantity of water purchased from Mekorot represents 13.4% of water resources in the Palestinian territory (Palestinian Central Bureau of Statistics, 2008).

Water availability in Palestine is, however, not only influenced by natural factors, but also political ones. Water is a contested resource between Israel and Palestine, and the controversy has also spilled over into the academic debate. Hydrological data on who receives how much water and who should receive how much water, are, unsurprisingly, controversial between Palestinians and Israelis, and their respective supporters, and their use is frequently part of the political narrative and hydro-political agenda to which those who use them adhere. Thus, figures and other factual statements need to be treated with a degree of caution.

However, it can hardly be disputed that today Israel is largely in control of water sources on both sides of the green line, i.e. the Israeli territory according to the 1948 armistice line, and the West Bank. This is a result, inter alia, of the way that control of the Palestinian territories has been split up in the Oslo accorded and the way that decision-making on water projects in these territories has been blocked by the competent bodies.

In the 1995 Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip, the Palestinian West Bank was divided into areas A, B, C. Area A is under Palestinian control, Area B under joint Palestinian jurisdiction and civil powers and Israeli security control, and Area C under territorial control by the Israeli Civil Administration. Area C represents almost 60% of the West Bank. This is an area where Palestinians cannot, without Israeli consent, implement any major projects, including e.g. the construction of waste water treatment plant. Moreover, for water, specific rules were agreed in the Interim Agreement. Pending final status negotiations, it specified quantities to be allocated to both side, and provided for the establishment of the Joint Water Committee. Moreover, the Palestinian Water Authority was created.

While several observers initially applauded the performance of the JWC (Silverbrand, 2008:235), some have by now declared it as "failed". It is at least doubtful whether the structures created through the Interim Agreement have led to improving the water situation in Palestine. According to a recent World Bank report, which the Israeli government strongly criticized, Israel used more than 80% of the Palestinian groundwater resources (World Bank, 2009). According to an Amnesty International 2010 report, the Jordan Valley water shed, which is the most important shared surface water, supplies up to 650 MCM of water to Israel per year and none for the Palestinian side (Amnesty International, 2009). Moreover, the Palestinian Authority also maintains that the Israeli separation wall further constrains Palestinian water use, resulting in the loss of 23 wells and 51 springs on the Palestinian side which together produce about seven million cubic meters of water (Palestinian Central Bureau of Statistics, 2009). Moreover, a significant number of water projects of relevance to the Palestinian have been blocked by the Israeli side in the Joint Water Committee (Ministry of Agriculture, 2004; Fishhendler/Dinar/Katz, 2011). The insight that water scarcity in Palestine is not only – and likely even not primarily – a result of natural factors, is important when discussing how climate change impacts water resources in the region and how it affects the Palestinian population. As the above shows, Palestinians already suffer from water scarcity which is largely caused by political restrictions.

2.2 Additional impact from climate change

In this situation, climate change is likely to further exacerbate water scarcity by increasing water shortages through lower rainfall and higher evaporation, insufficient rain to recharge aquifers, and reduced surface and groundwater quality (UNDP/PAPP, 2009). The last ten years have already seen reductions in the amount of rainfall received by the West Bank. Figure 2 shows that the average rainfall for the West Bank during the last ten years is 489.76 mm, which is about 9% below historic average of 537 mm. On the other hand, the average rainfall during 2007-8 and 2008-9 was 34% and 22% below the historic average respectively.

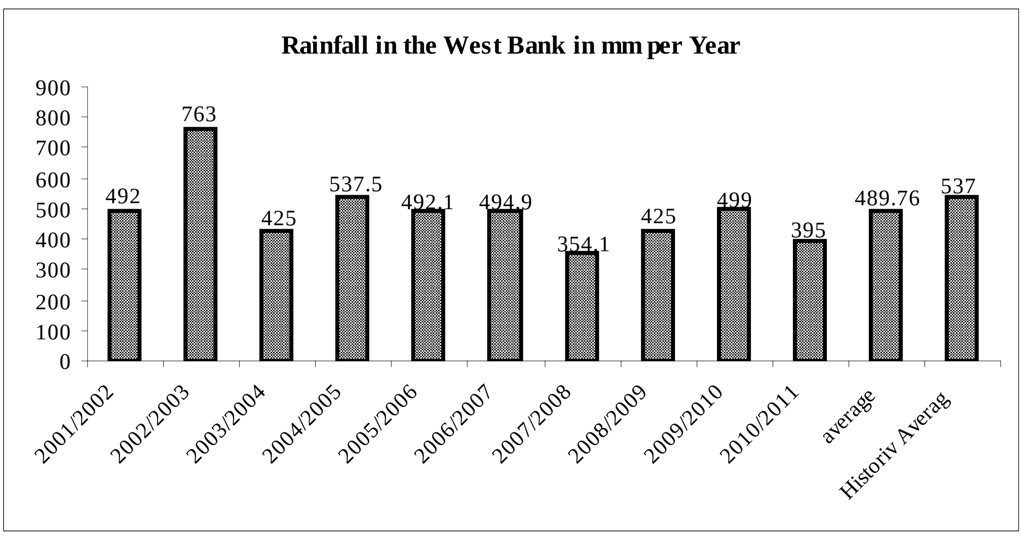

Figure 2. The amount of rainfall received by the West Bank in the last ten years.

Source: Ministry of Agriculture, 2010. b; 2011.

The effect of climate change on the limited water resources can be seen more clearly in the South of the West Bank, which is located in the arid and semi-arid region. This can be exemplified by the amount of rainfall in the Al-Samo'o, a village in this area. There, the average rainfall has dropped during the last ten years in to 297 mm, 30% below the historic average 420 mm (Figure 3). In fact, the average amount of rainfall received by Al-Samo'o during 2008-9 was 185 mm, about 56% below the historic average.

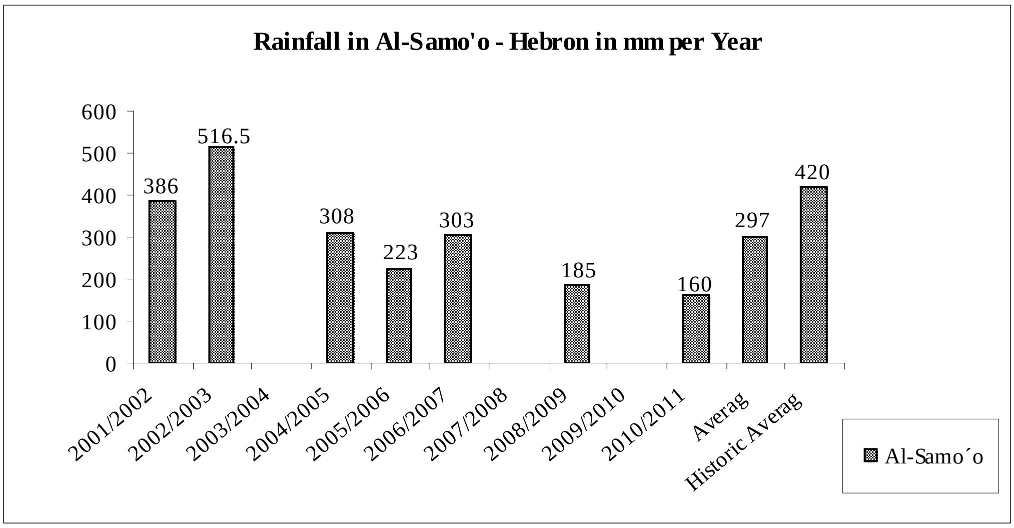

Figure 3. The amount of rainfall received by the Al-Samo'o in the last ten years

Source: Palestinian Meteorological Directorate, unpublished data on file with authors.

Water scarcity translates into water insecurity for many Palestinians. Water security may be defined as situation where "every person has access to enough safe water at affordable cost to lead a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced" (Global Water Partnership, 2000:12). Consequently, water insecurity exists where these conditions are not met. According to reports by human rights organizations, the average water consumption in the West Bank is an average daily 73 l per person, while international organizations recommend a minimum of a 100 l per person. In some areas, the daily per consumption of water is close to the minimum recommended by the World Health Organization for short term survival; and in some communities people need to buy water from water tankers (B'Tselem, 2011, 24f). Thus, water scarcity translates into water insecurity for at least a part of the Palestinian population. With political conditions unchanged, climate changed is likely to exacerbate this situation.

2.3. Likely climate change impacts on agriculture and food security

The Palestinian agricultural land area is approximately 1854 km^2, or 31% of the total Palestinian land area, i.e. the West Bank and the Gaza Strip. The rain-fed area constitutes 86% of the cultivated land, while the irrigated area consists of 14% of the total arable land. The area of rangelands is around 2000 km^2, of which 621 km^2 is available for grazing, and the forest area is 94 km^2. The areas of rangelands and forests have declined sharply as a result of the Israeli settlement activity and construction of the separation barrier (Ministry of Agriculture, 2010 a). About 62.9% of agricultural land is located in Area (C) under Israeli control, 18.8% in Area (B) under joint control and 18.3% in Area (A) under Palestinian control (Ministry of Agriculture, 2010 a). This means that Palestinian farmers, having lost a lot of their land over the past decades, are economically more vulnerable to potential future impacts of climate change than without these factors resulting from the Israeli occupation.

Irrigated agriculture is a very important sector of the Palestinian economy. Overall, it contributes a gross output of about US$ 500 million annually equivalent to 8.1% of the gross domestic product and 15.2% of exports; it is the third largest employment sector: Formal employment in the sector in 2005 was estimated at 117,000 people. However, it is also the dominant user of water (World Bank, 2009; Ministry of Agriculture, 2010 a). According to World Bank estimates, the removal of Israeli restrictions and provision of additional water quantities would raise the agricultural sector's contribution to the gross domestic product by 10% and might create approximately 110,000 additional job opportunities (World Bank, 2009). On the other hand, rain fed agriculture, which represents a secondary job for many villagers, is much less profitable. Farmers estimate a net income of $70 a dunum (0.1 hectare) when rainfall is good (World Bank, 2009).

Climate change is projected to have significant impacts on agriculture. While some aspects of climate change such as longer growing seasons and warmer temperatures may bring benefits (in cold regions), there will also be a range of adverse impacts, including reduced water availability, greater water need, and more frequent extreme weather resulting in drought, desertification, frost, and floods (Mimi and Abu Jamous, 2010; Ministry of Agriculture, 2010a). According to the Palestinian Ministry of Agriculture 2009, an increase in the average temperature of 1 Cº will increase water needs of agricultural crops by 6 – 11% in Gaza. On the other hand, if the temperature increases by 3 Cº and the rainfall decreases by 20% in the Jordan Valley, this region will need 2.95 MCM of additional water (Ministry of Agriculture, 2009).

Agriculture is the Palestinian economic sector most sensitive to weather. Some authors attribute reduced crop production to recent meteorological events (Tarquis et al., 2010). For example, in the 2007-08 drought season a 35-40% reduction in the production of rain-fed crops as given in Table 1 could be observed. Losses were estimated at approximately US$ 130 million (Ministry of Agriculture, 2009; Ministry of Agriculture, 2010a).

Table 1. Effect of drought on the productivity in 2007-8.

Crop	Wheat	Forage	Fruitful trees	Olives	Crapes
% decrease in productivity	40	35	35	40	35

Source: Ministry of Agriculture, 2009, 2010 a.

As a more specific example, the reduction in the agricultural productivity for certain crops in Yatta District in the South of the West Bank between 2000 and 2008 is given in Table 2. The reduced rainfall is claimed by the Hebron Agricultural Department to be the main more cause of significant drop in crop production in Yatta District in the last ten years (UNDP/PAPP, 2009).

Table 2. Agricultural productivity (kg/ dunum) in Yatta District.

Year	Wheat	Barley	Lentils	Vicia	Chickpeas	Biqia	Olives
2000	80	105	51	75	75	400	60
2008	60	50	30	50	50	300	50

Units are kg yield per dunum [1 dunum = 0.1 hectare], Source: UNDP/PAPP, 2009.

While more in-depth research would be needed to establish that other factors did not contribute to this reduction in production, it is, in the light of the quite substantial decrease in yields in the dry seasons plausible to assume that these were at least partially caused by the changes in rainfall.

Moreover, changes in the agricultural crop patterns, i.e. shifting toward new crops with less water demand, can be observed (Table 3). For example, the area cultivated with crops of low water demand such as date increased in the Palestinian Territories in the period 1993-2008 by 264%. On the other hand, the area cultivated with crops having a high water demand such as shamooty orange decreased by 80.2% in the same period. The corresponding decrease of the total production of shamooty is from 34006 ton in 1993 to 6233 ton in 2008.

Table 3. Total production and total area of certain kinds of fruit trees in the Palestinian territory

	Shammoty Orange		Valencia Orange		Guava		Banana		Date	
	Ton	Dunum	Ton	Dunum	Ton	Dunum	Ton	Dunum	Ton	Dunum
1993-4	34006	15859	71683	38132	15503	4557	18383	5688	3096	2984
1994-5	29847	17988	62384	34285	17491	4605	18383	5693	3100	2982
1995-6	29872	14347	83088	31449	14703	3423	19762	5885	3179	3119
1996-7	37262	14302	70702	29656	12895	4421	23132	5785	3429	3322
1997-8	34717	13493	59772	25086	15002	4857	20653	5165	3498	2809
1998-9	32466	12522	57181	21438	11893	4305	26365	5297	3470	3464
1999-2000	20368	7900	49149	21565	12656	4605	9430	2363	3852	3677
2000-1	22214	8898	54970	20543	11933	3843	5923	2031	3819	3784
2001-2	19241	7601	46046	19470	11731	3874	5442	1863	5051	4244
2002-3	11287	4708	30545	13033	4438	2458	7750	2782	3657	4764
2003-4	7577	3044	27421	11107	4796	2117	9148	3367	5015	5496
2004-5	6794	3039	24894	11149	4146	2012	9800	3305	3608	5501
2005-6	6438	2838	24151	9915	4306	2129	8000	2670	2443	5932
2006-7	5400	2992	26490	10053	5262	2882	6160	2106	3030	6416
2007-8	6233	3136	26915	10140	5949	2927	5120	1680	3997	7898

Source: Palestinian Central Bureau of Statistics, 1997 — 2010 (www.pcbs.gov.ps).

While again, more research would be needed to establish whether any other factors (e.g. economic attractiveness of growing of any of these crops) also played a role in these shifts, the move towards crops requiring less water is quite striking; again, it is plausible to assume that changes in rainfall were at least one factor behind it.

This is in turn is likely to have a negative effect on the Palestinian agriculture. The effects of a reduced amount of water available for agriculture are illustrated by the example of guava cultivation. Table 3 also shows that the total production of guava in the Palestinian Territories decreased by 36% in the period 1993-2008. Guava is the most famous agricultural crop in Qalqilia city in the North of the West Bank. Qalqilia has the highest amount of annual precipitation compared with the other parts of the West Bank, around 624.9 mm per year (88 mm above the historic average of the West Bank). However, it received an average amount of rainfall about 17% below the historic average in the last ten years. While Qalqilia is located on the Western aquifer, it suffers from lack of access to water resources. In fact, Qalqilia lost 19 agricultural water wells from its former 68 water wells, because of the construction of the separation wall. The reduction in the total production and total cultivated area of guava in Qalqilia in the period 1993 – 2008 is given in Figure 4.

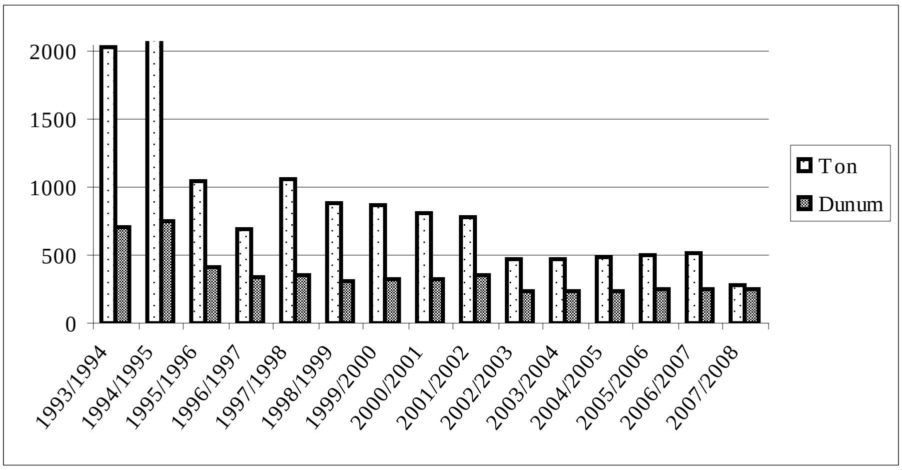

Figure 4. Total production and area of guava in Qalqilia in tons dunums respectively Source: Palestinian Central Bureau of Statistics, 1997-2010 (www.pcbs.gov.ps).

While predictions for the future are always difficult to make and the precise extent and impact of climate change in Palestine – which is geographically a very small area – cannot be predicted with precision, the above figures lend at least a certain plausibility to the assumption that Palestine is likely to see further climatic changes and reduced water availability in the future, which in turn is likely to have a negative effect on the production of some of the crops currently cultivated. This in turn, may also negatively affect food security for Palestinians as the main source of livelihoods of rural communities in the West Bank is agriculture and as many Palestinians are already living below the poverty line. According to UNDP/program of Assistance to the Palestinian People (UNDP/PAPP), 48% of Palestinians in the West Bank now live below the poverty line, which rises to 68% in southern Gaza and 72% in northern Gaza (UNDP/PAPP, 2009; Mimi et al., 2009). As discussed above, existing socio-economic and political conditions in Palestine exacerbate the vulnerability of those groups and sectors which are also most vulnerable to the negative effects of present and future climate change and variability.

2.4. Climate change and conflict

Another important aspect of climate change is its potential impact in the context of the Israeli-Palestinian conflict. In a region that already is witness to some of the greatest political tensions in the world some warn that the climate crisis and its potential physical and socioeconomic impacts may exacerbate cross-border political instability (EcoPeace/Friends of the Earth Middle East, 2007; Brown/Crawford, 2009). According to General Anthony C. Zinni – the Former Commander in Chief of U.S. Central Command – the “existing situation makes the Middle East more susceptible to problems. Even small changes may have a greater impact here than they may have elsewhere, any stresses on the rivers and aquifers can be a source of conflict” (Goodman et al., 2008). Different trajectories how climate change may translate into conflict have been pointed out. For example, climate change could increase competition for scarce water resources, complicating peace agreement, and it may hinder economic growth, thereby worsening poverty and social instability (Brown/Crawford, 2009).

However, it has also been noted that the relationship between climate change and conflict is a complex one. To what extent resource scarcity will translate into political conflicts or exacerbate existing ones, rather than trigger cooperation is an open question. Indeed, in the case of Palestine, climate change is likely only a small piece in a much larger, complicated mosaic. As described above, water scarcity in Palestine is, to a significant extent, a result of the political situation. Thus, some contend that the political obstacles surrounding water allocation to and water use by Palestinians have a much more significant impact on Palestinians and the Palestinian economy than climate change (Messerschmid, 2012 forthcoming). The EQA has been quoted as saying that they struggle more with (acute) water shortage than with (long-term) water scarcity (Hodgson/Cushman, 2010:4). This seems to confirm the analysis by Selby/Hofmann (2011) that in the case of Israel/Palestine, such as in other politically contested environments, the “most important causal pathway is not from environmental scarcity to conflict, but instead from conflict to environmental stresses and vulnerabilities”.

3. Opportunities for adaptation

However, even if climate change is only one factor among many affecting Palestinians, adaptation options should still be considered. Initially, as the Palestinian National Authority (PNA) was established in 1993, climate change was not mentioned in the sectoral strategies of the concerned ministries such as the Ministry of Agriculture (MoA) and the Environment Quality Authority (EQA). However, in 2010, new sectoral strategies for both the agricultural and environmental sector were designed with the support of the UNDP. Climate change was taken in the consideration therein. In 2008/2009, the EQA, supported by UNDP and external consultants, developed the Climate Change Adaptation Strategy and Programme of Action for the Palestinian Authority for Palestine”. These documents highlight the likely impact of climate change on Palestine and recommend measures to be taken.

Moreover, the National Committee for Combating Desertification and the National Committee on Climate Change were founded in March and April, 2010 respectively. Recently the UNDP financed the preparation of the National Strategy and Action Plan for Combating Desertification. The MoA, assisted and funded by the World Food Program (WFP), is working on establishing an Early Drought Monitoring System; future needs for national climate data and a drought monitoring system will be assessed. The International Center for Agricultural Research in the Dry Areas (ICARDA) had already finished a mapping of land suitable for water harvesting in the West Bank, a work commissioned by the WFP.

Important obstacles to implementing effective climate change policies in Palestine are the occupation, and the concurrent limitation of the PNAs administrative competences, and lack of cohesion between various government agencies at both national and local levels. It is also difficult for the PNA sometimes to accede international funding. The Palestinian status under international law is a specific one, given that there is no recognized Palestinian state so far. Palestine has been given observer status and some additional rights at the United Nations, but is neither a full member of the UN nor a party to multilateral environmental agreements so far. As funding is frequently linked to party status under environmental agreements, this also makes it difficult for the PNA to receive funding for certain environmental projects. Moreover, according to the Palestinian Water Authority (PWA) the frequent delays of projects, which result from the failure of the current JWC to agree on permits for such projects, restrict the ability of the PWA to develop and maintain more effective water infrastructure, exacerbating the impacts of drought in both the West Bank and Gaza (cf. Hodgson and Cushman, 2010).

Nonetheless, different adaptation measures have been proposed that could be taken by Palestinians. These include incorporating climate change in long-term planning, compiling an inventory of existing practices and decisions used to adapt to different climate, promoting awareness of climatic variability and change, creating a regional adaptation strategy, involving municipalities in adaptation efforts, and a continued focus on capacity building to identify overlap between various plans, thereby increasing efficiency. Moreover, specific policy options for adaptation concerning water and agriculture have also been suggested for Palestine, and the countries in the Middle East at large (Brown and Crawford, 2009; Hodgson and Cushman, 2010; Sowers et al., 2011; Sowers and Weinthal, 2010; UNDP/PAPP, 2009). These include:

Local increases in rainfall interception capacity and extension of water harvesting

- Introduction of more efficient irrigation techniques.
- Prioritisation of irrigation for highest value crops.
- Diversification of rural livelihoods.
- Incorporation of climate adaptation in land use planning.
- Increased use of precision agriculture for improved soil and crop management.
- Development of new crop types and enhance seed banks, avoid monoculture and encourage farmers to plant a variety of heat- and drought-resistant crops and saline tolerant crops.
- Promotion of water conservation measures.

The next part of this section will be focused on two particularly relevant water-related adaptation measures that involved using alternative water sources for irrigation to alleviate the mounting pressure on drinking water.

3.1. Wastewater and opportunities of reusing in agriculture

The Palestinian wastewater management sector has been neglected for decades, during the Israeli occupation and administration and up till now, and little investment has been made in the field since the Oslo Accords (Daibes, 2000; Mahmoud and Yasin, 2011).

The existing management practices for wastewater in the West Bank are limited to the collection of wastewater by sewage networks and cesspits (Applied Research Institute - Jerusalem (ARIJ) et al., 2011). Approximately, 65% of houses in the main cities are connected to the sewage system (Al Saed and Hithnawi, 2006). According to the Palestinian Central Bureau of Statistics (PCBS) the overall percentage of the households living in housing units that are connected to the public sewage network in the Palestinian territory in 2009 was 52.1%, of which 35.5% in the West Bank and 83.8% in the Gaza Strip. On the other hand, 45.5% use porous cesspits, 1.7% use tight cesspits, and 0.7% use other wastewater disposal methods (PCBS, 2010). Cesspits are emptied by vacuum tanks, which usually dump their contents into open ground, into wadis sewage networks, irrigation channels, and solid waste disposal sites (Fatta et al., 2004).

The total volume of wastewater generated in the West Bank in the year 2008 was estimated at 47.3 MCM. Of this, 13.5 MCM (30.1%) is collected by the sewage network. A small part of the wastewater generated in the West Bank is treated in centralized and collective wastewater treatment plants; the remaining 93.7% is discharged untreated into the environment (Applied Research Institute - Jerusalem (ARIJ) et al., 2011). 90% of partially treated water from the treatment plants is discharged into wadis, on the other hand, the reused wastewater from the treated effluent is only 10% (Fatta et al., 2004).

Wastewater treatment facilities are restricted to a few localities (Applied Research Institute - Jerusalem (ARIJ) et al., 2011), four in the West Bank and three in the Gaza Strip (Al-Sa’ed et al., 2008). The existing treatment plants are heavily overloaded and poorly operated and maintained. Lack of provision of effective wastewater collection and disposal system is causing ground water pollution through the infiltration of contaminated effluents to the aquifer (Zeer and Al-Khatib, 2008). A centralized wastewater treatment plant that is operating at a high efficiency rate exists in Al-Bireh city and is serving Al-Bireh city (Applied Research Institute - Jerusalem (ARIJ), (2011).

Based on water treaties signed between the Israelis and Palestinians, all wastewater treatment plants must be approved by the Joint Water Committee. Among the seven urban sewage works in Palestine, Albireh wastewater treatment plant is the only new urban sewage works put in operation since 2000 (Al-Sa'ed et al., 2008). In several instances, the wastewater that crosses the Green Line (Armistice line, 1949) is treated in Israeli treatment plants and reused for irrigation purposes. The cost of this treatment is normally charged to the Palestinian Water Authority (Applied Research Institute - Jerusalem (ARIJ), (2011).

Uncontrolled use of wastewater is frequently associated with significant negative human health impacts. On the other hand, treated wastewater, if properly planned and managed, can have positive environmental impact such as prevention of surface water pollution, and providing the plants with essential nutrients like nitrogen and phosphorus. (Mimi, 2002; Fatta et al., 2004). It can serve many purposes for which fresh water is used, mainly in agriculture, but also in industry, or households (Zeer and Al-Khatib, 2008). Using wastewater would not only increase the amount of water available to Palestinians, its use could also decrease Palestinians' reliance on Israel supplying freshwater. For an economy such as the Palestinian one, where agriculture is very important, these are important assets.

Proper treatment and adequate reclamation of urban wastewater is expected to provide additional water resources for agricultural and domestic purposes and could thus mitigate the effect of climate change on water scarcity.

3.2. Using saline water for irrigated agriculture in the Jordan Valley

In the last five years, nearly 450 water samples from different wells in Jordan Valley had been analyzed in the labs of the National Agricultural Research Center (NARC). Depending on the EC value, water in this area can be classified as moderately saline, (EC = 2–10 dS/m). However, values as high as 29 dS/m have been reported (Barghouthi, 2009).

Due to the availability of saline water in the Jordan Valley, there are two major approaches that should be considered to improving productivity in a saline environment: modifying the environment to suit the plant and modifying the plant to suit the environment (Sharma and Minhas, 2005). Identifying of salt-tolerant crops which can be irrigated by the Jordan Valley moderately saline water is an example of modifying the plant to suit the environment (Barghouthi, 2009).

NARC, through the Palestinian Ministry of Agriculture, joint the research project "Saving fresh water resources with salt tolerant forage production in marginal areas of the West Asia/North Africa (WANA) region", which was organized by the International Center for Biosaline Agriculture (ICBA) in the United Arab Emirates (UAE). Six crops were identified in the first phase of the project as salt-tolerant crops (Barghouthi, 2009). Using salt-tolerant crops represents an opportunity to raise the income of the rural poor by providing animal feed and other agricultural products irrigated with saline water.

4. Conclusion

Climatic changes in Palestine, particularly the reduction of the precipitation and frequent droughts have already led to changes in agriculture, the main source of livelihoods for rural communities. Climate change is likely to act as a risk multiplier; it threatens water security and reduces agricultural productivity. Consequently, it brings risks for food security and economic development by contributing to even greater water stress in the region. Climate change provides both challenges, and opportunities for cross-border cooperation to ameliorate and prevent the problems that are already occurring and are projected to further intensify. The great challenge for coming decades will be increasing food production with water shortage and climate changes on limited arable land. Using saline water and treated wastewater represent opportunities to save fresh water.

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Agriculture Water Demand Management Under Vulnerable Climate Changes in Gaza Strip

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Abstract

Like other countries in the Middle East, Palestine has a serious position regarding rainfall and water resources. It is forecasted that Palestine will have to face a severe water deficit likely to be exacerbated within the next years due to the consequence of the global warming and other reasons. Apparently, increased temperatures may lead to more groundwater pumping to meet the escalating crop water needs, particularly in the south. The most significant environmental effects of climatic changes for the Palestinian people, over this course of this century, are projected to be a decrease in precipitation and significant warming. Annual precipitation rates are deemed likely to fall in the eastern Mediterranean-decreasing 10% by 2010 and 20% by 2050, with an increased risk of summer droughts. The agriculture in Palestine is the most sensitive to climatic hazards both current and future. This means that agriculture will be affected and the price of vegetables, fruits, and other agriculture products will rise as well, bringing about a further negative effect on marginalized communities. A higher variability in precipitation translates into reduced yields for rainfed agriculture. Reconciliation is laying in adaptation agricultural water demand management and ensuring additional water supplies for irrigation like wastewater reuse and implementing extensive water saving measures and programs. This paper is an attempt to explore and analyze the probable climate change impacts on irrigation water requirements for the main crops in Gaza Strip, using downscaling techniques of a climate change model called CROPWAT which developed by Food and Agriculture Organization (FAO). The paper also concluded general guidelines of water policy including drought management measures to be ready to face the worst scenarios in the future.

Keywords: Climate Change, Crop Water Requirements, Irrigation Management, Gaza Strip.

1. Introduction

The environmental situation in the Gaza Strip was already serious due to under investment in environmental systems, lack of progress on priority environmental projects and the collapse of governance mechanisms. In addition to the environmental impacts of the recent escalation of violence, the population of the Gaza Strip suffers from environmental pollution and natural resource depletion related to the ongoing political situation and associated problems, which limit human, social and economic development. (Environmental Assessment of the Gaza Strip, United Nations Environment Program (UNEP, 2009). Furthermore, Gaza Strip is described as the most exploited place in the world where the level of demand on resources exceeds the capacity of the environment (Gaza Environmental Profile, 1994). This is especially true for the water and land resources, which are under high pressure and exposed to severe over exploitation, especially in the presence of a high rate of population growth. Groundwater is the main water resource to meet all needs of the different sectors in the Gaza Strip. Agriculture is the main water consumer in the Gaza strip (about 50% of the total consumption). Rainfall is insufficient for the cultivation of most crops and supplementary irrigation is needed in order to meet the crop water requirements. The existence of agriculture depends on the ability of the Gaza strip water and its efficient use, as high as possible. The Palestinian National Authority (PNA) recommends adopting this climate change adaptation strategy for the Palestinian Territories (PT) as the most effective means by which the PNA can enhance the capacity of the Palestinians to cope with current and future climate hazards. Initial efforts should be directed at addressing the six major climate-induced risks to food and water security identified, which are:

- Crop area changes due to decreases in optimal farming conditions;
- Decreased crop and livestock productivity;
- Increased risk of floods;
- Increased risk of drought and water scarcity;
- Increased irrigation requirements;
- Increased risks to public health from reduced drinking water quality.

1.1. Crop Patterns and Agricultural Water Demand in Gaza Strip

A wide variety of crops are grown in the Gaza Strip, but the most important are citrus, olives, vegetables and grapes. The agricultural water consumption was roughly estimated from the available cultivated areas multiplied by the irrigation water quota allowed for each crop allocated officially by the Palestinian Water Authority (PWA) and the Ministry of Agriculture (MoA), as most of the agricultural wells distributed allover the Gaza Strip have not been metered, and not well functioning, or not installed absolutely. The seasonal crop water requirements showed that two thirds of the total cultivated area is an irrigated area (118,000 Dunums out of the total irrigated area (161,000 Dunams). The approximate estimation of irrigation water demand based on the quota allowed and the available irrigated lands ranges from 80-90 MCM/year, as shown in Table 1.

Table 1. Areas and crop patterns in the Gaza Strip (MoA, 2010)

Items	Area (km^2)
Total Area of Gaza Strip	365
Total Cultivated Area	161
Total Irrigated Area	118
Total Rainfed Area	34
Buffer zones	9

In the last decades, the main water consumer crop is citrus in the Gaza Strip. Recently, the citrus farms restore its importance and its economic prices records remarkable jumps. On the other hand, water allocation for different crops needs a review. For instance, the crop water requirement (CWR) as shown in Table 2 should not only depends upon soil conditions and the type of crop cultivated, but also on the vulnerable climate changes predominated in the area. In addition, the problem identified is also that irrigation practices are only based on farmers’ own experience. They determine when and how to irrigate crops based on the appearance of the soil and the climate conditions.

Table 2. Water allocations for crops in Gaza Governorates (MoA, 1970-2006)

Crop Patterns	m3/dunam/yr
Citrus	900
Strawberry	1000
Vegetables	700
Olives and Almonds	300
Cut-Flowers	1800

2. Methodology

CROPWAT, Version 8 (FAO, 1998) is a decision support system developed by the Land Water Development Division of the UN’s Food and Agriculture Organization (FAO). CROPWAT is meant as a practical tool to help agro-meteorologists, agronomists and irrigation engineers to carry out standard calculations for evapotranspiration and crop water use studies, and more specifically the design and management of irrigation schemes. Calculations of crop water requirements and irrigation requirements are carried out with inputs of climatic and crop data. The development of irrigation schedules and evaluation of rained and irrigation practices are based on a daily soil-water balance using various options for water supply and irrigation management conditions. The climatic data included are maximum and minimum temperature, relative humidity, sunshine hours, wind speed, precipitation and calculated values for reference evapotranspiration and effective rainfall. The reference evapotranspiration has been calculated for all stations according to the Penman Monteith method, as recommended by the FAO Expert Consultations held in Rome, May 1990.

2.1. Study Area and Application of CROPWAT

To evaluate the potential impact of climate change on agricultural water demand, the Gaza North Governorate (GNG) is selected under different suggested scenarios of changing temperature and precipitation using the CROPWAT computer model. Climatic data of project area in average (1997-2006) (Meteorological Gaza Office, 2006) as shown in Table 3 was used. The total area of the GNG is about 61 km^2, and it was selected as the study area to examine the impact of changing climatic parameters (temperature and precipitation) on the irrigation water requirement of the district. The GNG was chosen for this study because it is distinguished criteria for citrus cultivation since decades. The effect of variable rainfall as well as temperature may be obvious in the GNG than other governorates in the Gaza Strip.

Table 3. Average of meteorological climate parameters in the Gaza North Governorate (GNG) (Meteorological Gaza Office, 2006)

Month	Rainfall mm	Min Temp oC	Max Temp oC	Relative Humidity %	Wind Speed km/hr	Average of Sunshine hours per day
Jan	94.3	10.8	18.1	65	11.3	4.8
Feb	78.9	11	18.2	67	12.3	6.1
Mar	35.7	12.9	19.8	67	11.5	7.6
Apr	10.6	16.3	22.9	67	11	8.4
May	0.1	19	24.6	72	10.2	9.7
June	0	21.7	27.2	74	9.8	9.8
Jul	0	23.8	29.6	74	9.7	10.7
Aug	0	24.5	30.2	72	10.1	10.6
Sep	13.2	23	29	68	10.5	9.7
Oct	42.6	20.3	26.7	67	10.5	8.3
Nov	68.5	16.3	23.5	62	10.6	6.2
Dec	114.4	12.6	19.6	64	10.9	4
Average	38.2	17.7	24.1	68	10.7	8

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level (IPCC, 2007a). The projected Israeli scenario indicated a ten percent (10%) increase in evapotranspiration in the region (Pe'er and Safriel, 2000).

The Palestinian projection of climate changes indicated that the mean summer temperatures, already high in the region, will rise significantly (0.81 ºC -2.1ºC) (Abu Taleb M., 2000), while projection of probable annual temperature change cited by Abu Jamos, 2009 and Waggoner, 2000 indicated a rise from 2-5 ^{o}C. According to the previous references, mean winter temperature will also increase but lower than the summer season. The current rainfall is likely to be reduced by 5-7% to 10-20% accompanied by a projected increase in temperature of 1ºC to 3ºC, efficient crop water use in the Gaza Strip will be of the most importance. In view of the uncertainties associated with future projections of climate change, a number of climate scenarios were constructed for testing the CROPWAT in this study as shown in table 4. The climate change scenarios applied relative precipitation (P) changes of P-5%, P-10%, and temperature T+ 1ºC, T+2ºC, to the monthly average series temperature and precipitation values respectively. For each climatic scenario, reference evapotranspiration (ETo), Crop Water Requirement (CWR) and Irrigation Water Requirement (IWR) for citrus in the GNG were calculated. The irrigation water demand by applying relative temperature changes of T+ 1ºC, T+2ºC, to the monthly average series temperature and relative precipitation changes of P-5%, P-10%, is summarized in Table 4.

Table 4. Total irrigation demand for citrus in the Gaza North Governorate (GNG).

Parameter	T (baseline)	T+1	T+2
P (baseline)	736	752 (2.17%)	777 (5.5%)
P-5%	743 (1.3%)	758.4 (5%)	783.5 (6.4%)
P-10%	755.2 (2.26%)	761 (3.5 %)	.4(8.4 %)

3. Results and Discussion

The results shown in table 4 clearly show that the crop water requirement (CWR) is very sensitive to the temperature increase, more than its sensitivity to the rainfall decrease. The CWR increases by an average of 2.2%, and 5.5% as temperature increases by 1ºC and 2ºC respectively, to compensate the water lost in evapotranspiration. Changing precipitation did not affect the CWR at the same level, but it affects remarkably the amount of irrigation water requirements (IWR) in general, as the effective rain provides part of the crop water requirement. The results of climate change projection in the Gaza Strip clearly show that the scenario of increasing temperature gets worse when combined with the scenario of decreasing precipitation; where (T+2, P-10%) scenario being the worst scenario resulted in additional 8.4% required annually to overcome the water lost in evapotranspiration under the proposed scenario. The CWR estimated for a variety of main crops grown in the Gaza Strip under the tangible depression of rainfall witnessed in the Strip in 2010 (50% depression) and with the incremental of 2ºC as recorded in the Palestinian meteorological climate records for the same period, showed that the rain-fed crops like olive trees and grains are highly influenced by the drastic vulnerable climate change in the Gaza Strip than the irrigated crops as illustrated in Table 5.

Table 5. Gross irrigation water demand of crops (m3/dunum).

Crop	Recommended Quota, m3/ dunam	Gross Irrigation (m3/ dunam)	% Increase of CWR
Citrus	900	1140	26.6%
Olive	400	630	57.5%
Fruits	500	765	53%
Alfalfa	1200	1626	35.5%
Grains	400	803	61%
Vegetables	700	953	36%

In light of the expected climate change in the region, and upon the fact that the entire existing agricultural demand is taken from the groundwater in the Gaza Coastal Aquifer System (GCAS), which is highly brackish, the Palestinian Water Authority (PWA) indicated that the long-term target is that only minimal fresh water will be provided for soil flushing and specific high value crops (National Water Plan, 2000). Other low water quality water and conservation practices (including brackish water, storm water harvest, blending of water and conjunctive use of saline and non-saline water) utilized to optimal economic and practical effect in accordance with the following targets:

- By 2015 the utilization of wastewater is planned to contribute 7% of the total required for agriculture and the utilization of brackish water has been reduced to 58%.
- By 2020 the utilization of wastewater is planned to provide 50% of the total required by agriculture, with the remainder being provided by the GCAS, in order to maintain the balance of salts in the soil and to provide the quality necessary for certain crops.
- The improvement in the quality of the aquifer, which is planned to have taken place by this time under effective aquifer management, will have reduced the quantity of brackish water in the aquifer.

Table 6. Water resource development for agriculture (in MCM) in the Gaza Strip.

Water Source	2000	2005	2010	2015	2025
Fresh water	40	35	30	25	27
Wastewater	0	0	1	7	40
Brackish	47	50	46	45	10
Rainwater Harvesting	4	5	[3]*	[3]	[3]
Total	90	90	80	80	80

Source: National Water Plan (modified), 2000
* Figures in brackets indicate rainwater harvest collected from greenhouses roofs

3.1. Effects of Higher Temperatures

Agricultural production can be described in terms of amount and quality. The reactions of an individual crop to global change will depend on the balance of shorter cycles resulting from increased air temperatures, shorter periods to accumulate yields products (at least in the case of determinate crops); higher potential yields resulting from increased assimilation of CO_2 and increased water-use efficiency resulting from enhanced regulation of transpiration with elevated CO_2. The projected cumulative effect of CO_2 and increasing temperature decreased the length of the different growth stages of citrus, having the greatest effect on the initial two developmental phases. The impact of climate change on the crop water use to obtain the same level of production as usual may not be so high as expected, as the shortening of the production cycle leads to a decrease in water use over time. The reduction in the growth development time of citrus may, however, make it more vulnerable to environmental stress such as short drought periods or abnormal weather during pollination. A shortened lifespan means the plant has to go through its critical reproduction period in a shortened time. Another important effect of high temperature is accelerated physiological development, resulting in hastened maturation and reduced yield. Decreased crop productivity may also be resulted from changes in monthly precipitation distribution and from the increased temperature in critical periods (heat stress) and loss of water retention capacity. In areas minimum only characterized for a relatively short summer periods, both vegetative and reproductive development may be very much restricted.

In the case of the Gaza Strip case, considering all aforementioned factors, increasing temperature will certainly exacerbate the salinity build-up in the soils as a result of increasing the evaporation from original saline soils and, in turn, will increase the leaching requirements for citrus and at the end, it will recompensate the slight and potential decrease of water use that may be occurred in specific initial stages of citrus growth. Some references (Durand W, 2004), indicated that the total growing season for perennial crops may be reduced by 15-30 days, depending on the climate scenarios used.

4. Conclusions and Recommendations

Demand management has become a must for the Palestinian Water Authority (PWA), as well as many other countries in order to sustain its development and satisfy population needs. The Irrigated agriculture sector in the study area (All Gaza Strip) may become more water demanding once climate change is predicted to increase irrigation water requirement, due to positive trends in evapotranspiration. One consequence of shorter growing seasons could be that it will be possible to produce two crops each year. At that point, irrigation water demand will increase significantly, perhaps beyond what can be supplied. The impact of climate change on the crop water use to obtain the same level of production as usual may be so high as expected, as the shortening of the production cycle leads to a decrease in water use over time, but other maturation, quality and leaching factors may recompensate the slight reduction of water use. Adopt a national and integrated water policy, including drought management measures to be ready to face the worst scenarios in the future, is imperative and immediate prerequisite, taking into account all the potential steps towards rainwater harvest techniques, irrigation scheduling, and fighting the plant diseases. Participation of all stakeholders at early stages in the planning and management processes has great impacts on the success of management plan.

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Impacts of Potential Climate Change on Rainfed Agriculture in Jenin District, Palestine

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Abstract

Global warming is expected to have a significant impact on the conditions affecting agriculture, including temperature and precipitation. According to the regional climate models there would be an increase in winter temperature combined with changes in rainfall amount and distribution and those climate changes are likely to affect the agricultural production. In the Occupied West Bank, Palestine, there has been an average decrease of 4.1% in annual rainfall over the past 35 years and there has already been an increase in the frequency of high rainfall intensity and a decrease in the mean annual rainfall. This paper evaluates the impacts of potential climate change on rainfed agriculture in the Jenin district that is one of the largest agricultural areas in the West Bank and contributing with about 16.2% of the Palestinian agricultural production. The analysis employs CROPWAT to estimate the change in yield in response to different scenarios of increasing temperatures and decreasing precipitation. Besides, the paper examines the impact of increased temperature on irrigation water requirement. The results show that the current traditions of rainfed agriculture in Jenin district are highly sensitive to potential climate changes represented by increased temperatures and decreased rainfall. The paper recommends a number of adaptation measures that might help policy makers in formulating effective strategies for reducing the harmful impacts of climate change.

Keywords: Climate change; Precipitation; Crop yield; Irrigation requirement; Seasonal shift.

1. Introduction

Climate summarizes the average, range and variability of weather elements (e.g. rain, wind, temperature, fog, thunder, and sunshine) observed over many years at a location or across an area. It has profound effects on vegetation and animal life, including humans, and plays a significant role in many physiological processes, from conception and growth to health and disease. Humans, in turn, can affect climate through the alteration of the earth's surface and the introduction of pollutants and chemicals such as carbon dioxide into the atmosphere. From this point of view, the concept of global warming and climate change appears (Obese, 2001). Climate change refers to the variation in the earth's global climate or in regional climates over time. It describes changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years. These changes can be caused by processes internal to the earth, external forces (e.g. variations in sunlight intensity) or recently human activities (IPCC, 2007a; Brown and Crawford, 2009).

The term “climate change” often refers to changes in modern climate, including the rise in average surface temperature known as global warming (UNFCC, 2002). The average surface temperature of earth is about 15 °C. Over the last century (years 1900-2000), this average has risen by about 0.6 °C. Scientists predict further warming of 1.4-5.8 °C by the year 2100 (Aldy, *et al.*, 2003). Such a temperature rise is expected to melt polar ice caps and glaciers as well as warm the oceans, all of which will expand ocean volume and raise sea level by an estimated 9 to 100 cm, flooding some coastal regions and even entire islands. Some regions in warmer climates will receive more rainfall than before, but soils will dry out faster between storms (Obese, 2001).

Palestine, which is located to the east of the Mediterranean Sea, has a semi arid to arid climate and has one of the lowest per capita share of water resources in the world. Food security in Palestine is constrained by continuing population growth, limited land and water resources, in addition to the Israeli occupation that controls all resources. Climatic change is expected to cause reduction in rainfall precipitation with fewer intense rainfall events and, thus, this climate change will intensify the food security problems in Palestine (Salem, 2011). The average population growth rate in the West Bank is 3.5%, which means that the population is expected to double in the coming two decades (Rabi, *et al.*, 2003; Khatib, *et al.*, 2007; Khatib, 2009).

Currently about 30% of the total area of the West Bank is cultivated and there are two predominant types of agricultural (land use) systems; rainfed and irrigated. About 6% of the total cultivated land area of the West Bank is under irrigation and the 9%١،٦ of the total cultivated land is rainfed (PCBS, 2006). The actual contribution of rainfed agriculture to the total plant production varies according to the amount and distribution of rainfall precipitation during the growing season (ARIJ, 2007).

Due to increased water scarcity, the irrigated area is unlikely to expand in the West Bank. The Jordan valley on the Palestinian side and the Jenin and Tulkarm districts are containing most of the cultivated and fertile lands in the West Bank. According to Al-Juneidi and Isaac (2001), 25% of crops in the Jenin district suffer from water shortage. The climate change in the Mediterranean region (including Palestine), is expected to undergo changes in rainfall patterns and temperature over the next several decades (Houghton et al, 2001; Salem, 2011). Temperature is projected to increase from 0.8-2.1 °C in all seasons of the Middle East (Bou-Zied, and El-Fadel, 2002; Khatib, 2009). According to Mizyed (2009), it is predicted that climate change will result in increasing temperature by 2-6 °C and a possible reduction of precipitation of up to 16% in the Mediterranean basin.

Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature and precipitation (IPCC, 2007b). According to climate models for the region, there would be an increase in winter temperature combined with changes in rainfall amount and distribution (Ben-Gai, *et al.*, 1998) and these climate changes are likely to affect the agricultural production (Gitay, *et al.*, 2001). In the West Bank, there has been an average of 4.1% decrease in annual rainfall over the past 35 years and there has already been an increase in the frequency of high rainfall intensity and a decrease in the mean annual rainfall (PWA, 2006). According to the local metrological stations in the West Bank, more than quarter of the precipitations had fallen during two days of the rainy season of 2007. In 1998/99, the rainfall record in the winter was the minimum in the past 100 year long history of rainfall record (PHG, 2005). Therefore, the great challenge for the coming decades will be increasing food production with water shortage and climate changes impacts under the restricted cultivated lands.

The greater vulnerability of poorer regions to climate changes is related to their high reliance on weather-related activities and the Palestinian farmers will face harder challenges to mitigate decreased water availability impact on agricultural economy (Bou-Zied and El-Fadel, 2002; Salem, 2011). Therefore, the livelihood of these communities is always threatened since these sources are directly affected by rainfall and drought incidence (Rabi, 1999). In addition to the socio-economic impacts associated with loss of agriculture and related jobs (ARIJ, 2007).

Recently, the concern about the increase in temperature all over the world caused by the global warming has increased dramatically, and there is a huge interest in the effect of climate change on agriculture. This study concentrates on rainfed crops in order to examine the potential problems facing the agriculture in Palestine. Within this context, it becomes necessary to study the vulnerability and adaptation of the rainfed agriculture due to the effects of climate change. That will clear the vision to the decision makers in order to deal with the problem in the future.

The aim of this paper is to study and assess the impact of potential climate change on rainfed agriculture in Jenin district. The specific objective is to study the impacts of different future scenarios of climate change (including reduced precipitation, increased temperatures, and seasonal shifts) on crop yield and irrigation water requirement in the study area.

2. Approach and Methodology

2.1. Study Area

The Jenin district is located in the northern part of the West Bank (Figure 1). It has an area of about 583 km^2 and populated by about 256,619 inhabitants living in 47,437 households and distributed in 76 towns and villages (PCBS, 2007). It is considered as one of the poorest District s in the West Bank (ECHO and USAID, 2006). The Jenin district is divided into four rainfall regions: (a) the eastern region with an average rainfall of about 200-300 mm/year, (b) the south-eastern region with an average rainfall of about 350-500 mm/year, (c) the northern and the north-western region with an average rainfall of about 300-400 mm/year, and (d) the western and south-western region with an average rainfall of about 600-700 mm. The maximum average of temperature in the district is about 27.4 ºC, while the average lowest temperature is about 13.4 ºC (PCBS, 2006).

The four target communities mainly depend on agriculture as a main source for their income, especially after the Israeli restrictions on admitting Palestinian workers after the second “Intifada” (popular uprising) in year 2000. Rainwater is a major source of agricultural water due to limited and restricted access to groundwater in the district. As a part of the West Bank it has one of the lowest per-capita world water availability worldwide. These different locations represent different rainfall gradients in the Jenin district and they are connected by road networks. The main source of water is the groundwater represented by the wells and springs in the district, and they mainly depend on the rainwater during the winter months. About 80% of the total consumed water is used for irrigation and the remaining 20% is for the domestic use. The total cultivated area fluctuated from year to another and the main factor affecting the size of the cultivated lands is the amount, intensity and distribution of the rainwater.

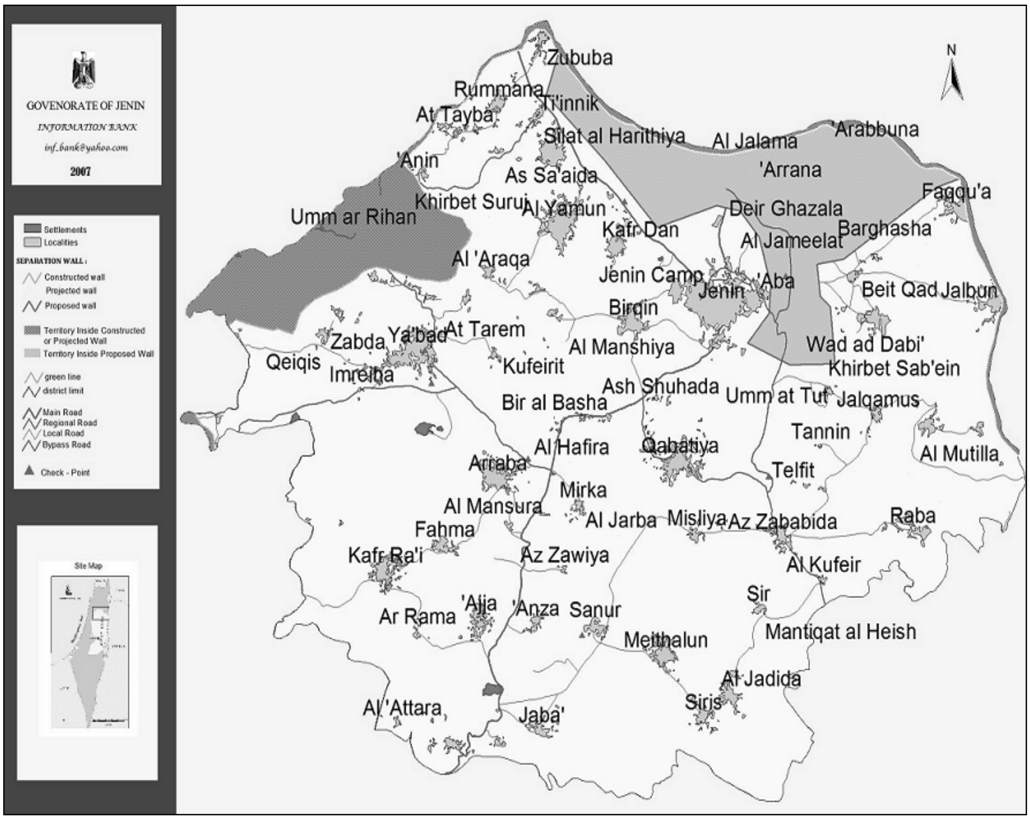

Figure 1. Map of Jenin district.

2.2. Data collection and analysis

All the required data was obtained from the Meteorological Department, the Ministry of Agriculture and the Palestinian Central Bureau of Statistics (PCBS). The available data in these institutions is from the year 1998 to 2008. These data were used in the CROPWAT computer model to calculate the potential yield reduction for the main crops in Jenin district, and to gain the net irrigation requirement for the crops in order to compensate for the shortage in rainfall. CROPWAT is a decision support system developed by the Land and Water Development Division of FAO; it uses the FAO (1992) Penman-Monteith methods (FAO, 1998). It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions, and the assessment of production under rain-fed conditions or deficit irrigation.

The selected crops for the analysis was chosen according to the area planted and the economical returns, so that seven field crops was chosen (chick-peas, wheat, clover, barely, lentil, sesame, onion), five Fruits (olive, almond, plums, grape, aloe), and four vegetables (tomato, okra, squash, snake-cucumber).

Three scenarios are used in the study representing increased temperature by 1, 2, and 3 ^{o}C and decreased in rainfall by 10%, 20%, and 30%. These scenarios were taken according to the previous studies which illustrate these changes with climate. The study is based on the scenarios identified by previous studies and expectations about the climate change for the next years.

The rainfall data was analyzed in order to find if there were a shift and changes in rainfall distribution and amount through a ten-year period (1998-2008). The rainfall during that period was sketched compared with the actual yield of the selected crops in Jenin district in order to find the relationships between the amount of rainfall and the yield response.

Rainfall and seasonal shift: The bulk of the data for this study were extracted from monthly rainfall and temperature figures for the period 1998-2008 published by Palestinian Central Bureau of Statistics (PCBS) based on the data records maintained by the Department of Meteorology. The rainfall data over a period of ten years (1998-2008) was analyzed on monthly basis to study if there is a shift or change in rainfall distribution and amount. The rainfall was sketched and compared with the actual yield of the selected crops in Jenin district to study the relationship between the amount of rainfall and the yield response.

3. Results and Discussion

The changes in climatic parameters affect the agricultural yield, production and the irrigation requirement for the plants. The data collected in Jenin district does not cover the entire district due to the lack of records and the available data cover a set of ten years only (1998-2008) as mentioned above.

3.1. Impact of increasing temperature and decreasing precipitation on yield reduction

Many crops are analyzed using CROPWAT program in order to investigate the impact of temperature and precipitation on crop yield reduction. Table 1 shows how yield reduction changed for wheat crop. The results show that with increasing T by 1°C for wheat (for example) yield reduction changes by 35.7%, and 36.6% for T+2 °C and 37.3% for T+3 °C, taking into consideration no changes in the precipitation.

This result is very close to what is presented by Singh et al. (1998) that indicated a decrease of 20–30% in yield reduction, but if the climatic parameters (T and P) have changed the results will be more severe; the changes will be 41.7%, for increased temperature by 3 ^{o}C and reduced precipitation by 30%. Table 1 shows that the effect of decreasing precipitation is more significant than increasing temperature for wheat crop. This is because wheat is cultivated in the rainy season (October and November). The total yield reduction for the selected crops in the Jenin district is shown in Table 2.

The yield reduction is calculated using climatic data input only using reference crop (FAO, 1998). The variation in the yield reduction values for each crop results from the variation in the characteristic of each crop (amount of water required), variation in the planting date, and crop cycle duration.

Table 1. Yield reduction for wheat crop (%).

Rain reduction				
(-)30%	(-)20%	(-)10%	0%	(+) T
39.2	38.2	37.2	34.9	0
40.1	39.0	38.0	35.7	1
40.9	39.8	38.3	36.6	2
41.7	40.6	39.6	37.3	3

It should be noticed that the yield reduction is calculated using climatic data input only using reference crop (FAO, 1998). The variation in the yield reduction values for each crop results from the variation in the characteristic of each crop (amount of water required), variation in the planting date and crop cycle duration.

Table 2 represents the relation between crop yield reduction and temperature for three scenarios of reduced precipitation. Figures 2 and 3 show how the yield reduction for some selected crops changes with increasing temperature and decreasing precipitation by 10, 20, and 30%. Although crops have different yield reduction, the increasing trend shown in the graph is almost the same. Also the trend of yield reduction is greater for decreasing precipitation by 30%.

Another analysis was done by drawing the amount of rainfall in comparison with crop yield as shown in Figure 3. Some crops have relationship between the amount of rainfall and the yield response; grape, aloe, olive, plums, wheat, barley, and dry-onion. On the other hand, some crops have less relationship with the amount of rainfall; almond, squash, tomato, okra, snake cucumber, chick-peas, clover, lentil, and sesame.

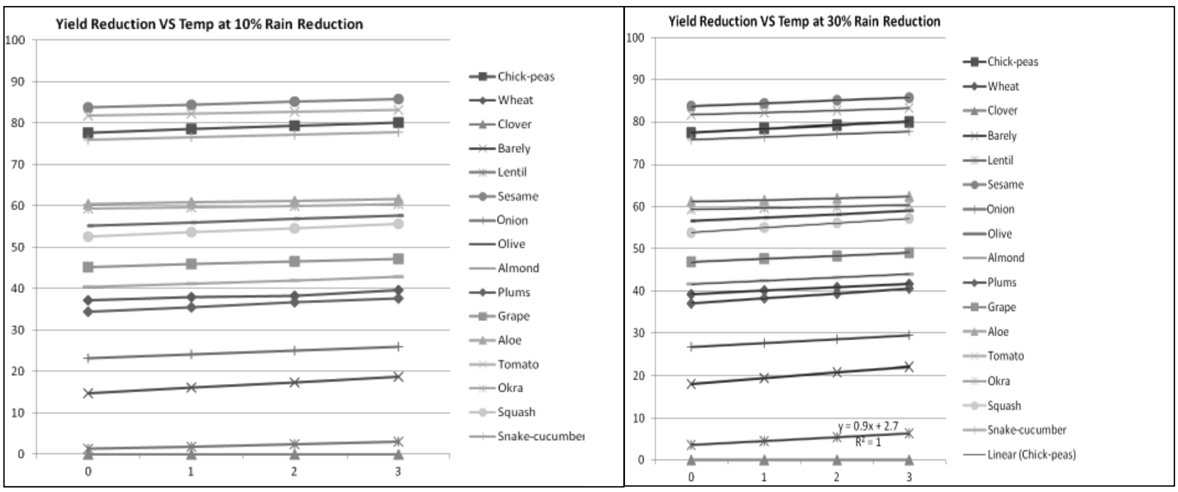

Figure 2. Yield reduction versus temperature at (10% and 30%) rain reduction.

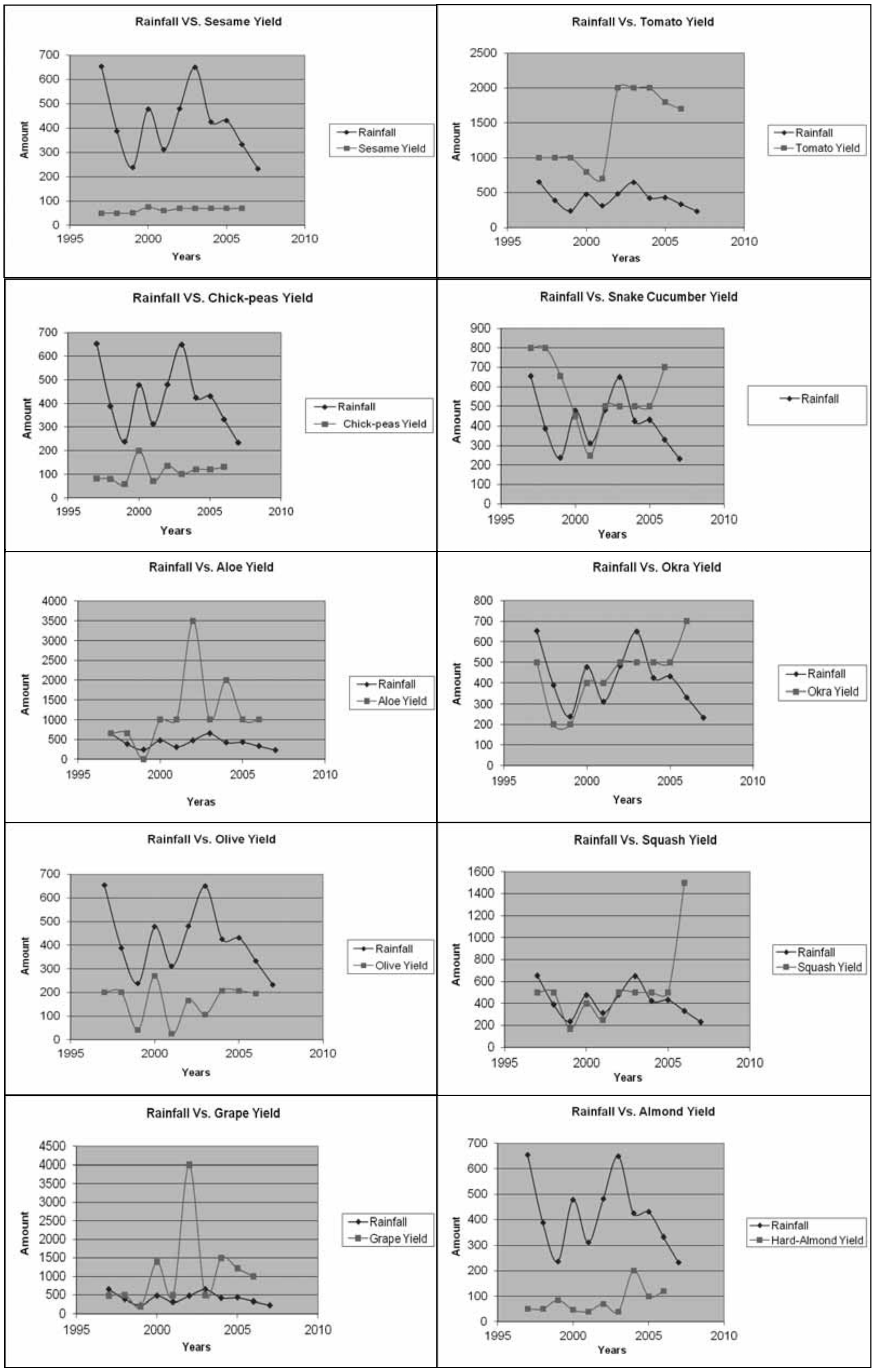

Figure 3. The relation between rainfall precipitation and yield for most vulnerable crops.

Table 2. Yield reduction equations*.

Crops	Line Equation at 10% Rainfall Reduction	Line Equation at 30% Rainfall Reduction	Vulnerability Rank
Sesame	y = 0.7x + 83	y = 0.7x + 83	1 (Most)
Tomato	y = 0.5x + 81.2	y = 0.5x + 81.2	2
Chick-peas	y = 0.83x + 76.8	y = 0.83x + 76.8	3
Snake-cucumber	y = 0.64x + 75.25	y = 0.64x + 75.25	4
Aloe	y = 0.4x + 60.8	y = 0.4x + 60	5
Okra	y = 0.36x + 58.95	y = 0.36x + 58.95	6
Olive	y = 0.8x + 55.8	y = 0.8x + 54.4	7
Squash	y = 1.1x + 52.8	y = 1.06x + 51.45	8
Grape	y = 0.73x + 46.15	y = 0.66x + 44.55	9
Almond	y = 0.8x + 40.8	y = 0.8x + 39.6	10
Wheat	y = 0.83x + 38.4	y = 0.75x + 36.4	11
Plums	y = 1.14x + 35.95	y = 1.11x + 33.3	12
Onion	y = 0.93x + 25.75	y = 0.9x + 22.3	13
Barely	y = 1.37x + 16.65	y = 1.33x + 13.4	14
Lentil	y = 0.9x + 2.7	y = 0.6x + 0.65	15
Clover	y = 0	y = 0	16 (Least)

* y: amount of yield reduction (%), x: Temperature (°C). *R^2=1 for all values*

3.2. Impact of increasing temperature and decreasing precipitation on irrigation requirement

The impact of temperature increase on irrigation requirement was examined; from analyzing the results it was shown that the main driving factor to increase irrigation requirement is the increase in temperature. Table 3 below represents the sensitivity of IWR (irrigation water requirement) of wheat crop to increased temperatures and decreased precipitation. For increasing temperature by 1, 2, and 3 °C in comparison with the current climatic condition, the IWR values are 499.4, 514.6 and 530.1, but for decreasing precipitation by 10, 20, and 30%, the IWR values are 506.5, 517.4, and 531.7 respectively. The results show that the scenario of increasing temperature gets worse when combined with the scenario of decreasing precipitation; i.e. at T +3 and P -30%.

Because all the previous studies based on expectations about the climatic conditions, In order to make the yield reduction and irrigation requirements more comprehensive for the different temperatures, an equations were created in order to calculate the yield reduction and irrigation requirements even if the temperature exceeded the expected increase (+3 °C) or less than the minimum increase (+1 °C). Table 4 illustrates the equations derived for calculating irrigation water requirement (IWR) for the most vulnerable crops in the Jenin district.

Table 3. Irrigation requirement (IR) for wheat crop.

T (+)	IR (mm)			
	0%	(-)10%	(-)20%	(-)30%
0	484.39	491.05	501.89	514.96
1	499.41	506.54	517.38	531.74
2	514.61	522.16	533.4	548.58
3	530.13	538.15	550.54	565.89

Table 4. Irrigation requirement correlations for major crops in Jenin.

Crops	Line Equation at 10% Rainfall Reduction	Line Equation at 30% Rainfall Reduction
Sesame	y = 12.27x + 501.5	y = 12.27x + 501.5
Tomato	y = 18.94x + 765.1	y = 18.94x + 765.7
Chick peas	y = 12.94x + 520.6	y = 12.94x + 521.2
Snake-cucumber	y = 16.68x + 672.8	y = 16.68x + 673.3
Aloe	y = 23.98x + 892.5	y = 24.04x + 902.7
Okra	y = 20.15x + 813.6	y = 20.19x + 814.2
Olive	y = 21.49x + 750.7	y = 21.74x + 766.7
Squash	y = 9.901x + 359.7	y = 10.20x + 364.7
Grape	y = 16.94x + 597.3	y = 17.73x + 610.4
Almond	y = 12.71x + 455.5	y = 12.71x + 464.1
Wheat	y = 15.69x + 475.2	y = 16.96x + 497.8
Plums	y = 9.419x + 286.0	y = 9.419x + 298.9
Onion	y = 8.928x + 199.9	y = 9.901x + 223.0
Barely	y = 8.548x + 237.1	y = 9.508x + 252.5
Lentil	y = 5.151x + 96.02	y = 6.724x + 112.9
Clover	y = 3.999x + 36.37	y = 4.656x + 56.49

y: Irrigation requirement (mm); x: Temperature (°C). *R^2=1 for all values*

The results also showed that crops vary in their sensitivity to temperature increase and precipitation decrease; some crops are very sensitive to temperature increase, like aloe, olive and okra. But for precipitation decrease the situation is different because some crops do not have any change with respect to change the amount of precipitation due to the time of cultivation, the most vulnerable crops are onion, wheat and clover.

The benefit from calculating the irrigation water requirement is to find the amount of water required by the plants (crops) in order to compensate for the shortage in the amount of rainfall, for each mm calculated it represents a 1.0 m^3 for each Dunum. For example at the current situation the IWR for wheat crop is 484.39 mm, which means 484.39 m^3 of water required to compensate for the shortage in precipitation.

3.3. Climate change and seasonal shift

There has been a significant change in rainfall pattern and distribution in Jenin district over the last ten years (Figure 4). The results show that there is an increase in rainfall in the months of January (a very little increase), February (a significant increase), April (an increase), and November (a significant increase). The results also show that some months have a decrease in the amount of rainfall; March (a significant decrease), May (little decrease), September and October (little decrease), and December (significant decrease). During June, July, and August there were no precipitation recorded ever in the district. It can be concluded that the winter season has shifted a little bit toward November in the beginning of the rainy season and towards April in the end of the season.

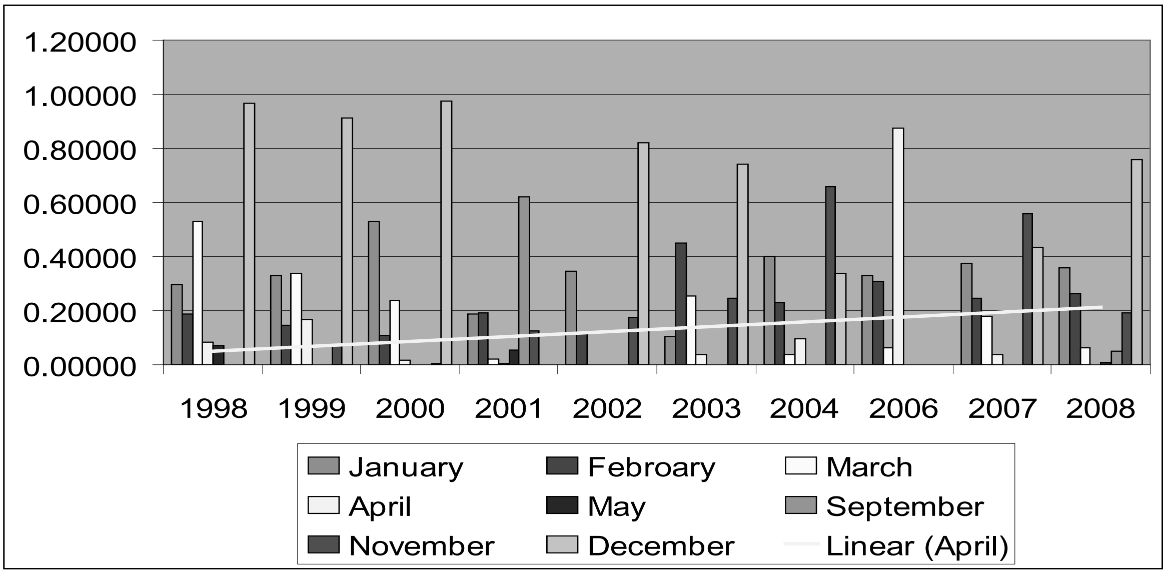

Figure 4. Changing in rainfall pattern during April (as a sample) in previous ten years

4. Conclusions and Recommendations

Any change in the climate variables will have a significant impact on the yield reduction and the irrigation water requirement for the selected crops and subsequently a profound effect on the economical losses. This study investigated how climatic variables, specifically temperature and precipitation, affect the rainfed agriculture. The study takes Jenin district as a case study, examining different climate change scenarios including increasing temperature, and decreasing precipitation.

The main conclusions of this study are as follows:

- It is obvious that the actual yield of the selected crops is changing according to the changes in the amount of rainfall especially for the plants cultivated in the rainy season.
- Under increasing temperature and decreasing precipitation, the yield reduction will be greater and the amount of irrigation water required for compensating the deficit in rain fall will be greater.
- The rainy season in Palestine is shifting toward April and May with a delay in September and October.
- The results also show that the impact of the scenario of increasing temperature on the yield reduction and the irrigation water requirement for the Jenin district gets worse when temperature increases by 3 °C and precipitation decreases by 30%.

In response to the above-mentioned results and conclusions the following measures are recommended:

- This study should be taken place in all the Palestinian districts, in order to make integration between these districts, so that each district plants the most useful crop and the best economical revenues.
- There should be comparative studies between the Palestinian districts in order to find the most vulnerable and affected district in all the Palestinian territory.

- It is time for planners to think in terms of expected change in yield reduction and irrigation water requirement due to climate change.
- The Ministry of Agriculture should use the study specially the irrigation water requirements in order to irrigate the plants with the required amount of water.
- Adaptation measures should be considered to cope with climate change potential impacts on yield reduction and irrigation water requirement, and it should be noted that most of the adaptation measures are no-regret options, in other words, they would be beneficial regardless of climate change impacts especially that Palestine is already facing water shortage due to natural water resources scarcity and other political restrictions.
- Simulated adaptation measures (such as changing planting dates, altering varieties, changing optimum value and dates of fertilizer application, using a longer maturing hybrid and irrigation) were considered as potential responses that may modify any effects of climate change on crop production. Adaptation analyses showed that mitigation of climate change effects may be achieved through new cropping varieties.
- The government should act immediately to raise awareness of framers and extended farmers.
- It is very important to have an agricultural policy that promotes certain crops for specific areas of Palestine.
- Further research is needed on the appropriate time for irrigating the plants to compensate the shortage of rainfall. Besides, other crops should be studied.

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Drought-Induced Socioeconomic Changes Among Herding Communities in Southern West Bank Area

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Abstract

The southern area of the West Bank (> 500,000 people) has undergone successive climatic stresses (i.e. water scarcity) during the last 6-7 years. Access constraints to pastures as a direct consequent of separation wall and settlements have been negatively impacting grazing activities. Besides, the significant reduction in productivity of rangelands had already forced the majority of herders in southern West Bank to feed their sheep and goats with commercially purchased fodder for the whole year around. Results of this study indicated that out of the interviewed herders, 15% faced a decrease in their herds, 16% have succeeded to keep almost 70% or more of their herds and that 56% of interviewed herders have maintained 100% of their herd size. Only 13% who have reported an increase in their herd size which is below the normal expected increase levels. Also, 42.1% of respondents indicated that they have sold part of their herds to cover household expenses, namely food. This compound water scarcity critical situation in the southern areas of the West Bank is exacerbating the perilous position of many rural communities and Bedouin hamlets. Therefore, there is a need to draw a longer term livelihood security strategy to reduce pressure on natural resources and in same time to provide better lives for affected farmers and their families.

Keywords: Drought, Coping Mechanism, Livelihoods, Herding, Flock size.

1. Introduction

Over the past six years, similar to other neighboring countries in the region, Palestine has suffered the negative effects of water scarcity and the consequent reduction of herding range lands potential. For many of the drought affected areas, global mean temperature rises with 1.5°C on average are considered as reason to reduced water supply and quality (IPCC, 2001). Bates *et al.* (2008) reported that warming over several decades has been linked to changes in the large-scale water cycle such as: increasing atmospheric water vapor content; changing precipitation patterns, intensity and extremes; reduced snow cover, widespread melting of ice; and changes in soil moisture and runoff. It's evident that water-induced challenges (i.e. having excess water, having shortage in water, and/or having unstable condition of other resources) will definitely lead to a series of coping mechanisms and socioeconomic macro changes in the lives of millions of people. In addition, Palestine is expected to be subject to water scarcity conditions for further coming years. The southern area of the West Bank has been subject to decreasing and/or fluctuating rainfalls during the last years. (Figures 1 and 2).

Food insecurity and poverty are both prevailing problems in Palestine; namely West Bank and Gaza Strip. The continuous Israeli activities on ground such as: land confiscation, free access prohibition, and control over water basins have negatively affected and often jeopardized the livelihoods of many Palestinians who rely mainly on herding and small scale plant production. The mixture of politically vs. environmentally-derived shocks have immediate, negative impacts on farmers and herders and has already perplexed wise and realistic coping mechanisms practiced by herder's families (Reyada et al., 2009). Recently, Israeli occupation is greatly limiting and threatening hundreds of herders around Jerusalem and Jericho clusters (OCHA, 2011). In terms of rangelands, some 30% of land in the West Bank is inaccessible for herders since it is considered as military buffer zones, (21%) or Israeli declared natural reserves (8.7%). (FAO and OCHA, 2008).

Taken together, the access constraints to pastures as a direct consequent of separation wall and settlements and the significant reduction in productivity of rangelands had already forced the majority of herders in southern West Bank to feed their sheep and goats with commercially purchased fodder all year round (Nassr, 2010). This compound water scarcity critical situation in the southern areas of the West Bank is exacerbating the perilous position of many rural communities and Bedouin hamlets. Therefore, there is a need to draw a longer term livelihood safety strategy to reduce pressure on natural resources and at the same time to provide better lives for affected farmers and their families.

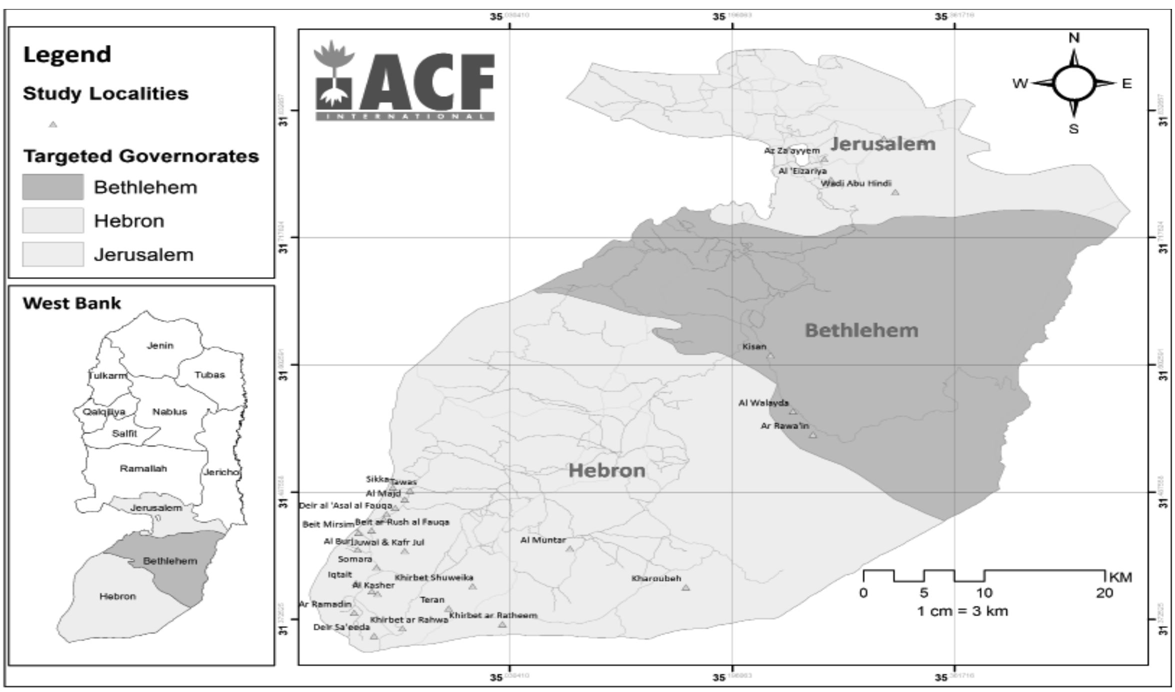

Figure 1. Graphic courtesy of Action Against Hunger showing the study sites.

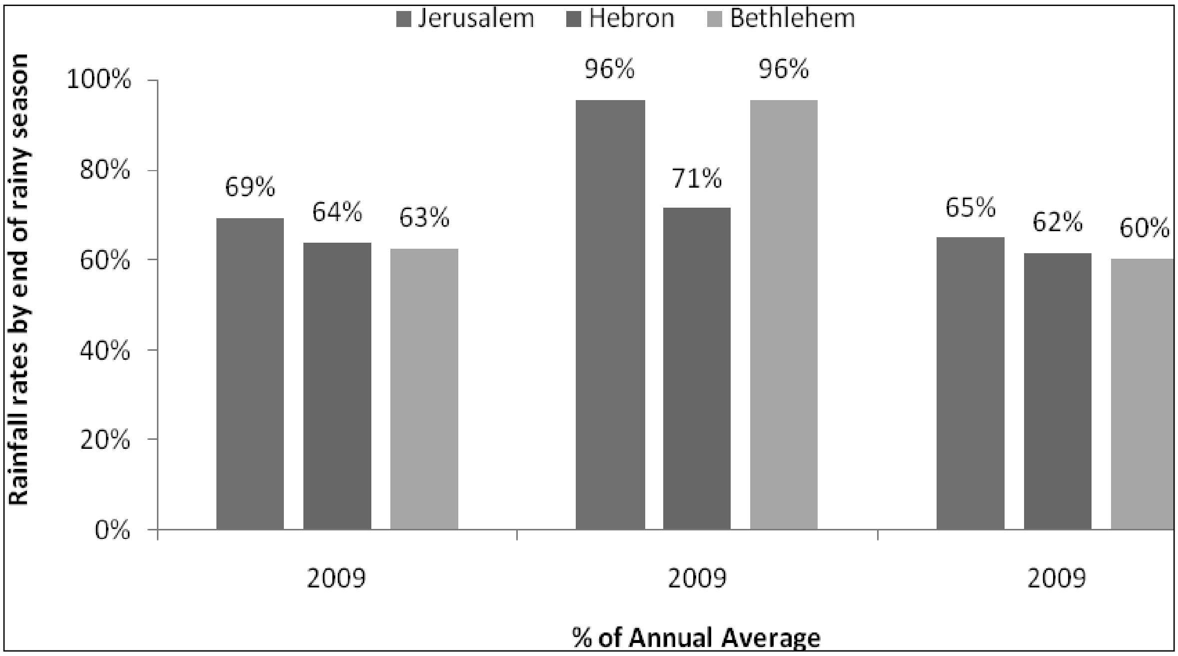

Figure 2. Historical rainfall rates in Hebron, Bethlehem & Jerusalem Governorates over the past 3 years.

1.1. Signs of Drought or Water Scarcity

The usual signs of water scarcity/drought which have been observed and reported since 1995 in southern West Bank (Basheer and Nassr, 2010) areas include:

- Drying of springs.
- Grazing of premature field crops.
- Collapse of economic trees (i.e. Olives, stone fruits) and critical affect on shrubs and grasses utilized by herbivorus animals.
- Reduced rainfall rates with an appropriate distribution.
- Overgrazing exacerbated as a consequence of stressed/reduced productivity and biomass.

1.2. Coping Strategies practiced by herder's families

Usually, and in case of drought conditions, herders have limited choices to respond to surrounding challenges. Depending on location, family's saving rates, herd size and productivity, they might adapt several strategies including but not limited to:

1.2.1. Practice overgrazing in rangeland areas; hence herders may also allow grazing on trees and productive crops sometimes thus causing additional harm to fruit trees longevity.

1.2.2. Reduction of animal ration; by reducing animal ration delivered daily with the aim of saving for more days of feeding. Within longer periods of such dangerous practice, the productivity and health measures of small ruminant sector is put at risk. (Nassr, 2009)**.**

1.2.3. Use low quality feed; which has a direct impact on animal health and productivity, as well affects the animal capacity of feed conversion.

1.2.4. Selling part of the flock; (selling part of productive mothers). In this case, herders sell the best of what they have, which will have negative multiplier effect on flock performance and sustainability of sheep and goat production. (Reyada, 2009).

1.2.5. Increased dependency of food aid and free subsidies.

1.2.6. Seeking loans (possibly falling in debts); this will further put families in risk of failure and cash needs besides compromising dignity of households used to be proud of their tribal wealth and safety. In addition, this will risk herding as a whole as a sustainable livelihood. (O'Callaghan, et al., 2009).

1.2.7. Tendency to use less veterinary care services; which in turn can expose the flock to zoonotic and infectious diseases, nutrient deficiency and weakened animal immunity in general.

Whilst the above mentioned resiliance strategies could alternatively provide short term choices for herders, ability to withstand prolonged water scarcity and droughts are still questionable given the available resources and challenges. Plus the absence of national strategy for protecting livilihoods and organizing sectorial policies. Collectively, it is imperative to highlight the relevance of support programs to herding communities with respect to global strategies to combat drought, namely agenda 21. The localized Agenda 21 affirms that "Improving the socioeconomic conditions especially for the marginal and degraded dry lands is also as a key to combating land degradation and desertification. This needs to be taken into account in the development of strategy plans" (ARIJ, 2001). This implies that improving the socio-economic conditions of herders in the marginal and degraded areas is part of combating drought and desertification as a national goal for development in West Bank localities.

2. Objectives and Methodology

2.1. Preparatory and Briefing Meeting

Prior to the survey work, a preparatory meeting was held between the researcher and the field team to elaborate on the methodology and agree upon the sample of interviewed families. The questionnaire has been discussed and agreed.

2.2. Study Tools

2.2.1. Quantitative Tool

For the data collection in this study, a questionnaire was developed; it focused on beneficiary's impressions and views from drought related stories. The survey has further explored the impact of some fodder assistance projects in respect to drought response and impact of the intervention on herding households, as well as coping strategies.

2.2.2. Beneficiary Survey:

In order to provide a representative sample, the total sample size of 176 herding households from 32 locations was proposed (Table 1). The sample had a confidence level of (95%) and an estimated (±5%) margin of error. The sample was built based on several parameters including:

- Geographical areas of herding communities.
- Herder's family size.
- Bedouin areas versus semi Bedouin/village locations.
- Gender.

Table 1. Geographical distribution per locality of the survey sample

No.	Locality	# Interviews	No.	Locality	# Interviews
1	Beit Ar Roush Al-Tahta	1	17	Teran	2
2	Dair Al Asal Al-Tahta	7	18	Eqtait	2
3	Somara	1	19	Annab Al-Kabir	4
4	Beit Mersem	2	20	Shwaikeh	1
5	Wadi Ali	4	21	Al-Burj	2
6	Al-Majd	4	22	Dair Sa'ede	1
7	Kofor Joul	9	23	Al-Walaydeh	9
8	Tawas	1	24	Ar-Rawa'en	8
9	Deir Al-Asal Al-Fouka	8	25	Al-Eizariya	10
10	Beit Al-Roush Al-Fouka	5	26	Al-Rashayde	13
11	Sikka	5	27	Al-Kassarat	13
12	Ar-Ramadin	13	28	Kesan	22
13	Ar-Rahwa	2	29	Al-Mentar	4
14	Ghofra	2	30	Al-Khan Al-Ahmar	8
16	Abu Kharroba	2	31	Wadi Abu Hindi	7
			32	Al-Z'aem	4

3. Results

3.1. Family Structure (size of the interviewed households)

The majority of the surveyed families were composed of a relatively large family sizes. 8.6% of those surveyed indicated a family size of more than 15 members, which reflects the nature of herding households and their size-associated vulnerability.

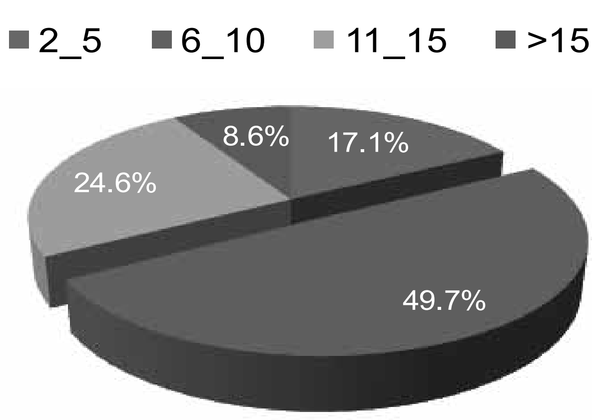

Figure 3. Herders families' size classification.

3.2. Has the status of flocks changed during the last 2 months of the survey date?

Results in Figure 3 above indicated that out of the interviewed herders, 26 faced a decrease in their flock, 35 were able to maintain 70% of their flock size, 25 have succeeded in keeping 70% or more of their flock, and 99 herders maintained 100% their flock. Only 13% (23 herders) have experienced an increase in their flock, which is below the normal expected increase level. Taken together, we assume that the fodder distribution projects duration by different organizations was slightly short for monitoring the herds' numbers at this level of study. The intervention's 2 month (~17-20% coverage) was not enough to prevent the decrease in flock in the areas affected by drought and the decline of sheep health conditions.

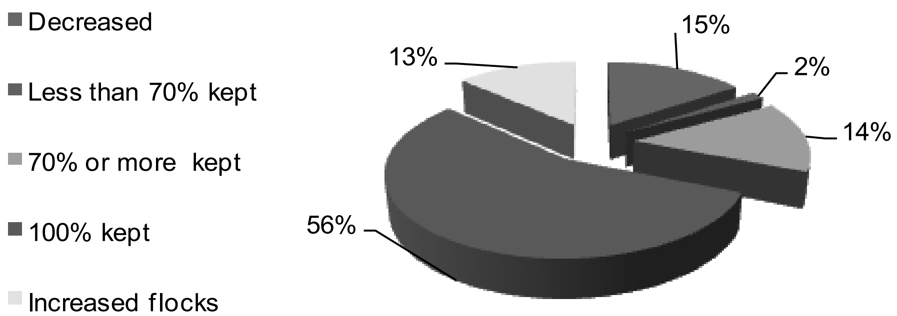

Figure 4. Percentage of herds kept during 2 months period

10.5% of those who lost parts of their herd pointed out that the reason was due to specific diseases, while 36.8% of the respondents reported the reason was unidentified death. Also, 42.1% of respondents indicated that they sold part of their animals to cover household expenses, namely food. 10.5% were sold as part of normal trade practices. It is assumed that herders sell their sheep as a first coping mechanism to deal with accumulated fodder-suppliers debt in addition to providing basic food needs.

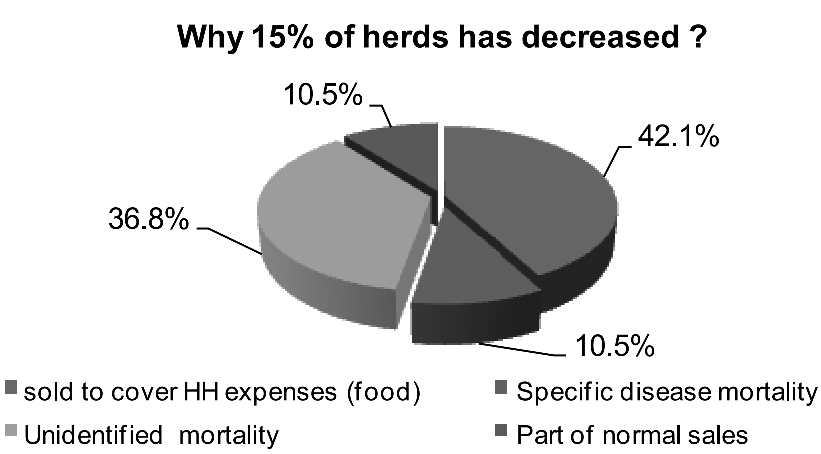

Figure 5. Reasons given for decreased herds

3.3. Reduction in fodder expenditure over the project period

The surveyed households reported that the fodder received has reduced their direct expenditure on fodder. On average, for the whole sample surveyed, herders were able to reduce their expenditure on fodder by 20%. (Figure 5)

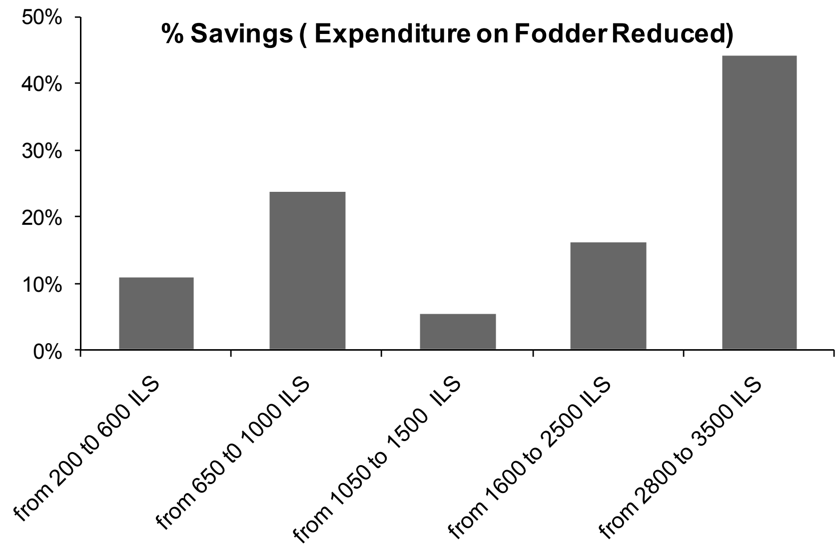

Figure 6. Percentage of savings as a result of fodder subsidies to herders.

3.4. Satisfaction with the date of delivery, amount of fodder received and Selection criteria.

Survey results (Figure 6) indicated that 96% of the interviewed beneficiaries were satisfied with the date of fodder distribution they received. A total of 4% did not think it should have taken place in October month of the year. 66% of the surveyed herders were satisfied with the amount of fodder they have been given, while 34% indicated that the quantity was not enough. In addition, 26% of the respondents expressed satisfaction with the selection criteria, while 52% were unsatisfied with it, claiming that criteria should be changed as is illustrated in the example below.

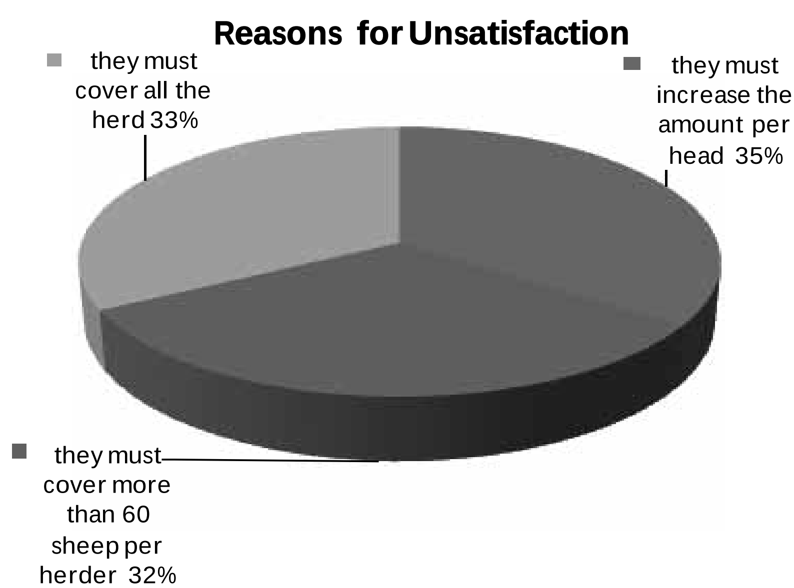

Figure 7. Reasons why interviewed herders were unsatisfied with selection criteria for fodder aid programs.

3.5. Fodder misuse (i.e. sale to other party).

None of the beneficiaries have reported for a misuse behavior such as selling part of his fodder to another party. While this phenomenon has been observed in the past when the fodder distribution projects were implemented with weak selection criteria and estimations of communities demands/needs.

3.6. Where barley seeds received by aid organizations seeded according to technical extension guidelines and trainings?

Data indicated that 89% of interviewed herders have planted the seeds they had been given, while 11% did not. As a result of the decline in the rainfall levels in some areas during the rainy season of 2009/2010, some herders didn't plant their seeds in anticipation of more sufficient rain. By the end of January, it was expected that most herders were planning to plant their seeds.

3.7. Selection Transparency

The majority of respondents (92%) believed that the selection process implemented by different implementing organizations was transparent, and only 8 % felt that it was not. They highlighted reasons for why the influence of leaders or dominating groups has affected inadequate sensitization.

3.8. Coping Mechanisms

Results indicated that 36% of the interviewed herders will continue using the system of buying fodder on credit while 37% will continue selling more productive females of their herds. In addition, 28% reported that they will adopt both practices.

Figure 8. Nature and percentage of coping mechanisms adopted by herders facing drought impacts.

4. Conclusions and Recommendations

Drought is becmoning more and more a highly probable scenario in Palestine. By distributing fodder, drinking water and field crop seeds (i.e. barley, vetch, etc.) the short-term livilihood support offered to herders and farmers from actors have temporarily contributed to relief actions in the areas affected. However, the challenge of drought in real terms has exceeded herders tolerance by inducing coping behaviours. At the long run, Palestinain herders and small farmers will be severely affected and will, in absence of national policy, change their livilihoods accordingly.

Environmental emergency preparedness is a precondition for the effectiveness of responding to emergency situations. In several countries, farmers unions and movements play a crucial role in directing national policies toward compensation and protection against environmental threats (i.e. floods, winds, frosts, drought, pests, etc.). A rights based approach is needed to address the access to emergency services provided and support needed/demanded by all these affected families. This survey has further indicated also the need to continue acting against drought, to support the small ruminant sector by collective and organized action lead by ministry of agriculture and other partners. Otherwise, the social cost of losing livelihoods because of drought will be much higher as time proceeds each year. Access to Information on drought update and families information via shared databases is important to provide joint feedback and guiding to the response partners. There is a need also to develop a national steering committee for agricultural information systems and to pay special attention to the issues of drought and livelihoods in marginalized areas. In addition, enabling more in depth livelihoods targeting and beneficiary selection mechanisms is essential to induce more ownership feeling in affected communities, insure a gender balanced distribution of the support. On the other side of the triangle, longer term interventions/drought fighting strategies have to be further investigated and lead by PA.

In addition, actors in the agricultural sector and ministry of agriculture shall work to encourage a specific support programs to Bedouin communities. Several reports and evaluations in last few years have indicated strongly that the Bedouin communities stay at edge of vulnerability in Palestine and receive little attention in national protection plans as well as recognition at international actor level.

Figure 9. Fodder distribution to herders affected by drought in Palestine.

5. Acknowledgment

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Evaluation of Treated Wastewater Reuse Regulations and Standards in Palestine

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Abstract

Although treated wastewater (TWW) is an important source for irrigation water in the West Bank, there are no major projects for TWW reuse in the area. This is due to the lacking of fully operational wastewater treatment plants with the exception of Al-Bireh plant. However, understanding the importance of treated wastewater reuse, Palestine Standard Institute issued Palestine standard 2003-742 for treated wastewater reuse. The Ministry of Agriculture adopted that standard as a requirement for TWW reuse in Palestine. In addition to that, the Ministry of Agriculture adopted regulations for TWW reuse to govern reuse activities and protect human health. Since, these standards and regulations have not been implemented yet, actual field data to evaluate their impacts and their adequacy are lacking. Thus, any evaluation of these regulations and standards will be based on comparing them with other international and regional standards and regulations. In addition to the perception of these standards by farmers and residents affiliated with reuse.

This paper tries to evaluate these standards and regulations to see their role and effects in implementing TWW reuse activities. The evaluation starts with comparing these standards and regulations with international standards. Then it moves into the response of farmers and residents to reuse activities in areas where TWW plants are proposed. This evaluation is based on interviews and surveys of farmers and locals at different parts of the West Bank.

The survey included farmers and residents from different localities including: Jenin villages (Qabatiya, Yamun, Yaabad), Azzoun (Qalqilya), Tayasir (Tubas), north West Villages of Jerusalem (Al-Qubiebeh, Beit Igza, Beit Anan, Beit Sureek, Qattanna, Bidu), Villages west of Ramallah (Betunia, Ein Jariot, Ein Qinya), Tarqumiya and Dura in Hebron.

Based on these interviews and evaluation, it was found that there is a general acceptance of TWW reuse in these villages. Farmers were concerned at the quality of TWW and the marketing potential for their crops. Comparing these standards with international standards such as WHO, it was noticed that these standards are stringent in reuse activities and demand a lot of effort and investment from the farmers. These requirements will be hard to satisfy by the farmers and they will need a lot of support and financial subsidy to be able to fulfill these requirements.

However, there is a lack of regulations, monitoring processes and actions against violators to guarantee that the quality of TWW produced at treatment plants satisfies the conditions granted in the permits of these treatment plants. Therefore, it is recommended to relax some of the regulations in reuse to encourage farmers to invest in reuse activities and projects. At the same time, put more effort on passing regulations and mechanisms to guarantee that the quality of TWW produced at treatment plants is accepted in accordance to permits and standards.

1. Introduction

The amount of water used in agriculture is estimated at about 60 mcm/a (PWA, 2011) used to irrigate about 130,000 dunums of agricultural land in the West Bank (PCBS, 2009). Irrigated agriculture contributes about 38% of agricultural production in the West Bank. Agriculture contributed about 5.3% of the GDP in 2010 (PCBS, 2011) and employed about 13% of the Palestinian labor force (PCBS, 2009). The domestic sector in the West Bank is currently utilizing about 96 mcm/a of water (PWA, 2011). Due to the increase in domestic water consumption, more water is being diverted from agriculture to the domestic sector. Thus, the need to find additional water sources for agriculture is becoming more crucial for the sustainability of the agricultural sector. One of these important sources is the utilization of treated wastewater for agricultural reuse.

There are more than 500 villages and towns in the West Bank. Most of these villages and towns do not have wastewater collection systems. Although the major cities and towns in the West Bank have wastewater collection systems, but most of them do not have operational wastewater treatment plants. Many of the existing wastewater treatment plants are under designed and not capable of treating wastewater produced at these towns with the exception of Al-Bireh wastewater treatment plant. Most major population centers in the West Bank collect their wastewater and dispose it untreated to the wadis. The disposal of untreated wastewater is creating a lot of environmental and health problems to the people and areas located around wadis where such waste water is disposed.

The negative implications of untreated wastewater disposal are clearly shown in the example of the city of Nablus due to its size. In Nablus, wastewater is collected and disposed untreated either through wadi zeimar to the west or wadi Fara'a to the east. Wastewater disposed to the east flows to Baddan where it gets mixed with fresh water there. The mixture flows along al-Fara'a wadi and is being used for irrigation along the wadi in Nassariyeh, Frush Beit Dagan and Jeftlick villages. Untreated wastewater disposed through wadi zeimar flows through the Enabta and Tulkarm creating environmental and health hazards along the wadi. Due to these negative impacts, the city of Nablus is currently constructing a wastewater treatment plant on the western side (wadi zeimar location) and is involved in designing a new wastewater treatment plant for the eastern side.

Nablus is not the only city in the West Bank with plans to construct wastewater treatment plants. Many towns and cities in the West Bank are also either planning or designing wastewater treatment plants for safe disposal of wastewater in the environment. These cities and towns are assisted by various international donors who are assisting them in designing and constructing wastewater treatment projects.

In all of these activities, reuse of treated wastewater is a major and an important component. Palestine Water Authority and Ministry of Agriculture fully understand the importance of reusing treated wastewater in agriculture for the Palestinian conditions. The amount of water used in agriculture has been severely restricted Israeli authorities which limited the amount of water extracted from irrigation wells. The total amount available for agriculture got reduced in the past 10 years due to the drying of some springs and the diversion of water from agriculture to the domestic sector which has been demanding more water due to fast growing population in the West Bank. At the same time, the increasing population is demanding more food which puts load on agriculture to produce more agricultural products thus demanding more water. Since agriculture cannot compete with the domestic sector for fresh water sources, there is a need to look at new options for agricultural water. One of these most important options is treated wastewater.

As the domestic sector is consuming about 96 mcm/a, if it becomes possible to collect and treat 50%-60% of that quantity, then an additional amount of 50-60 mcm/a is added to agricultural water supply and thus doubling the amount of water available for agriculture. The importance of these quantities is that their sustainability and the expected increase in volume over time with increasing populations and increasing domestic water demands.

The importance of reusing wastewater in agriculture resulted in developing standards and regulations for wastewater reuse activities. Such standards and regulations are essential in the success of any reuse activities.

2. Objectives and Methodology

The objectives of this study are to evaluate the existing regulations and standards for treated wastewater reuse in agriculture. The evaluation includes assessing the role and suitability of these regulations and standards in guiding and encouraging safe and appropriate treated wastewater reuse activities in the West Bank.

Since there are no significant reuse activities practiced in the West Bank, the approach utilized was to follow an indirect approach for the evaluation. This approach starts by reviewing the standards and regulations and compare them with regional and international standards. Then, field surveys for areas proposed for potential reuse activities were implemented. The areas surveyed included potential beneficiaries from a number of treated wastewater projects planned all over the West Bank from Jenin to Hebron.

2.1. Palestinian standards for treated wastewater reuse

To regulate and guide treated wastewater in a way protecting public health and safety, Palestine Standard Institute issued a reuse standard (PSI 742-2003) in 2003. The institute recently issued obligatory technical guidelines for treated wastewater reuse (PSI 34-2012). PSI 742-2003 standard covers the requirements that should be met in treated wastewater coming from wastewater treatment plants that will be discharged or reused in accordance to criteria shown in the standard itself. The standard presents a general classification for treated wastewater quality (table 1) and a number of barriers approach to utilize treated wastewater in the reuse of different crops (table 2). Therefore, depending on the quality of treated wastewater coming out from the proposed treatment plant, the farmer will need to select a number of barriers for each type of crops that will be irrigated. The number of barriers will reduce to zero for all crops presented in the standard when high quality treated wastewater will be reused. According to PSI 742-2003, the high quality treated wastewater is expected to have BOD less than 20 mg/l, TSS less than 30 mg/l and feacal coliforms less than 200 per 100 ml. The barriers include (Table 3) actions such as positioning the emitters at a distance far from crop canopy, utilizing sub-surface irrigation, utilizing filters for irrigation water, storing irrigation water, cutting off irrigation before harvesting and other possible actions that the farmer could utilize in the farm to reduce the possibility of contamination of the fruit with wastewater. The crops presented in those specifications include fodder crops, fruits, ornamentals etc that could be utilized in reuse. The standards do not allow utilizing treated wastewater reuse in irrigating vegetables.

Table 1. Classification of Treated Wastewater Quality in Accordance with Palestinian Standards (PSI 742- 2003, PSI 34-2012).

Grade	Quality	Description
Grade A	High quality	BOD5 20 mg/l at most, TSS 30 mg/l at most and Feacal coliforms at most 200 per 100 ml
Grade B	Good quality	BOD5 20 mg/l at most, TSS 30 mg/l at most and Feacal coliforms at most 1000 per 100 ml
Grade C	Average quality	BOD5 40 mg/l at most, TSS 50 mg/l at most and Feacal coliforms at most 1000 per 100 ml
Grade D	Low quality	BOD5 60 mg/l at most, TSS 90 mg/l at most and Feacal coliforms at most 1000 per 100 ml.

Table 2. Number of Barriers for Crops Irrigated with Treated Wastewater According to Palestinian Standards (PSI 742-2003).

Crop	Low quality (D)	Medium quality (C)	Good quality (B)	High quality (A)
Gardens, sports fields, parks	Not allowed	Not allowed	Not allowed	0
Groundwater recharge by infiltration	Not allowed	0	0	0
Discharge into seas at least 500 m in sea	Not allowed	0	0	0
Crops for seeds	0	0	0	0
Corn	4	2	2	0
Green fodders	Not allowed	0	0	0
Dry fodders	0	0	0	0
Citrus irrigated by drip irrigation	3	2	2	0
Citrus irrigated without drip	4	3	3	0
Crops with uneatable skin: dry almonds, walnuts, pomegranate, pistachios, pine nuts etc.	3	2	2	0
Fruits: apples, peaches, cherries, apricots	3	2	2	0
Tropical fruits: mangos, coco	3	2	2	0
Grapes with high frames	3	2	2	0
Grapes with regular frames	3	2	2	0
Cactus	3	2	2	0
Palms	3	2	2	0
Olives	3	2	2	0
Ornamentals	3	2	2	0
Forests not used as parks	0	0	0	0
Industrial crops and grains	0	0	0	0

Table 3. Examples of Barriers in Accordance with Palestine Standards (PSI 742-2003).

- An over ground surface spacing not less than 50cm between emitters and the crop or fruits of fruit trees is considered as two barriers.
- An over ground surface spacing not less than 25cm between emitters and the crop or fruits of fruit trees is considered as one barrier.
- A distance not less than 50cm between sprinkler irrigation and fruits is considered as one barrier.
- A plastic mulch between treated wastewater and fruits is considered one barrier.
- Subsurface trickle irrigation is considered two barriers.
- Other barriers
- Crops or fruits with uneatable skin is considered one barrier
- A crop or a fruit which eaten only cocked is considered one barrier.
- A Sand filter is considered one barrier
- A detention time for treated wastewater of 15 days or more is considered one barrier.
- Water storage ponds with at most 10% treated wastewater are considered one barrier.
- Disinfection of treated wastewater with chlorine with a free residual chlorine of 0.5 mg/l or more and a contact time of at least half an hour or any other disinfection method is considered one barrier.

The Obligatory Technical Guidelines for treated wastewater reuse (PSI 34-2012) require that all reuse activities should be only in accordance of uses specified by authorized authorities. The Palestinian Ministry of Agriculture which participated in developing these standards and regulations is responsible for issuing annual reuse permits for treated wastewater. These permits require that reuse is implemented in accordance to the Palestinian Standards for reuse as given by standard PSI 742-2003. In addition to that, it requires color codes for irrigation pipes carrying treated wastewater to distinguish them from fresh water (this requirement is also specified in PSI 34-2012). It also requires fencing lands irrigated with treated wastewater and putting signs on those lands indicating treated wastewater reuse. To protect the safety of agricultural workers, the Ministry of Agriculture requires that workers at fields irrigated with treated wastewater should wear special clothes and have special protection in addition to the utilization of shower rooms to allow workers to improve the hygiene situation at such farms and thus minimize health risks associated with treated wastewater reuse. However, it is not very clear who is suppose to monitor wastewater treatment plants to guarantee that treated wastewater quality is according to the permit issued. The Environmental Quality Authority (EQA) issues the permits for wastewater treatment plants, however it does not have regular plans to monitor the quality of treated wastewater. Thus, farmers who will use treated wastewater do not have guarantees that the treatment plants will continue to produce treated wastewater according to a defined preset quality.

In accordance with the regulations, the Ministry of Agriculture will monitor the farmer and if the quality of treated wastewater is not accepted, the Ministry will do actions against the farmer. Such actions might include destroying the crop and thus resulting in financial loss to the farmer. Although in such situations, the inadequate quality could be as a result of improper management of the treatment plant which should be held responsible for the quality of treated wastewater produced. Thus, the regulations put the restrictions and responsibility on the farmer when some of these responsibilities could be put on the operators of the treatment plants.

2.2. World Health Organization Guidelines for Treated Wastewater Reuse

The World Health Organization (WHO) issued several guidelines for treated wastewater reuse, the latest guidelines by WHO were issued in 2006 (WHO, 2006). WHO recommends that policies for wastewater reuse should take into consideration local conditions and policies may be emphasized within the food security or within the environmental protection policy framework. According to WHO, the main policy issues in reuse to investigate are:

Public health: To what extent is waste management addressed in national public health policies? What are the specific health hazards and risks associated with the reuse of wastewater, excreta and/or greywater in agriculture and aquaculture? Is there a national health impact assessment policy?

Environmental protection: To what extent and how is the management of wastewater, excreta and greywater addressed in the existing environmental protection policy framework? What are the current status, trends and expected outlook with respect to the production of wastewater, excreta and greywater? What is the capacity to management wastewater, excreta and greywater? What are the current and potential environmental impacts? What are the options for reuse in agriculture or aquaculture?

Food security: What are the objectives and criteria laid down in the national policies for food security? Is water a limiting factor in ensuring national food security in the short /medium /long term? Are there real opportunities for the use of wastewater, excreta and greywater in agriculture and aquaculture to (partially) address this problem? Is reuse currently practiced in the agricultural production system? Has an analysis of the benefits and risks of such waste use been carried out?

WHO understands that within the next 50 years, more than 40% of the world's population will live in countries facing water stress or water scarcity. Growing competition between agriculture and urban areas for high quality freshwater supplies, particularly in arid, semi-arid and densely populated regions, will increase the pressure on this resource. More fresh water is abstracted and used in agriculture in arid and semi-arid countries than for any other purpose (i.e. for domestic uses and industrial uses combined). In many cases, it is better to use wastewater, excreta and greywater in agriculture than to use higher-quality fresh water, because crops benefit from the nutrients they contain. Thus, wastewater, excreta and grey water can help to meet water demand and allow the preservation of high-quality water resources for drinking water. Thus, the guidelines issued by WHO in 2006 were more flexible and relaxed than the older ones. The relaxation is aimed at improving food security through utilizing more treated wastewater in agriculture. The bases of these regulations is to achieve health based targets through health protection measures such as wastewater treatment, health and hygiene promotion, crop restriction, cooking food, washing product, use of personal protective equipment etc.

2.3. FAO guidelines

FAO guidelines for the evaluation of irrigation water quality emphasize the long term influence on crop, production, soil conditions and farms management (Ayers and Westcot, 1994). Thus, FAO guidelines emphasize the impacts of water salinity and water toxicity on the plant and crop production. The guidelines present management tools to deal with the quality of irrigation water in economic and environmentally sustainable ways. The guidelines are a first step in pointing out the quality limitations of a water supply and present methods to overcome or adapt to these quality limitations. For health protection including protection of workers and consumers of agricultural products, FAO recommends using WHO guidelines for the use of treated wastewater in agriculture (Pescod, 1992).

2.4. Israeli standards

The Israeli standards are very similar to the Palestinian standards in regulating wastewater reuse in agriculture. These standards classify treated wastewater into categories and specify number of barriers to be used for each type or category of treated wastewater. The differences between Palestinian and Israeli standards are minor. Very high quality effluents are suitable for unlimited irrigation including crops eaten fresh. The very high quality effluents are those with BOD5 20 mg/l and suspended solids of 30 mg/l. These effluents contain no more than 10 E.Coli/100 ml. High quality effluents with 20/30 BOD5/SS are obligated to have two barriers in order to be used for irrigation according to the Israeli standards.

The Palestinian standards do not allow unlimited use of treated wastewater even if the quality is very high or high. The Palestinian standards do not allow irrigating vegetables with treated wastewater which is the major difference from Israeli standards.

3. Farmers Response and Acceptance for treated wastewater reuse and reuse standards

Farmers have no experience in reusing wastewater in agriculture in the West Bank, as there are no existing schemes for such reuse. Considering available standards for reuse, it is required to change some agricultural practices and patterns to cope with the standards. To assess the acceptance of farmers for reuse and reuse standards, several workshops were held at different municipalities and localities in the West Bank during the last two years. The surveys and interviews included farmers and residents from different localities including: Jenin villages (Qabatiya, Yamun, Yaabad), Azzoun (Qalqilya), Tayasir (Tubas), north West Villages of Jerusalem (Al-Qubiebeh, Beit Igza, Beit Anan, Beit Sureek, Qattanna, Bidu), Villages west of Ramallah (Betuniya, Ein Jariot, Ein Qinya), Tarqumiya and Dura in Hebron. These locations were selected because there are plans to construct wastewater treatment plants at these locations.

The proposed wastewater treatment plants at the locations above are expected to produce treated wastewater sufficient to irrigate about 6300 dunums. Considering an average farm size of 10 to 15 dunums, the expected number of families who will benefit from these projects will be 400 to 600. In the interviews and workshops about 160 people attended and answered the questionnaire. This indicates a response from about 30% of the potential beneficiaries representing a sample size which allows making some conclusions about the targeted population.

During the meetings, Palestinian standards and regulations for reuse in addition to the reuse potentials in these areas were explained to farmers and measures required in reuse were discussed and explained. In addition to these meetings, a questionnaire was distributed to farmers to see their acceptance to reuse. It was clear from the meetings, the questionnaire and the interviews with farmers that they have no serious objections to the reuse of treated wastewater in principle. However, the following observations and concerns were obtained:

- Average farm size was found to be 14 dunums with an average family size of 8 people of which 3 people worked in agriculture. Out of those interviewed, about 80% had either high school education or more. In addition to that about 69% of those interviewed had more than 10 years of experience in agriculture. This shows that most families involved in agriculture have members who are educated and experienced in agriculture. This result is important to indicate that it is feasible and safe to adopt new agricultural methods and practices in the West Bank. Thus, the risks in reusing treated wastewater are small in the West Bank and it is possible to educate people involved in implementing reuse safely instead of putting stringent reuse standards.

- It was also found that about 83% of those interviewed own the land they cultivate. Thus, educating these people on how to reuse treated wastewater could be intensive in the beginning but will become less costly with time as the same people will continue the practice. The education will continue to improve practices and to introduce new crops and methods as there will be potential to do so.

- It was noticed that agriculture is a part time job for farmers interviewed as agricultural income was less than 50% of their total income for about 75% of people interviewed. This due to the dependence on rainfed agriculture which depends on the highly variable precipitation rates and thus the low productivity of land. Farmers utilizing irrigated agriculture cultivated small plots (1 to 10 dunums) which are not sufficient for families to fully depend on financially. Farmers and members of their families have to look for other jobs to provide sufficient income to pay their expenses.

- Although about 77% of farmers interviewed did not hear or know about Palestinian Standards and regulations for treated wastewater reuse, but nearly 90% believed it is possible to reuse treated wastewater for crop production. A similar percentage was also willing to reuse treated wastewater in agriculture. This indicates a good understanding for the benefits of treated wastewater reuse in agriculture.

- There was a great variability in the areas cultivated by different farmers, some were cultivating 2 to 4 dunums while others were cultivating 10 to 100 dunums each. In many areas, irrigation water is not available for most farmers and those utilizing irrigated agriculture pay more than 7 NIS per cubic meters (mostly from domestic networks).

- It was noticed that the majority of farmers interviewed (72%) preferred reusing treated wastewater to irrigate fruit trees and for supplementary irrigation of olive trees. This is an important observation as the Ministry of Agriculture does not recommend reusing treated wastewater for supplementary irrigation of olive trees. Only 20% preferred using treated wastewater for fodder production. Thus, there is a discrepancy between the plans of the Ministry of Agriculture and farmers attitudes and preferences.

- Farmers are concerned about marketing of agricultural products irrigated with treated wastewater and the health risk associated with treated wastewater reuse. The majority of the farmers interviewed (about 80%) said they are willing to consume agricultural products irrigated with treated wastewater provided that these crops are cultivated in accordance of reuse specifications and regulations.

- Farmers are not willing to pay high prices for treated wastewater. They are willing to pay only conveyance cost. The cost that many farmers said they are willing to pay was 0.5-1.0 new Israeli shekels per cubic meters of water

- Farmers are interested in reusing treated wastewater in agriculture to move from rainfed agriculture to irrigated agriculture. They understand the importance of irrigation in the West Bank as many of them use irrigated agriculture at a very small scale.

4. Conclusions and recommendations

The study showed that Palestinian standards and regulation for treated wastewater reuse in agriculture are sufficient for regulation purposes. The standards and regulations are more stringent than international and Israeli standards. The Palestinian farmers are generally educated and could implement these standards and regulations. However, due to the limitations that the standards and regulations put and the extra cost required in implementing them, many farmers might not abide with them or reject treated wastewater reuse. The implementation mechanisms for these regulations are still not clear. Therefore, there will be a possibility that farmers might violate the standards and regulations to try to achieve more economic returns from the reuse while others might decide not to reuse treated wastewater. Therefore, it will be required from the various Palestinian ministries and institutions to re-consider relaxing the regulations and evaluate options and procedures for monitoring their implementation. Since, farmers who will be reusing treated wastewater have some degree of education, it will be possible to train them and educate them about the impacts of treated wastewater. Thus, it will be possible to advise them on how to use treated wastewater to produce crops with higher values to increase economic return from reuse. Education is a substitute for restrictions on reuse.

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Characterization of Grey Water from Country-Side Decentralized Water Treatment Stations in Northern Palestine

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Abstract

Fresh-water problem in Palestine dates back to the early 1900's due to various geographical settings and political turbulences. The problem is exacerbated by the ever-increasing demand on water by population growth and development. As pressures on freshwater resources grow in Palestine and as new sources of supply become increasingly scarce, expensive, or politically controversial, utilizing alternative options has become a must, to meet water needs. To reduce water demand by increasing the efficiency of water use and to expand the usefulness of alternative sources of water previously considered unusable. One option of supply is "greywater." The project seeks to treat and reclaim household grey water to supply irrigation water, and enhance crop production in patch gardens. The task results reveal that grey water from household activities has the potential for irrigating crops and offers many social and financial benefits to improve the residents' source of revenue. Various parameters were monitored and measured for a decentralized constructed wetland system yielding some interesting and promising data.

Keywords: Treated Grey Water, Irrigation, Agriculture.

1. Introduction

Scarcity and misuse of water are serious and growing threats to sustainable development and protection of the environment. Human health and well fare, food security, industrial development, and the ecosystems on which they depend are all at risk, unless water and land resources are managed more effectively than they have been in the past to meet the increasing population demands (Al-Jayyousi, O. 2003).

With increased population growth and development in Palestine (PCBS, 2010), the conventional groundwater sources supply is becoming increasingly vulnerable and scarce. This growth, combined with recent years of low rainfall, political turmoil, has resulted in increasing pressure on water supplies in Palestine (Amjad, 1999). To circumvent this problem, an alternative water resource plan is being advocated. Among these potential alternative sources of supply is grey water (Faruqui, & Al-Jayyousi, 2003).

Grey water from a single household, if treated appropriately, can be considered a resource and can be used on-site for garden and lawn irrigation, toilet flushing, washing machines, and other outdoor uses (Al- Hamaiedeh, & Bino, 2010). Garden watering and toilet flushing, for example, do not require water with drinking quality (Bino, Al-Beiruti, and Ayesh, 2010). Grey water refers to the wastewater generated from kitchens, laundries and bathrooms, not black water, which is waste water containing human excrement. Grey water can be used untreated, or it can be treated to varying degrees to reduce nutrients and disease-causing microorganisms. The appropriate uses of grey water depend on both the source of grey water and the level of treatment. The potential health risks associated with grey water recycling when it has been sourced from a multi-dwelling or commercial premises are considered potentially greater than those associated with grey water recycling within single domestic premises. Therefore, grey water recycling must always occur in a safe and controlled manne (Al-Hamaiedeh, 2010). In the northern part of the Palestine (West Bank), there are many communities with sparse population and large landscape area that have no permanent water resources. For domestic and agriculture purposes these communities get their water from either the seasonal rainfall or they resort to trucking water in tanks from a distant source. Those towns and villages lack proper sewage system. The reuse of grey-water at household scale has become an important tool to enhance water efficiency, which enables them to use for water for multi-purpose irrigation.

The aim of this project is to evaluate the grey water at decentralized rural treatment systems. Those stations were built within an area that has both low rainfall and low socio-economic status. Furthermore, our intention is to enhance public perception about grey water from negative to positive. This will help create better public awareness that will address the water problem effectively. Education and awareness-building campaigns play a critical role in building public knowledge and support for new water solutions. Poor water quality may negatively impact productivity due to illness, social and societal decay, and declines in public order. Also, increasing media attention, community pressure, and education on the impacts of poor water quality might lead to more support that is worth of capital investments to protect public health and water quality through the construction of grey water treatment stations.

2. Materials and Methods

2.1 Site selection

Remote, rural towns located in the Northern West Bank were considered in this project for various factors such as the amount of rainfall in the area, the willingness of the household and farmers to reuse treated grey water for certain crops, and infrastructure available at target site Jenin and Tubas governorates, located in northern West Bank, are fertile land with rain-fed agriculture and limited water resources. Both governorates depend mainly on common rainfed crops such as wheat, barely, and some forage. Also, almonds and other rainfed trees beside olive trees are the most common fruit bearing trees found in this area of West Bank. The Eastern part of this area is considered a margin region with limited rainfall that does not exceed 300 mm annually. The areas have no permanent water resources, have no sewage collecting systems, and have very low income. They also represent areas that located near NARC center which makes it easy to visit, contact and follow up. As a result, three villages in Tubas Governorate were chosen (Tammon, Aqqaba, Tayasir) and in the Jenin Governorate five towns were slected (Deir Abu Da'if, Faqoua, Jalboon, Balama, and Arab-bounah).

2.2 Household selection

Several people showed a strong interest in the applying the safe and productive use of treated grey-water in their houses, however, some were selected because they fit within the required criteria. In each locality, two public awareness workshops were held for the selection process. A list of about 35 members each representing a household attended the workshop. Eleven households were chosen to apply the project after reviewing the surveys households filled out. The following parameters were considered in selecting households to engage in the activities leading to the safe use of grey-water in irrigation: Household is not connected to a sewage collection system; the number of person per household is more than 5 persons; has at least 500 m2 garden space close to the house; flexibility and interested in reusing of grey-water irrigation; the ability of grey-water separation from the domestic wastewater; the monthly consumption is more 15 cubic meter; presence of electricity source; and the landscape nature is easy to work in.

2.3 Grey water station construction

NARC research team built grey water treatment system to meet household needs. The constructed wetland system was developed by ICARDA, adopted and modified by NARC. The design of the treatment unit - "wetland system" is comprised of a gravel filter medium, mostly crushed, volcano rocks (Zeo-Tuff-2cm). The system was divided into four compartments as shown in Diagram 1: The grey water from the house is transferred to the manhole through a PVC pipe (diameter = 4 inches) for further gravity separation. The manhole contains two valves for maintenance and controlling overflow to cesspits, and is covered with a concrete lid (diameter 50cm, depth 50cm). Gravity separation: A 100 L tank which separates grey-water into three layers: solids in the bottom (if present), upper layer of grease and oils, and middle layer consisting of grey-water.

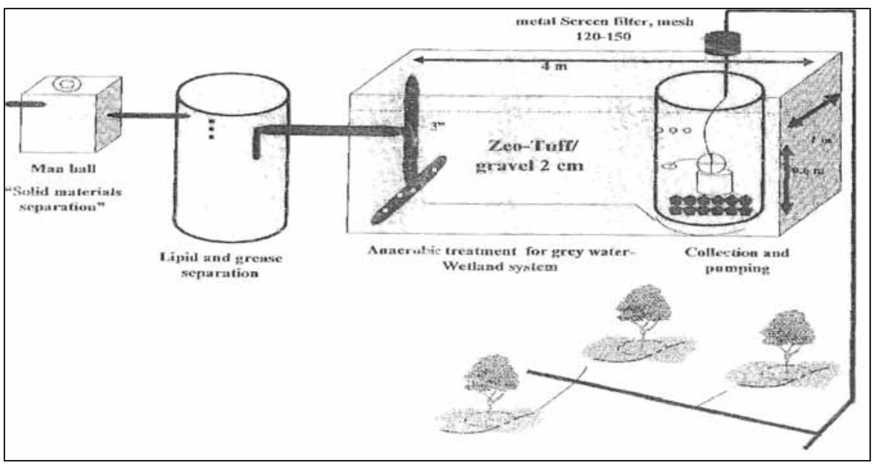

Diagram 1. Sketch of the Grey Water Treatment Station.

There is a filter connected to the end of the line to take the water to the next part. The other end is connected to a pierced horizontal 3˝ tube. The upper end of the U-tube is connected to a 50cm tube for sampling. The 3˝ U – pipe tube where used to transfer the middle layer (water) to the next part. The third compartment is used as upflow tuff. This part has been constructed from concrete and cinder-blocks (Dimensions W=80cm, H=80cm, L= 4m). The compartment has slight ground slope of 1%. There is a layer of soft sand to adjust the slope and to protect internal black-plastic cover (thickness 600 micron). An insulating sheet of polystyrene (thickness 2cm) is placed between the walls of the compartment and the black-plastic cover. Finally, the volcanic tuff (diameter ~20 mm) was placed in the compartment.

The fourth compartment (barrel = 100 liter) is a collection and a pumping stage. This drum is placed below the ground level by a 25 cm. A concrete slab is poured in the barrel to hold it in place. Holes of 0.5 cm are then drilled through the sides of the barrel to a height of up to 50 cm. Then, a submergible pump is installed within the barrel and an electric aeration unit is installed to pump the air from bottom of the barrel to the top (bubbling air). A drip irrigation system is connected with the setup to efficiently distribute the water to the garden trees.

2.4 Instrumentation and Chemicals

For measuring the BOD values, 250 mL of wastewater of samples collected and stored in amber jars. The BOD sensor (VELP Scientifica) that fits on these bottles was used. Samples were incubated at 25-30 C for five days. This instrument reads the values over five days. An electric conductivity (E.C. 214, HANNA Instrument) meter was used for measuring the EC values from which the TDS values were calculated. A spectrophotometer (LABOMED, Inc.) was used for measuring the nitrates values at 220 nm. A flame photometer (spectrolab FP 102) was used for the determination of the sodium and potassium cations. Water hardness (magnesium and calcium) was measured using standard titrimetric method after buffering the samples with ammonia/ammonium chloride buffer. Eriochrom Black T (EBT) was used as indicator for calcium and magnesium EDTA titrations. The murexide indicator was used for calcium (pH at 13) EDTA titrations.

3. Results and Discussion

A water treatment system shown in (Diagram 1) can serve as an efficient, self-contained, wastewater treatment system. Because the system treats and dispose of household wastewater onsite, they are often more economical than centralized sewer systems in rural areas where lot sizes are larger and houses are spaced widely apart. Water quality can be analyzed by tests designed to measure its suitability for agricultural purposes. Water that looks clear and pure may be contaminated with pathogenic microorganisms. For example, 105 (100000) bacteria per milliliter of water is invisible to the naked eye. Therefore, even water that appears “pure” must be tested to ensure that it contains no microorganisms that might cause disease. On the other hand there are so many potential pathogens that it is impractical to test for them all. Because of this, tests have been developed for indicator organisms. These are organisms that are present in feces (or sewage), survive as long as pathogenic organisms, and are easy to test for at relatively low cost.

Indicator organisms signify that fecal pollution has occurred and microbial pathogens might be present. Total and fecal coliforms, and the enterocci-fecal streptocci are the indicator organisms currently used in the public health arena. Coliform bacteria include all aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas formation. There are three groupings of coliform bacteria used as standards: Total Coliforms (TC), Fecal Coliforms (FC) and Escherichia coli. Total coliforms are the broadest grouping including Escherichia, Enterobacter, Klebsiella, and Citrobacter. These are found naturally in the soil, as well as in feces. Fecal coliforms are the next widest grouping, which includes many species of bacteria commonly found in the human intestinal tract. Usually between 60% and 90% of total coliforms are fecal coliforms. E. coli are a particular species of bacteria that may or may not be pathogenic but are ubiquitous in the human intestinal tract. Generally more than 90% of the fecal coliform are Escherichia (usually written as E. coli). A decentralized modified-wetland water treatment system was adopted for several advantages. First, an extensive sewer system is not necessary. Second, low-cost solutions are possible. Third, the system is applicable in densely as well as sparsely populated areas. Fourth, Segregation of grey wastewater from “black” wastewater is possible. And fifth, environmentally feasible grey water treatment and sustainable water management are possible.

The grey water treatment station collects, stores, treats and may disinfect grey water. Our stations were built and installed in residential households to provide treated grey water for use for irrigation (agricultural garden needs). Some measured parameters included the following indicators: (a) Biochemical Oxygen Demand recorded over five days (BOD5) (b) Total Suspended solids (TSS) or Total Dissolved Solids (TDS). (c) Thermo-tolerant Coliforms or E. Coli (an indicator of fecal contamination) forming units (cfu) per 100 mL. (d) Anions such as Residual chlorine and carbonates.

(e) Cations and water hardness such as sodium, potassium, calcium and magnesium cations. Table 1 shows mean values of the various testing parameters. The data indicate a significant reduction in all parameters, with the exception of EC and pH.

Table (1) The Summary of Averaged Data Acquired from the Stations for Raw and Treated water

Parameter	Raw water	Treated water	Differences eses
pH	6.1	7.6	1.4
Ec(mmohes)	1.5	1.5	0.0
HCO3(ppm)	476.1	441.8	-34.3
Hardness (ppm)	770.0	605.7	-164.3
TDS(ppm)	987.3	917.3	-69.9
Na^+ (ppm)	330.8	297.8	-33.0
Ca^{2+}(ppm)	89.5	78.4	-11.1
Mg^{2+} (ppm)	132.2	99.6	-32.6
Cl^- (ppm)	297.5	334.2	36.7
K^+(ppm)	37.3	32.1	-5.2
$NO3^-$(ppm)	38.0	17.5	-20.5
BOD (ppm)	126.6	30.0	-96.6
E-coli (cfu/100ml)	395.0	176.4	-218.6
T.Coliform (cfu/100ml)	*232.3	*208.3	-24.0

The efficiency of treatment in the stations shown in Figure 1 indicates the removal capacity of the treatment unit. Mean BOD5 from five locations was lowered by 96.6 ppm. Average BOD5 over the entire period for all sampling stations was 126.6 mg/L (with a range from 86 mg/L-245 mg/L). We sampled the sites since March 2011. Although we are working with a limited data set, it appears that BOD5 values fluctuated from period to period and from station to another. Typical BOD5 values for grey water as reported in the literature range from 33-290 mg/L, while values for untreated domestic wastewater range from 100-400 mg/L (Siegrist, 1977).

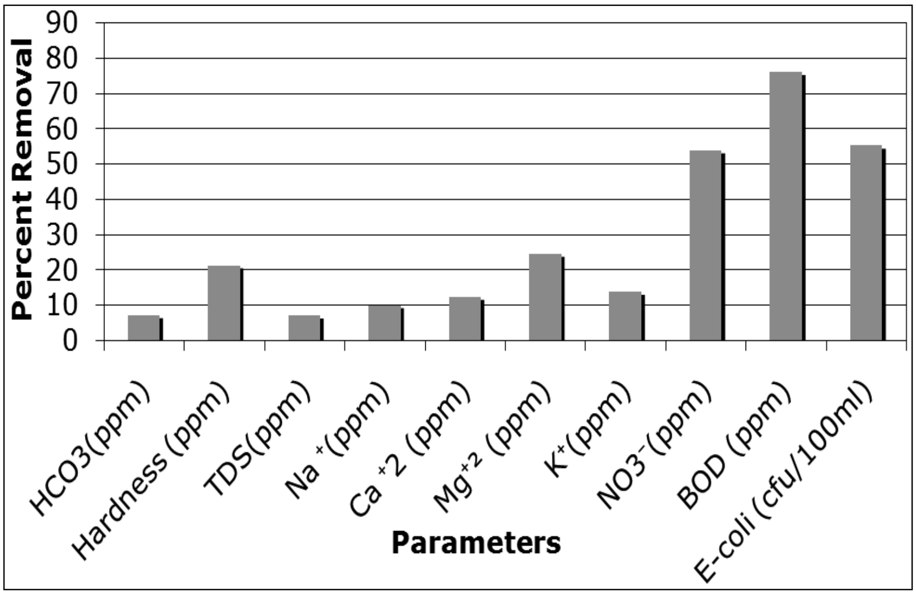

Figure 1. Efficiency of Treated Grey Water System as Percent Removal

Wastewater contains organic substances typically in the form of carbon, hydrogen, oxygen, and nitrogen and may contain other elements. Common concentrations of these organic materials in grey water in the forms of proteins (40 to 60 percent), carbohydrates (25 to 50 percent), and oils and fats (8 to 12 percent). The water may also contain small amounts of synthetic organic molecules (i.e., pesticides and solvents), which may range from simple to complex in structure. Biochemical oxidation reactions convert organic material using oxygen and nutrients into carbon dioxide, water, and new cells, which can be expressed as follows:

Organics + O2 + nutrients → CO2 + H2O + new cells + nutrients + energy

In this equation, one can assume that organisms use oxygen to breakdown carbon-based materials for incorporation into new cell mass and energy. As mentioned previously, the frequent measure of this oxygen use is biochemical oxygen demand (BOD). BOD is defined as the amount of oxygen used in the metabolism of biodegradable organics. If water with a large amount of BOD is discharged into the environment, it can deplete the natural oxygen resources. Heterotrophic bacteria utilize deposited organics and O2 at rates that exceed the oxygen-transfer rates across the water surface. This can cause anaerobic conditions, which leads to noxious odors and degradation of water quality. BOD5 in grey water sampled just prior to discharge to gardens averaged 30 mg/L with a range of 29-79 mg/L, TDS ranged from 400-2400 mg/L with a mean of 987 mg/L.

Many of the microorganisms that exist in wastewater might be beneficial. In fact, many wastewater treatment technologies are dependent on these beneficial microorganisms for remediation of wastewater so that it won't destructively impact the environment. One of the primary purposes of water treatment system is to remove organic matter from wastewater so that excessive oxygen consumption won't become a problem when it is released to the environment.

Another aim of these treatment systems is nitrification/denitrification. Nitrification is an aerobic route in which bacteria oxidize reduced forms of nitrogen (NH_4, NO_2, NO_3). Denitrification is an anaerobic route by which oxidized forms of nitrogen are reduced to gaseous forms (NO_3-, NO_2-, N_2O or N_2), which can then escape into the atmosphere. This is important because the release of nitrogen to the aquatic environment can also cause eutrophication, which is really not so important in our case, since the water will be used in direct irrigation rather than release into streams.

However, the specific health problem associated with increased levels of nitrogen is methemoglobinemia or blue-baby syndrome. This disease is a direct result of elevated concentrations of nitrite in water. In this project, it was observed that stations decreased concentrations of nitrogen as shown in Figure 3 nitrate values ranged between 12-83 mg/L with a mean of 38 mg/L. Nitrate values were lower in effluent than in the raw grey water with reduction of 53.99%. This indicates that a significant amount of de-nitrification occurred, which is shown clearly in Figure 3.

The pH values averaged 6.1 before sampling (range 5.04-7.01) and 7.6 after sampling (range 7.1-7.99). The lower pH values may result from the use of water without any alkalinity adjustment, whereas the high figures indicate the presence of bleach. Total Coliform counts generally were high and exceeded our dilution ranges. Guideline (Dixon, Butler, & Fewkes, 1999) for Fecal Coliforms in reclaimed water for irrigation is set at 200 cfu/100. Jefferson et al. (2001) published data showing suggested appropriate values for domestic wastewater recycling of <10,000 and <2,000 cfu/100 mL for TC and FC, respectively. Our results show that grey water samples occasionally exceed these values. This suggests that direct human contact with grey water should be avoided, unless the wastewater is disinfected.

TDS values were reduced by 7% as represented in Figure 2. Total coliforms were lowered by 11.5%

which was good considering that these microbes occur in large quantities in the soil. E. Coli detected in the effluents by 55% lower than in the raw grey water. This indicates a high efficiency of the stations in removing pathogens. Data showed a considerable variation both within and between different sites.

The interesting result shown in Figures 2 and 3 give efficiency of 76% for BOD, 7% for TDS, and 54% for NO_{3-} which falls within the standards approved by the Palestine Standards Institute recently and by the Palestinian Authority (2012). The institute classifies the water quality according to A (high quality), B (good quality), C (medium quality), D (low quality) system. As an example, the institute gives the specifications for BOD_5 as 20 mg/Liter (A-quality), 20 mg/Liter (B-quality), 40 mg/Liter (C-quality), and 60 mg/Liter (D-quality) respectively. With respect to NO_3-, the institute gives 20 ppm for high quality, 20 ppm for good quality, 30 ppm for medium quality and 60 ppm for low quality. The TDS values were 1200, 1500, 1500, and 1500 ppm for high, good, medium and low quality respectively.

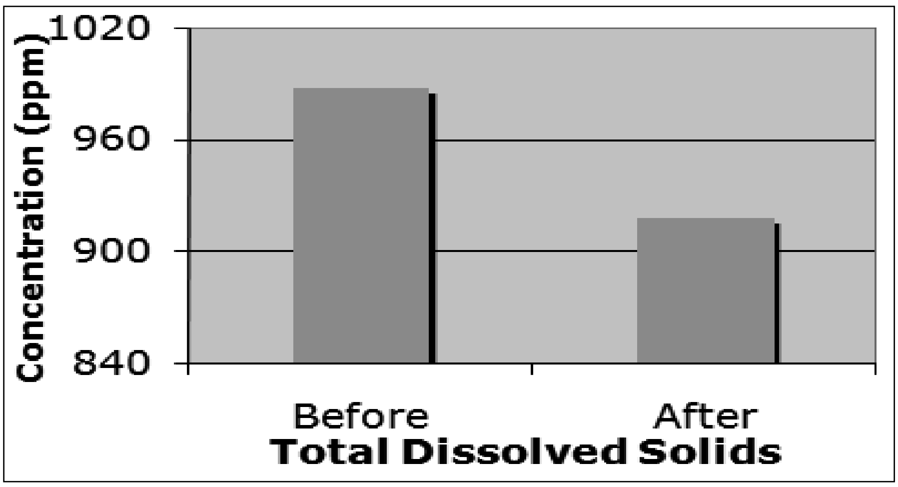

Figure 2. Lower TDS Reading in the Treated Water than Untreated Water.

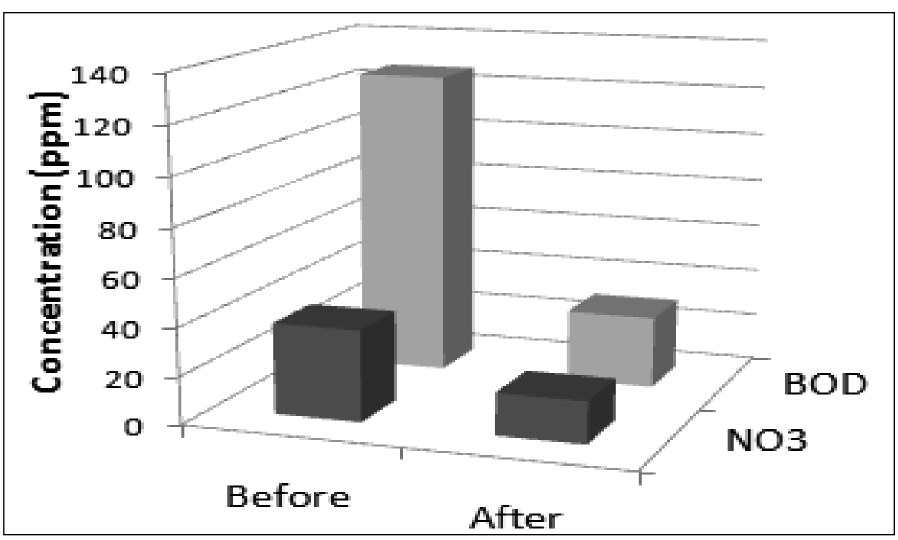

Figure 3. Values of Measured Nitrates and BOD5 prior and after treatment

4. Conclusions

Various treatment processes are suggested in the literature, but since on-site grey water recycling is a relatively new practice in Palestine, only few systems can be constructed in this area due to it geographical location.

The treatment stations build are based on physical process that diverts water after treatment and allows immediate use of water for landscape and garden irrigation or storing it temporarily in a tank. Overall, the grey water stations worked well, and interviews with community members indicated wide community interest in, the grey water stations.

Grey water reuse might serve as a promising strategy in terms of the significant local water saving, reducing the risk of water borne diseases, especially in marginalized rural areas. However, some important questions may arise regarding grey water reuse such as acceptability with regard to religious and cultural values; affordability and financial benefits; difficulty; and ability to improve access to sufficient quality and quantity of water. Answers to such questions can be addressed by in public awareness seminars and training activities related to such projects.

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Wastewater Sector Status in Palestine and Reuse Opportunities

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Abstract

The Palestinian wastewater treatment sector in Palestine is manifested by inadequate management due to insufficient infrastructure, unsafe disposal of untreated or partially treated effluent and unplanned use of low water quality. The current wastewater treatment plants, established during 1970-1980 under the Israeli occupation, are overloaded and badly maintained with aging equipment, thus posing serious environmental and public health hazards. The challenges behind this unsustainable wastewater sector are exacerbated by the lack of institutional coordination reflected by multiple stakeholder involvement leading to institutional fragmentation and lack of coordination. By law, the Palestinian Water Authority (PWA) is responsible for all regulatory, planning, monitoring, research and training functions. Despite the current valid Palestinian effluent quality standards, urgent efforts pertaining to effluent monitoring and regulations enforcement are needed. To promote feasible wastewater treatment facilities (WWTFs) crucial strategic regulatory and planning policies were stipulated. Wastewater should be collected, treated and reused where feasible and the design of WWTFs should be modular and community-based with effluent using different options. The institutional capacity for implementing and enforcement of water-related rules and regulations should be enhanced. WWTFs including reuse schemes form a key element of an integrated water management strategy with coordinated institutional cooperation.

The PWA is committed to sanitation services enhancement in the Palestinian communities to protect public health and the aquatic environment, where the reclaimed effluent must be used for various applications. But the effluent reuse practices and reuse are not limited to be used as nonconventional water resources, but also it is used and infiltrate to the groundwater and to the receiving water bodies mainly the wadis.

Keywords: Sanitation, wastewater, wastewater treatment, effluent reuse, Palestine.

1. Introduction

The wastewater sector status in Palestine is characterized by poor sanitation, different wastewater quality, insufficient treatment, unsafe disposal of untreated or partially treated wastewater and the use of untreated wastewater in some areas to irrigate edible crops. Few treatment plants are found in Palestine and most of the treatment plants were built in 1970s and 1980s under the Israeli occupation, while the most recent one was built in the 1990s in Al-Bireh by a German fund. The majority of the treatment plants are overloaded, badly maintained, and poorly equipped which form a major threat to the plant workers, the farmers, and the consumers. The reuse of treated wastewater is practiced on a small scale and this option has been generally absent from wastewater treatment plans.

Reuse of treated wastewater often disproportionately benefits to poor quality. It must be combined with strategies to prevent or mitigate health risks from pathogens, heavy metals, pesticides, and endocrine disrupters and environmental damage from heavy metals and salinity. Long-term institutional coordination among water, agricultural, environmental, and service providers and end users is a requirement for water reuse investments to pay off. Investments in urban water supply and sewerage coverage are raising, however, adequate treatment for agricultural reuse with acceptable risk mitigation for human health and the environment will require further investments. While there will be investment reuse after treatment, it is critical to ensure that investments in treatment appropriate for reuse schemes will be made to reduce the cost of treatment. Moreover, the urban wastewater is well suited to agricultural reuse and landscaping because of the reliability of supply, proximity to urban markets, and its nutrient content. To have an impact on scarcity, reuse of wastewater must substitute for, but not add to the existing uses of fresh water.

The Palestinian Water Authority, the regulator of the water sector, prepared a draft reuse strategies in 2003 that encourage and enforce the reuse of treated wastewater, the followings are the main principles of the strategy:

- The reuse of treated wastewater must be established in all treatment projects.
- Co-operation and coordination must be established with all relevant stakeholders.
- Flexible reuse plans should be developed to enable the reuse and storage in winter season and when the effluent quality drops below the standards.
- Establishment of the planning tools (Regulations, Standards, Guidelines, etc.) for reuse and recharge.
- Discharge to the surface water may be considered as an interim action, or if reuse is not feasible.
- Irrigation of crops eaten raw is prohibited, enforcement means should be applied.
- For better water quality and reuse efficiency, consider (i) mixing of treated effluent with urban and surface runoff, (ii) artificial recharge of groundwater with treated effluent wherever possible, and (iii) establish surface storage of treated effluent with or without harvested runoff.
- Allow private sector and/or public to manage or share the management of wastewater reuse projects.
- Develop a program for modifying use habits to include reuse of treated effluent in urban centres (greening, fountains, urban parks and landscape irrigation forestation, and other areas).

The water and wastewater sectors in Palestine are governed by two agreements with the Israeli side:

- The Palestinian-Israeli Interim Agreement on the West Bank and Gaza Strip, Washington, D.C, September 28, 1995; Annex III, Protocol Concerning Civil Affairs, Article 40, Water and Sewerage.
- The Memorandum of Understanding on Guidelines and Technical Criteria for Sewerage Projects, signed on 31st December 2003, Israeli-Palestinian Joint Water Committee.

The MOU is the most recent document that governs treatment and reuse standards and will consequently drive the treatment technology and reuse strategies that will be used in Palestine. The MOU sets out agreements for the collection systems, wastewater treatment, sludge treatment, effluent reuse and disposal, sludge reuse and disposal and cooperation between the two sides. The MOU's very high standards will make implementation costly and very difficult even though a phased implementation approach to meeting requirements has been agreed.

The implications and requirements of the MOU include the following:

1. All sewerage projects must be complete systems-i.e. collection systems from source, conveyance to treatment plant, treatment plant, a plan for reuse or safe disposal, conveyance to point of reuse or discharge, and safe disposal or reuse of sludge.

2. Treatment plants must be modular to allow for future expansion: in the first phase secondary treatment must be achieved; in the second expansion phase tertiary treatment must be achieved.

3. Agricultural reuse is to be the primary focus for reuse. This must include seasonal effluent storage.

4. Other forms of reuse must gain mutual agreement from both parties.

5. Industrial wastewater must be treated separately in a pre-treatment facility.

6. Alternatives for the location of treatment plants must be presented to both parties and the selection will be agreed in the Joint Water Committee.

The challenges facing the sanitation sector are further compounded by the existence of a multitude of governmental and non-governmental institutions involved in the water sector, leading to institutional fragmentation and lack of coordination. In overall, there is an unclear understanding as to the roles and responsibilities of each institution in the treatment and reuse of wastewater. Today, most of the municipalities are in charge of supplying water and collecting wastewater, but these institutions suffer from limited financial and managerial capacities to perform their functions. In order to achieve more coherent institutional framework, the PWA is therefore pushing for the establishment of strong regional water utilities which would be responsible for all services, including water supply, wastewater collection and reuse. The PWA would be responsible for all regulatory, planning and research functions. This institutional arrangement is reflected in the Palestinian Water Law of 2002. Efforts have been made by the PWA to adopt effluent quality standards of WHO and USEPA, but more needs to be done in terms of monitoring the quality of effluent and the enforcement of regulations.

In addition, a reliable financial structure with cost recovery mechanisms and incentives for farmers to use the treated wastewater is lacking in the West Bank and Gaza (WBG). There is no comprehensive pricing policy or prices for reuse in the Palestinian Territories. Currently, farmers do not pay for the reuse of treated wastewater, if any, nor do they pay a penalty for irrigating crops with untreated wastewater.

Although finding the proper financial incentives is critical to cover, at a minimum, the operation and maintenance costs of any reuse scheme, capacity-building, awareness raising and assistance to farmers are also key to achieving a rational pricing policy and to encourage farmers to use treated wastewater for crop irrigation. Farmers do not trust the monitoring of water quality carried out in the WBG and have a preference for reliable, inexpensive and better quality groundwater. However, there are indications that farmers are willing to pay and use treated wastewater for irrigation of crops. In addition to marketing skills training, they need to receive proper information about the impact of treated wastewater on crops. They also need to understand the more severe restrictions on the cultivation of high-value crops with treated wastewater.

Therefore, given the scarcity of water resources and the projected growth of water demand in the next decades in the WBG, wastewater is seen by the Palestinian Water Authority not only as a means to protect the environment and the quality of surface and groundwater resources but also as a means to increase the availability of water supplies mainly for agriculture and, where appropriate, for aquifer recharge.

2. Wastewater Collection and Treatment in West Bank and Gaza

Before the Israeli occupation of the West Bank, the Palestinian communities were small and used cesspits to treat the wastewater generated in their dwellings, this having been the traditional system for sewage disposal for many centuries.

Nowadays, the existing management practices for wastewater in the West Bank are limited to the collection of generated wastewater by sewage networks and cesspits. Furthermore, wastewater treatment facilities are restricted to a few localities in the West Bank. This, combined with the population growth, exerts such pressure that sewage systems in urban areas together with wastewater treatment plants have become a major priority: sewage networks are very limited and are insufficient. In the West Bank, 30% of the population is connected to wastewater collection networks (many of them are old and badly designed, which is the cause of frequent floods and leaks), whereas the rest of the population depends on cesspits, open ditches and a small part on septic tanks.

As for the rural population of the West Bank, which accounts for 25.8% of the total population, the situation is no better. Only 36 localities out of 510 in the West Bank are connected partially to sewage network, whilst other communities discharge their wastewater into cesspits (without appropriate lining, which facilitates its infiltration into the soil) and open ditches. Moreover, tankers are hardly used due to the high cost of this type of service. For all these reasons, wastewater is almost uncontrolled, and this causes serious environmental problems and health risks (PWA, 2012). This situation is aggravated by the impact of untreated wastewater that is disposed of by the 257 Israeli settlements which are in the West Bank region affecting the neighbouring Palestinian villages and agricultural land.

The West Bank population generates 72 million m^3, which implies an amount of supplied water of 100 million m^3/year. As mentioned before, most of the collected wastewater is discharged untreated into the environment. The effluent of 52% of the public sewage networks flows untreated into open areas, while the effluent of 6% of the sewage networks treated or pre-treated in wastewater treatment plants. The effluent of the remaining percentage (42%) of the sewage networks is treated in Israeli treatment plants and reused for irrigation purposes (PWA, 2010). The major wastewater stream flow is in WadiZeimar, Wadi el-Sajour (Nablus), WadiBeitunia (Ramallah), Wadi en-Nar (Bethlehem) and Wadi as-Samen (Hebron). However, sewage networks in the West Bank are rarely supported by wastewater treatment facilities. Appropriate treatment of wastewater has been neglected throughout the West bank; both during the Israeli occupation and to the present conflict, and little investment has been made in the field of wastewater treatment since the Oslo Accords. There are 5 existing central wastewater treatment plants (WWTPs), 13 existing collective wastewater treatment systems.

In several instances, the wastewater that crosses the green line or Armistice line in 1949 is treated in Israeli treatment plants and reused for irrigation purposes. The cost of this treatment is normally charged to the Palestinian Water Authority. In 2010 the costs deducted by Israel amount to approximately 200 million Israeli Shekels (NIS) of Palestinian Tax Revenues for Wastewater Treatment (EWASH Advocacy Task Force, 2010).

3. Central Wastewater Treatment Plants

There are two existing central wastewater treatment plants (WWTPs) located in Al-Bireh and Ramallah cities in addition to Tulkarm pre treatment wastewater plant. The old WWTP in Jenin is currently under rehabilitation and is expected to start operation in October 2010. A new central WWTP will be constructed to serve the western parts of Nablus city and the nearby five villages with the support of the German Government through the German Development Bank (KfW). The table below outlines the location of the existing and under rehabilitation and construction central treatment plants, the applied wastewater treatment technology, the operational year and status of the WWTPs (table 1) in the West Bank and (table 2) the general features of wastewater production and collection in Gaza Strip.

Table 1. Treatment Plants in West Bank

Governorate	Name of Wastewater Treatment plant	Wastewater Treatment Technology	Operational Year	Design Flow for Dry Weather (m3/day)	Actual Flow (m3/day)	Population served (person)	Status of WWTP
Ramallah & Al-Bireh	Al-Bireh Wastewater Treatment Plant	Extended Aeration Process	2000	5,750	5,000	46,000	Operating well with high efficiency
Ramallah & Al-Bireh	Ramallah Wastewater Treatment Plant	Extended Aeration Process	1975 and rehabilitated in 2002/2003	na	2,200	22,000	Not operating well (overloaded) and does not meet the requirements for effluent discharge
Tulkarm	Tulkarm Wastewater Pre-Treatment Plant	Primary Treatment (Stabilization Ponds)	1972 and rehabilitated in 2004	na	7,120	73,270	Operating well with high efficiency
Jenin	Jenin Wastewater Treatment Plant	Aerated Lagoons	Operation is expected to start in October 2010	9,250	9,000	40,000	Under rehabilitation
Nablus	West Nablus Wastewater Treatment Plant	Activated Sludge Process	Operation is expected to start by the end of 2012	1st design phase (year 2020): 13,509	2010): 7,500 (2020): 14,000	110,000	The construction is expected to start in August 2010

Table 2. General features of wastewater production and collection in Gaza Strip.

Governorate	Population Capita	Connect to Sewage network %	Sewage Production M3 / day	Treatment Availability	Final Destination
Northern	290, 000	80%	23,000	Available Partially Treatment	100% Infiltration basins East & North of Gaza Strip
Gaza	550, 000	90%	60,000	Available 80% Partially Treatment & 20% Raw	100% to sea (50,.000 partially 10,000 Raw)
Middle	220, 000	55%	10, 000	Not Available	100% Wadi Gaza and to the Sea 10,000 Raw
Khan Younis	280, 000	40%	9,000	Available Partially Treatment	100% to sea (30.000 cesspit)
Rafah	185, 000	65%	10,.000	Available partially Treatment	100% to sea 10.000 partially
Total	1,525,.000		41 Mcm / yr		38 Mcm /y To sea

4. Status of wastewater infrastructure

The wastewater sector in the West Bank and Gaza (WBG) is characterized by poor sanitation, insufficient treatment of wastewater, unsafe disposal of untreated or partially treated water and the use of untreated wastewater to irrigate edible crops. Few treatment plants are found in the West

Bank and Gaza and most of the existing treatment plants have been built in the 1970s or 1980s under the Israeli occupation. The majority of the treatment plants are currently overloaded, badly maintained, poorly equipped and thus represent a serious environmental and public health hazard for both plant workers, farmers and consumers. Whether in urban or rural areas, the reuse of treated wastewater is practiced on a small scale and this option has been generally absent from wastewater treatment plans.

Approximately 60% of the houses in the urban communities are connected to sewage systems. The connection rate in the major cities varies between 50% in Qalqiliya to 85% in Bethlehem. Some large towns and cities have no system at all, and wastewater is discharged into septic tanks and/or emptied into Wadis. The wastewater collection system in Nablus and Hebron are combined systems that collect both wastewater and storm water. In most cities, rainwater is allowed to runoff on the surface and eventually reaches the Wadis. The situation in the refugee camps can only be classified as very poor. Wastewater is channeled into open drains until it flows into either a sewage network in a nearby city or is simply transported to outside camp boundaries. In the villages no sewage networks exist and wastewater is collected in cesspits or septic tanks. Most of the Israeli settlements in the West Bank have sewage networks and most of these settlements discharge the wastewater into Wadis without any treatment.

The conditions of the sewage systems vary, depending on the age and material of the pipes. Older pipelines, especially those of glazed clay are badly deteriorated or are too small for the present increased wastewater flow. In some areas, the system is further deteriorated due to poor house connections made by unqualified plumbers or by households themselves.

There are three malfunctioning wastewater treatment plants (WWTP) in Jenin, Tulkarem and Ramallah and non-operating one for Hebron. This without mentioning the WWTP in Gaza strip that facing the same problems but more acute, since its direct impact on the water resources stored in the fragile geological structure mainly composed by sandstone formations that characterize the area

5. General benefits of wastewater reuse

The reuse of wastewater reduces the demand on conventional water resources, and so may postpone investment in a new mobilization of conventional water resources / developing new drinking water supplies. Additionally, the reuse of wastewater reduces the volume of wastewater discharged, resulting in a beneficial impact on the fresh water resources (surface and groundwater), the environment and public health by protecting receiving areas against pollution. For certain types of reuse, constituents of the wastewater can be used for beneficial purposes, such as for example nutrients in agriculture.

6. Effective management of wastewater across the West Bank and Gaza

Improving wastewater treatment and reuse in the West Bank and Gaza is a high priority because these are highly water-stressed areas. Water quality suffers from pollution and over-abstraction. Wastewater treatment plants are overloaded, so some is discharged without treatment. In many parts of the area the existing municipal water supply system can provide an average daily consumption of no more than 70 litres/capita, compared to the World Health Organization minimum standard of 100 litres/day for small rural households.

Better management of wastewater could reduce total water demand, reduce the stress on the water supply system, and address health issues. The Palestinian Water Authority (PWA) is increasingly keen to act, especially given the predicted increase in population and the fact that water is a highly sensitive political issue.

There is currently some limited reuse of wastewater, but it is carried out in an unsustainable manner. The situation has not been helped by the existing weak institutional capacity for wastewater reuse, an incomplete legal framework, very low cost recovery and the continued political conflict. Rural Palestinian areas in the West Bank and Gaza Strip are subject to serious environmental threats. These threats stem from gaps in institutional and policy measures available. Discharge of untreated wastewater, unregulated agricultural practices, and a general lack of infrastructure lead to adverse environmental impacts – such as deterioration of ground and surface water quality.

7. Reuse of treated wastewater in irrigation as a strategic approach for semi arid zone.

Treated wastewater is now being considered as a new source of water that can be used for different purposes such as agricultural and aquaculture production, industrial uses, recreational purposes and artificial recharge. Using wastewater for agriculture production will help in alleviating food shortages and reduce the gap between supply and demand. The interest in the reuse of treated effluent has accelerated significantly in the West Asia region since 1980 for many reasons;

- Expansion of sewerage system networks and the increasing number of treatment plants.
- Production of large quantities of wastewater which makes its use for agriculture a viable alternative.
- Wastewater is a rich source of nutrient and can reduce the use of fertilizers.
- The reuse is a safe disposal of wastewater which will reduce the environment and health risks, and
- The treatment of wastewater to be used for irrigation is cheaper than that needed for protection of the environment. Regulations to discharge water into sea and streams or groundwater recharge are stricter than reuse for irrigation.

In addition, the reuse potential in West Asia countries is very high due to the extreme water scarcity. Now, there are at least eight countries in the region that operate modern wastewater reuse facilities for agriculture production. About six countries are practicing reuse in unplanned uncontrolled and direct use for irrigation without restriction. In Yemen, Syria, Lebanon, Palestine Territories, Egypt and Iran, raw sewage is being used for agriculture production. Three countries in the region discharge raw wastewater to the surface water (rivers) without considering management of reclaimed water as a source. In Bahrain, about 12 MCM of tertiary treated wastewater is used for irrigation of fodder crops in a government farm. Some private farmers are using treated effluent for the production of alfalfa. At present the remaining part of their 50 MCM treated effluent is discharged to the sea. The government of Bahrain is planning for full utilization of the treated sewage effluent for irrigation purposes by the year 2005. This of course will reduce the pressure on their already mined groundwater resources.

In Egypt, the practice of reuse of wastewater started in Cairo city in 1911 to irrigate Jabal al-Asfar farms covering an area of 1260 hectares. In 1994, about 200 MCM of treated wastewater was estimated to have been used for irrigation; the rest of about 450 MCM was discharged to surface water bodies of the Nile, drainage canals and the sea. By the year 2000, the treated wastewater production will reach a potential of 4.9 BCM per year. This amount is planned to irrigate an area of about 400,000 hectares of desert land.

In Jordan, the volume of treated wastewater produced in 1998 reached 74 MCM per year, of which about 95% is reused for irrigation. The reuse of treated wastewater in Jordan reached one of the highest levels in the world. About 80% of the treated effluent is discharged to Zerqa river where it is collected and stored downstream in King Talal Dam to be used for restricted irrigation in the southern part of the Jordan Valley. The remaining 20% which is not located within the Zerqa river watershed is reused on-site. The treatment and reuse of this vital resource is well organized. Future plans aim at improving the quality of effluent and expanding its reuse in other areas in the upland.

In Kuwait, about 25% of its agriculture and green areas are irrigated using 52 MCM of treated wastewater. The rest is either used for artificial groundwater recharge through basin filtration or being discharged to the sea. For the rest of the Gulf States, the future aim is to achieve a high quality effluent through secondary and tertiary treatment for irrigation of green areas and ornamental trees in the streets.

In the Palestinian Territories (West Bank and Gaza), the untreated effluent was used for irrigation of trees and vegetables in an uncontrolled manner. The situation will improve in the future with the heavy involvement of donor agencies and the Water Authority in reconstructing the whole water supply and sanitation infrastructure.

The trend in other countries like Lebanon, Syria, Iran, Iraq and Yemen is to expand the use of wastewater for irrigation. In Iran, for example, there is about 70 MCM of primary treated effluent that is used for irrigation. The new management reform action related to the water sector considers wastewater as a new source that should be used for irrigation.

Farmers in Yemen living near discharge sites of wastewater in major cities like Sana'a and Taiz are practicing reuse of non treated or partially treated effluent. Wastewater from the waste stabilization pond near Sana'a Airport is conveyed through open channels to agriculture plots where farmers use the water for irrigating maize, wheat and barley. At present, there is a continuous development in Yemen to implement sewerage networks and treatment plants. The produced wastewater can reach 40 MCM by 2005 where it will be used for irrigation.

Artificial recharge of groundwater is another option for reuse of reclaimed wastewater either directly or indirectly. By this, the already over exploited aquifers in the region can be restored. Few cases of artificial recharge have reported in the region; especially in Oman, Egypt and Jordan. Recently PWA in cooperation with PHG (NGO) both are involved in assessment project to evaluate the potentiality and possibility of this technology taking the existing Biet Lahia wastewater treatment plant as a pilot. Cities of Ismailiyah and Suez of Egypt and Aqaba of Jordan use the effluent of their wastewater stabilization ponds for artificial recharge of groundwater via rapid infiltration basins.

Table 1 summarizes the current type of reuse in the West Asia region and describes the level of treatment and restriction regulation on crop selection and disposal to the sea. The reuse opportunity potential in West Asia is very high due to the following conditions:

- Extreme water scarcity, which affects economic development with little chance to create feasible alternatives for a water supply having excellent quality and competitive price as in the case of reclaimed water.
- Wastewater is a good reliable source and if there is a good design for reuse, there will be no health problems expected.
- The reuse capital investment can be paid back with a reasonable period for both suppliers and users.
- The socio-cultural acceptance is there.

In most West Asia countries sewage effluent provides a convenient and economic source of water for irrigation can be summarized in Table 3. In the last decade there has been a significant move to formalize health risks and use the treated effluent with the highest possible efficiency. In addition to wastewater being reused, nutrients can be recycled through irrigation as well. This will protect water bodies from eutrophication and will at the same time use the fertilizer value in the reclaimed wastewater to meet the fertilizer requirements of a wide range of crops.

Table 3. Summary of existing and proposed re-uses installations in West Asia countries.

Country	Reuse application						Level of sewage treatment			Policies
	Roads	Parks	Indust	Aqua-culture	Agri.	AR	Primary	Second-ary	Tertiary	
Bahrain					*			*		O3+ R
Egypt				*	*	*	*	*		ND
Iraq							*	*		To river
Jordan					*	*		*		R
Kuwait					*			*	*	R
Lebanon					*		*			ND
Oman	*				*	*		*	*	R
Qatar	*	*							*	TI
Saudi Arabia	*		*		*			*	*	O3+ R
Syria					*		*			ND
UAE					*		*	*		O3+ R
Yemen					*		*			ND

AR:artificial recharge ND: not decided	R:restricted TI: trickling irrigation

In comparison with other neighboring countries, although Palestine is the less in term of water consumption, nevertheless the share of treated wastewater in reuse is almost neglected and does not exceed the community level and small wastewater treatment plant with low cost technologies. The bellow table gives an overview of the quantities of wastewater discharged through the sewerage network and the quantities that are being re-used in seven countries. The quantities that are not being re-used are directly or indirectly discharged into the sea or evaporate from streams and reservoirs.

In Palestine there are several types of technologies in the research levels or on the applied levels most of them can be categorize as in (table 4) below.

Table 4. Wastewater Collection Systems in West Bank and Gaza.

Locality	Wastewater Treatment Technology	Operational Year	Design Flow (m3/day)	Actual Flow (m3/day)	Status of PWWT
Kharas	Up flow Anaerobic Sludge Blanket (UASB) - Horizontal Flow Constructed Wetlands	2003	120	100	Not Functioning (since March 2010)
Nuba		2002	120	200	Malfunctioning
BaniZeid (Al-Gharbiyeh)	Up flow Anaerobic Sludge Blanket (UASB) - Vertical Flow Constructed Wetlands	2004	100	20	Functioning well with moderate efficiency
DeirSamit	Septic Tank - Anaerobic Up flow Gravel Filter	2001	13.5	na (Overloaded)	Malfunctioning
Hajja	Sedimentation Tank – Horizontal Flow Constructed Wetlands	2004	30 - 40	40	Functioning well with moderate efficiency
Sarra	Constructed Wetlands	2004	na	na	Not Functioning (since 2006)
Biddya	Septic Tank – Horizontal Flow Constructed Wetlands	2007	11.2	na (Overloaded)	Malfunctioning with low efficiency
Zeita	Septic Tank – Anaerobic Upflow Gravel Filter – Aerobic Trickling Filter – Polishing Sand Filter	2008	14	30-35	Functioning well with moderate efficiency
Sir	Septic Tank – Anaerobic Upflow Gravel Filter – Aerobic Trickling Filter – Polishing Sand Filter	2008	2006	14	15
‘Attil	Septic Tank – Anaerobic Upflow Gravel Filter – Aerobic Trickling Filter – Polishing Sand Filter	2006	14	na (Overloaded)	Malfunctioning with low efficiency
Zeita	Septic Tank – Constructed Wetland	2004	na	na	Malfunctioning with low efficiency
‘Ein Siniya	Anaerobic Baffled Reactor – Activated Sludge Process – Multimedia Granule Filtration – Ultraviolet Disinfection	2007	10	na	Not Functioning (since the mid of 2009)
Nahhalin	Extended Aeration Process – Chlorine Disinfection and Sand Filtration	Extended Aeration Process – Chlorine Disinfection and Sand Filtration	2007	50	50

8. Institutional Framework for Wastewater Management:

The development of an appropriate and effective institutional framework for the safe and efficient installation and implementation of water re-use projects was seen as a vitally important factor in ensuring the success of water re-use projects. The success of water re-use projects does not just depend on the effectiveness and suitability of the technology, but also on the presence of an institutional framework that ensures that the treated water can be distributed and used safely and efficiently. Wastewater Reuse in some MENA countries summarized in the following Table as general stud y for the generated and treated wastewater according to figure 1

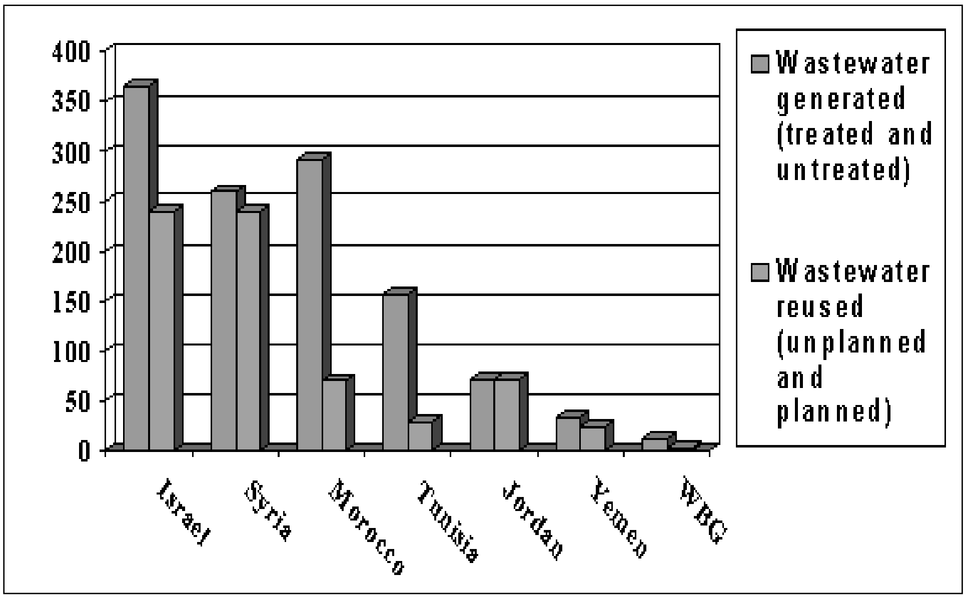

Figure 1. Wastewater reuse in MENA countries summarized report of the regional workshop held in Cairo, 2001.

9. Wastewater Treatment and Reuse, Institutional and Legal Aspects.

The large number of institutions involved and the complex system of wastewater treatment and reuse require the establishment f a sound institutional framework for coordination among the stakeholders. A reuse project should be a result of coordination between the stakeholders where each stakeholder has its part of shared responsibility. Unfortunately in the developing countries the institutional arrangement is very controversial and complex. The complications could run from an overlap of responsibilities to the absence of well-defined mandates. The general role s that everybody wants the benefits but none feels responsible when work and/or expenses are necessary. The fore-mentioned obstacles are present in Palestine and the challenges facing the wastewater sector are further compounded by the existence of a multitude of governmental and non-governmental institutions involved in the wastewater sector leading to institutional fragmentation and lack of coordination. Overall, there is an unclear understanding as to the role and responsibility of each institution in the treatment and reuse of wastewater. Today, most of the municipalities are providing the wastewater collection and few are providing the wastewater treatment. The PWA is pushing for the establishment of strong regional utilities which will be responsible for providing the water services including wastewater collection, treatment and reuse.

The NWC which is the platform for coordination between the stakeholders and the decision making level is at present nothing but a group of inactive members headed by a very busy Prime Minister who has little time to spend on water resources management. Today there is an urgent need to activate the NWC to resolve the dispute on responsibilities between the stakeholders of the water sector and one of the workable suggestions for the activation is to reconsider the level of the governmental members in the NWC and the chairman of the NWC.

The appropriate management of wastewater treatment and reuse requires a well-established legal and regulatory framework. The absence of some regulations and laws or lack of their enforcement could result in serious damages, of health, economic and environmental natures. In Palestine the laws and regulations for wastewater treatment and restricted reuse for agriculture and groundwater recharge are drafted, the problem lies with their enforcement due to many internal and external factors. A reliable financial structure with cost recovery mechanisms and incentives for farmers to use the treated wastewater is lacking in Palestine. There is no comprehensive pricing policy or prices for reuse in Palestine. The farmers do not pay for reuse nor do they pay a penalty for using wastewater in irrigation. On the ground the situation is further compounded by the existing weak institutional capacity for wastewater treatment and reuse, an incomplete legal framework, very low cost recovery and the continued political instability.

The PWA as the regulator for the water sector and in close cooperation and coordination with the stakeholders should start a carefully phased approach to treatment of wastewater, reuse, and implementing the regulatory framework that prohibits untreated wastewater use, this will significantly mitigate the environmental and public health risks associated with the practice elsewhere in the world.

10. Institutional and Regulatory Framework

Most West Asia countries have issued regulations and standards that are used to implement their wastewater management policies. The application of these regulations is stricter in oil producing countries, whereas they are relaxed in other countries. These regulations cover agencies in charge of, collection of sewage, treatment process and disposal and discharge. In Jordan, Saudi Arabia, Oman, Egypt and other countries, the discharge of industrial and commercial wastewater into the sewerage system is strictly prohibited unless such effluent comply with standards of domestic wastewater. If these regulations are violated, the concerned agencies have the full right to take immediate actions including imposing penalties. All house owners or leaseholders residing in an estate, which is served by a sewerage system network, are encouraged to connect.

The discharge of surface runoff water or storm water into the sewerage system networks is strictly prohibited. The regulation and standards for the quality of effluent, its disposal and reuse are well established in many countries. In the Gulf States, tertiary treatment of wastewater including ozonation or chlorination is needed before effluent is allowed to discharge into the sea. Receiving water standards are applicable for Egypt, Iraq, Syria, and Lebanon and to a lesser extent, in Jordan.

Recently, a guideline to direct the reuse of reclaimed water has been given the necessary importance with regard to the associated health and environmental impact. The first draft for proposed guidelines for effective wastewater management and_wastewater reuse in Palestine is prepared by Bir Zeit University through a MEDA project named efficient Management of Wastewater (EM water).This project is part of a regional project includes Egypt , Jordan, Tunes and other European courtiers, where Bir-Zeit university was awarded to implement it at National level. To this end a steering committee from different stakeholders encompasses Ministries such as PWA, EQA, Ministry of Agriculture, in addition of Bir Zeit University and other stakeholders at community level was formed to steer the project's progress. Final draft will be available at MEDA web site after being approved by the donor and SC members. There is a Palestinian Standards for the Treated Wastewater – PS-742-2003 - & industrial effluent discharge Standard PS-227–June 1998 which have been prepared by a special committee & accredited by the Palestinian Standards Institute**.**

The main components of standards are as below:

1. Field.
2. Definitions (Wastewater & Reclaimed wastewater).
3. General Guidelines.

4. Specifications / (Quality of the treated wastewater).
5. Classification of reclaimed wastewater (A, B, C, D)
6. List of Restrictions or Barriers (11 barriers)
7. Allowable crops for unrestricted irrigation with the following general criteria:
   - The treated wastewater must meet the specified standards that vary according to the planned use.
   - When treated effluent is used for irrigation of fruit trees, cooked vegetables and fodder crops, irrigation must be ceased two weeks before collecting the products. Fallen fruit should be discarded.
   - The adverse effect of certain effluent quality parameters on the soil characteristics and on certain crops should be considered.
   - Use of sprinkler systems for irrigation is prohibited.
   - Use of treated effluent in the irrigation of crops that can be eaten raw such as tomatoes, cucumber, carrots, lettuce, radish, mint, or parsley is prohibited.
   - Closed conduits or lined channels must be used for transmission of treated effluent in areas where the permeability is high, which can affect underground and surface water that could be used for potable purposes.
   - Dilution of treated water effluent by mixing at the treatment site with clean water in order to achieve the requirements of this standard is prohibited.

Use of treated effluent to recharge an aquifer, which is used for irrigation water supply purposes, is prohibited. Nevertheless; (this issue is still under discussion from PWA and MoA) waiting the evaluation of a pilot project named (Gabardine) that is under implementation in cooperation between Palestinian Hydrology Group and PWA.

The Palestinian wastewater and reuse sector strategy calls for adequate institutional capability to manage resources and infrastructure and to regulate wastewater sector activities. This necessarily implies substantial capacity building actions in the areas of wastewater reuse management, operation and maintenance, and development of service utilities. It is anticipated that institutional activities implemented under this management scenario will include a wide range of interventions, including planning and management, legislation and standards, environmental protection, financial and economic actions and institution building.

Some of the main current institutional bottlenecks include:

- Lack of adequately trained human resources;
- Unclear designation of responsibilities between stakeholders with a tendency of insufficient delegation;
- Low level of enforcement - due in particular to the insufficient number of inspectors, the lack of monitoring data and equipment, and conflicts in allocation of regulatory responsibilities, plus a culture of producing data without analysis. Legislative change will not have any effect if enforcement is not improved;
- Insufficient awareness of issues related to wastewater; and
- Lack of a separation of governance functions from service delivery.

11. Guiding Principles

- Wastewater reuse governance and institutional strengthening – develop institutional capacity for implementing water law, monitoring, analysis and enforcement of quality standards, awareness raising and education on potential of wastewater reuse (inter alia through pilots).
- Clarification of roles and responsibilities amongst institutions urgently needs to be defined.
- Utility development – develop institutional framework to facilitate development of public water utilities to maintain wastewater reuse service in. As a first step this means bringing together local actors, e.g. clusters of villages in Joint Service Council for Planning and Development (JSCPDs) to show them the advantages of belonging to a bigger institutional network.
- It is important to take the existing capacity of institutions that will be or need to be involved into consideration in the appraisal of any options. In areas where good cooperation has been established between clusters of villages and successful work has been carried out on acceptability of wastewater reuse, this would provide a positive environment for introducing options.
- Options that meet the requirements of the MOU of 2003 between the Israelis and Palestinians should be preferred. The legal/political status is a pivotal factor that will ultimately determine the success or failure of the options and therefore needs to be given adequate consideration.
- Implementation of the water law in the area of wastewater treatment and re-use will require the development of by-laws on the reuse of wastewater (jointly with MoA) and pre-treatment of industrial wastewater.
- The Palestinian wastewater sector has strategically to consider the development of Regional water and wastewater utilities, for example in the southern, central and northern parts of WBG. These need to manage water and wastewater services, O&M of infrastructure, and fee collection. At present, none of these utilities are in operation.
- Awareness raising should be coupled with market assessments, promotion and other studies which demonstrate the value of benefits from treatment and reuse. Marketability should be a major consideration, particularly if produce is recommended for export to outside markets.

12. Treated wastewater quality standards

The wastewater quality achievable in practice depends on the treatment processes provided at any particular treatment plant and it is essential to match the use of the final water requirements with that level of quality. From the point of view of wastewater re-use in agriculture, however, additional quality characteristics important for health and agronomic reasons are necessary including bacteria, viruses, helminthes, protozoa and physio/chemical parameters such as conductivity and the sodium absorption ratio.

Primary treatment of municipal wastewater will remove primarily settled solids together with any adsorbed or entrained materials, such as heavy metals, which might be associated with the solids. The effect of primary treatment on health and agronomic parameters is of minor significance, except that there may be a high level of toxic heavy metals accumulated in the sludge. Conventional secondary treatment of sewage in biological filters or activated sludge plants is designed to remove more of the biologically degradable organic material, and typically removes up to 80–90% of the BOD5 remaining after primary treatment. Again, the health and agronomic parameters are little affected by conventional secondary treatment processes.

Further upgrading of secondary effluent is possible in tertiary treatment processes but complex combinations of unit processes are required to achieve a high quality of effluent for unrestricted use in agriculture. Stabilization ponds can achieve high quality effluent standards with low cost, easily operated systems but the land take is high. In order to meet the need for highly quality treated wastewater new technologies are being developed and studied throughout the world.

12.1. Planning of wastewater re-use projects

Because there are risks associated with the reuse of treated wastewater and sludge in agriculture, any proposed wastewater re-use scheme must be carefully planned and strictly controlled through local and national institutions.

12.2. Risks and potential constraints

There are several constraints to wastewater reuse: Health problems, such as water-borne diseases and skin irritations, may occur if people come into contact with reclaimed water or products that were produced with reclaimed water. In some cases, reuse of wastewater is not economically feasible because of the requirement for an additional distribution system. The reuse of reclaimed wastewater may not be culturally or religiously accepted in some societies therefore; treated wastewater standards must be achieved by the involvement of different key ministries like EQA, MOH, PCBS among others. PSI, EQA, PWA, MoH and MoA has conducted a standers draft study for treated wastewater for irrigation.

The success of a wastewater re-use scheme depends on the strong commitment of the wastewater treatment organization to achieve consistent operational performance at all times. The need for a properly empowered body to control the allocation of land for irrigation with treated wastewater was seen as an urgent priority.

Using reclaimed wastewater in urban areas is not practiced so far, but it appears that reclaimed wastewater reuse in urban areas for toilet flushing and street cleaning is feasible. This is because the majority of countries in the West Asia region face an increasing growth of high-rise buildings, where reuse for toilet flushing is a promising option, since it is the most economic application method for highly-populated urban areas, if a nearby agricultural area is not available. In West Asia countries there are three cities of over three million people, according to 1996 statistics, where this method can be applied. Decision-makers of local authorities must consider this option as a technically feasible option.

13. Main Institutions Involved in the WWT and Reuse Process

In terms of wastewater treatment and re-use main institutions that in a way or another are and should be involved in the whole process starting from generating the wastewater, going through building the necessary facilities for its treatment up to its control, monitoring , evaluation and finally its post management for agricultural purposes :

13.1. Governmental Ministries and Authorities

- **Palestinian Water Authority (PWA):** It is the main authority responsible of water related issues in Palestine. Consequently, it is considered the main source of data related to water sector in the Palestinian territories as a whole. PWA fields of responsibilities include the planning, licensing and currently implementation of water related projects and infrastructure. Due to this important role played by PWA it is considered as one of the important authorities that to be involved in wastewater management. Its role will be important in analyzing monitoring, controlling, assessing, planning and defining the wastewater and its treatment considering it not only a source of pollution that might affect the ground water resources but also as additional non conventional source for agricultural purposes.

- **Ministry of Agriculture (MoA):** It is one of the important sources of agricultural sectors data. MoA is the governmental body responsible for different agricultural activities in the West Bank. The main goal of it is to improve and develop agricultural sector in Palestine by transferring new technologies to the farmers through their extension staff, as well as formulating the long-term and short-term Palestinian Agricultural Policy, in order to achieve the food security approaches.

- **Environment Quality Authority (EQA):** EQA seeks to promote sustainable environmental development of the Palestinian society. The main goal of EQA is the protection of all elements of environment as will as preventing health risks facing all organisms. EQA has developed the PES with the objective to identify and analyze the main environmental problems and their causes in Palestine and define environmental targets and to present series of prioritized measures that will lead to reach these targets. The implementation of the strategy requires the monitoring of the environmental situation in the Palestinian territories and the enhancement of public awareness of the people regarding environmental protection and conservation.

- **Ministry of Local Government (MoLG):** It is the main source of local communities' sectors data. It's responsible on the physical planning for the expansion of the built up areas. MoLG by its law is the governmental body responsible in providing the municipalities and village council with financial and administrative assistance.

- **Ministry of Health (MoH):** Through its Department of Environmental Health. The MoH is responsible for the public health. Therefore, it is involved in the control and monitoring of potable water quality, food quality, wastewater related diseases etc.

- **Palestinian Standards Institute (PSI):** It's the main and official institute of accreditation to standers measures and specification for wastewater qualities and reuse.

- **Palestinian Central Bureau of Statistics (PCPS):** is the main source of information and data about the Palestinian territories. Its responsibilities include the provision of relevant data population, economy as well as physical aspects in the form of statistical databases such as population estimation and projections, built up areas, land-use, public health, and infrastructure as well as social and economical activities prevailing in the local communities.

- **Civil Society Institutions:** the civil society institutions play a supportive role to the water sector in Palestine and are considered an important stakeholder in the water sector.

13.2 Academic Institutions

- An-Najah National University: An-Najah University is a major university in the northern parts of the West Bank. It implemented several academic programs related to environment, water and agriculture, water quality analysis, groundwater monitoring and data collection. An-Najah provides education for undergraduate and graduate students in the field of environment. In addition to that, An-Najah has several centers to provide services for the community.

- Bir Zeit University: Beir Zeit University prepared different survey reports about the existing environment including: socio-economic, existing infrastructure, determination of problems and needs, water resources and supply, water rights, water use efficiency, land degradation and erosion in the area, and others information related to natural resources. Water Studies Institute (WSI) an institute within Bir Zeit University has conducted a several research studies related to wastewater covering almost all aspects. Recently it is involved in the preparation of a national wastewater guideline for agriculture and artificial recharge. It is also involved in conducting a pilot project for wastewater reuse in cooperation with inWent through the application of low cost technologies.

13.3. Research Centers

- Lands Research Center (LRC): It conducted a study about the soil erosion and land degradation through introducing their work in research and studies.
- Applied Research Institute-Jerusalem (ARIJ): ARIJ responsibilities can be summarized in strengthening cooperation and coordination of research and extension activities with institutions having common objectives, contributing to the training of extension personnel, and others.
- Water and Environmental Studies Institute (WESI): This is part of An-Najah National University, is involved in teaching, research and public awareness related to environment and water aspects. WESI is involved as an implementing institution for several ongoing projects. These include: “the Impact of Global Changes on Water Resources in the Wadi Contributing to the Lower Jordan Basin (GLOWA)”, and “the Agro-Biodiversity in the Northern parts of the West Bank including Wadi Al-Fara’a”. in addition of its own laboratory that can be used in conducting several wastewater test analysis

13.4. Community Services Organizations:

- Palestinian Hydrology Group (PHG): It’s one of the important Palestinian NGO’s working on water and environment in Palestine. PHG works in assisting the construction of infrastructure related to watershed and environment in the area. PHG assisted the farmers in improving irrigation conveyance system through the construction and lining of many irrigation ditches. PHG conducted also several water harvesting projects. These projects consist of cisterns and pools, data collection and analysis, water quality tests, well rehabilitation, public awareness for water conservation and quality protection, and building a water data base. PHG is involved in conducting a stakeholder analysis as part of “the Impact of Global Changes on Water Resources in the Wadi Contributing to the Lower Jordan Basin (GLOWA)” project. PHG is also considered as one of the important water and environmental data sources of the non-governmental organizations in Palestine. Therefore PHG should be taken into consideration in any institutional performance for the wastewater issues. Its Diector General (Dr. Abed Al- Rahman Al Tamimi) is representing the NCOs in the National Water Council.
- Palestinian Agricultural Relief Committees (PARC): It’s one of the important agricultural organizations in Palestine related to agricultural development, working in the rural Palestinian areas as in the project area specifically, in public awareness and guiding the farmers to improve farming practices. PARC also assists farmers in dealing with agro-chemicals and is currently working in the field of small scale wastewater treatment plant for both gray and black wastewater. Therefore, it should be considered one of the main stakeholders in any future reuse management. PARC, as a non-governmental organization, was founded in 1983 to serve nearly all aspects of agriculture especially in plant production, training and extension programs, the role and social state of living of women in agriculture, in addition to loans and funds. It is worth to mention here its significant role in the creation of Water Agriculture Associations, since it is

now involved in similar project within MEDA program jointly with two regional countries (Jordan and Egypt) titled MEDWA. The project aims to create WAAs strengthening them to manage their limited water resources in an integrated and sustainable manner. The project is also including the construction of three wastewater treatment plant at community level in order to be reused by the local farmers to irrigate specific crops.

- Recently, PWA has signed a memorandum of understanding with (PARC) aims to encouraging the creation of Water Agriculture Association in the Jordan Valley only for treated wastewater reuse for Palm and almond crops .this association will enter in a future agreement with Al-Bireh Municipality to use the whole treated wastewater generated from Al- Bireh treatment plant to irrigate their crops (mainly Palm and almond), where PARC will be committed to buy all their crops and thus being responsible on its Marketing under the condition that the crops are meeting the Ministry of National Economy (MoNE) and Ministry of Agricultures' (MoA) Standers. Both institutions now a day are assessing its feasibility and preparing a draft agreement to be singed between Al- Bireh Municipality in coordination with MoA and foreseeing Association, also PARC is preparing a draft by law for this association.

13.5 International Aid Agencies:

- USAID is the main international donor for the Palestinian Authority mainly in the field of water resources development and to some extent Wastewater (Gaza WWTP).
- Germany through (GTZ and KfW) are the biggest contributor in Wastewater sector through their enormous contributions for building different Wastewater infrastructure ranging from WWTP and Sewage networks to Wastewater capacity building programs and institutional reforms.
- European Union (EU): EU is among the main international donor for the Palestinian Authority. In the case of Al-Fara'a Integrated Watershed Management Project Palestinian Environment Quality Authority (EQA) received financial support from the EU Environmental Partnership Program (SMAP)and from the Dutch Ministry of Environment (VROM).
- American Near East Relief Aid (ANERA): It focuses on construction and rehabilitation of services infrastructure related to water resources facilities, wastewater collection, treatment and reuse, wells rehabilitation, springs development, rain harvesting and groundwater recharge.
- United Nation Developing Program (UNDP): It is one of the United Nation (UN) organizations, UNDP is involved in construction and rehabilitation of services infrastructure related to water and electricity networks, health and sanitation, education, social facilities, and others.

13.6 Palestinian Local Partners

- Local Councils: They are considered as the representative of the government on the local level. Therefore, they should be considered among the stakeholders of any project because of their important role. They are considered a cornerstone in public acceptance and willingness to support the sustainability; therefore, their role is very important. These villages' councils are considered as grassroots organizations with involvement essential to the success any future project.
- The Joint Services Councils: It has been established by the MoLG through a fund from the UNDP. It is so active in many areas of West Bank and Gaza (Hebron, Tulkarem, Jenin, Khan Younes Governorates).

- Water users, land owners and farmers: The society as a whole in the project areas will benefit directly, since integrated watershed management plans will be developed, that will address the watershed related environmental problems in an optimal and integrated manner. However, no active organized groups are available which directly represent the farmers and the water users in the area.

13.7 Private sector

Although the role that Private Sector can play in the wastewater sector development and management is not clearly defined in Palestine, but however it is expected that with political stability the private sector will be more encouraged to take part on the development of the water and wastewater sectors. PWA on its development strategy relay on the involvement of the Private Sector in the water sector; therefore and for the importance giving to this sector, this study will spot the light with more detail in the role that the sector is expected to play and the kind of involvement.

13.8 Occupation Authorities

From 1996 to 1999, the Palestinian Side submitted to the Israeli Side in the Joint Sewage Subcommittee a list of (11) projects which will be implemented in the West Bank. Most of the projects are under discussion in the committee and until now only (2) projects have a full approval from the JWC and Coordinator office, (3) projects are approved from JWC but not approved from the Coordinator office and (6) projects are until under discussion in the Sub Committee.

The objections of the Israeli Side for the unapproved projects can be summarized as follows:

- The Israeli Side requested to connect the colonies with the Palestinian facilities (This request in all Palestinian projects)
- The Israeli Side requested to establish Joint Sewage projects (in the Jerusalem area).
- The Israeli Side requested to transfer the wastewater from Palestinian committees to the Israeli.

Note: The Donors now put the approval from JWC in sewage projects as conditions to fund the projects. The cost to establish the eleven projects is (145) million Dollars, and the 11 projects will serve 675 thousand people and the fund for it is available. On the other hand, the fact of shared water resources and shared basins between Palestine and Israel, where Palestine formed the up stream for major quantities of effluents that in a way or anther flows into Israeli territories (down stream), this makes evident the influence of Israel in any future management of the wastewater. To this end this study will allocate a paragraph to describe the future perspectives and limitation in the joint management approaches in the shared basin management for wastewater issues.

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Anaerobic Treatment of Strong Domestic Sewage in up Flow Reactors Under Fluctuating Ambient Temperature

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Abstract

Two community onsite UASB-Septic tank and Anaerobic Hybrid (AH)-septic tank were operated in parallel under the same HRT of 2 days over around eight months period overlapping the cold and hot periods of the year, Palestine. The mean ambient air temperatures were 15.86 °C and 26.92 °C during the cold and hot periods of the year. The sewage was characterised by a high CODtot concentration of 1081 mg/L, with a high fraction CODsus, viz. around 65%. The achieved removal efficiencies of CODtot in the UASB-septic tank and AH-septic tank during the cold and hot periods were respectively "50(15) and 48(15)" and "66(8) and 54.73(7.9)". This shows that the UASB-septic tank performed significantly better ($p<0.05$) than the AH-septic tank during the hot period of operation, viz. after rather long period of operation. The difference in the CODtot removal efficiency was mainly due to the better CODss removal efficiencies in the UASB-septic tank. The removal efficiencies over the last 50 days of operation for CODtot, CODsus, CODcol and CODdis were "70, 72, 77 and 55%" and "53, 54, 78 and 45%" for the UASB-septic tank and AH-septic tank, respectively. Comparing those achieved COD removal efficiencies in the UASB-septic tank with previously attained results of UASB-septic tanks in Palestine clearly shows that the reactor performance has improved substantially by being started with well adopted anaerobic sludge. Therefore, the UASB-septic tank is recommended for pre-treatment of concentrated sewage in Palestine.

Keywords: Anaerobic Treatment, On-site, Domestic Sewage, UASB, Septic Tank, Anaerobic Hybrid.

1. Introduction

Decentralised wastewater treatment and disposal is practiced world wide to provide adequate wastewater management systems particularly in rural and remote human settlements (Al-Jamal and Mahmoud, 2009). Anaerobic reactors are mostly found as inherent parts of the decentralised treatment schemes due to process simplicity and low operational cost. The septic tank had been used for onsite wastewater pre-treatment since more than 130 years. A significant improvement of the septic tank was achieved last two decades by applying upward flow and gas/solids/liquid separation device at the top, which resulted in the so called UASB-septic tank reactor. The reactor is operated in an upflow mode as a UASB reactor resulting in both improved physical removal of solids and improved biological conversion of dissolved components (Zeeman *et al*., 2000). It was firstly investigated for the onsite sewage treatment at Dutch and Indonesian ambient conditions (Lettinga *et al*., 1991; Bogte *et al*., 1993; Lettinga *et al*., 1993). Recently, the system has also been investigated for sewage treatment in Palestine by operating in parallel two UASB-septic tanks at 2 and 4 days HRT over a year (Al–Shayah and Mahmoud, 2008; Al-Jamal and Mahmoud, 2009). In

Palestine, and some other Middle Eastern countries like Jordan, sewage is characterised with high COD concentrations exceeding sometimes 1500 mg/L with high fraction of CODss (up to 70-80%). In addition, sewage is characterised with temperature fluctuation between 15 and 25 ºC during the cold and hot periods of the year, which is a typical characteristic of the Mediterranean climate (Mahmoud *et al*., 2003; Halalsheh *et al*., 2005).

The reactors operated in Palestine achieved moderate results in terms of CODtot removal efficiencies which exceeded 50%, but the VFA and CODdis removal efficiencies were negligible and frequently negative in both reactors. For instance during the hot half of the year the VFA and CODdis in the effluent of the reactor operated at 4 days HRT were respectively 160 and 304 mgCOD/l (Al-Shayah and Mahmoud, 2008). Those values are noticeably high when compared with the VFA and CODdis in the effluent of a conventional UASB reactor operated in Jordan of respectively 10 and 210 mg COD/l, during the hot season (Halalsheh *et al*., 2005). Moreover, the effluent anaerobic biodegradability of the both reactors operated in Palestine were respectively 42 and 39% resembling 225 mgCOD/L and 192 mgCOD/L indicating that the reactors can achieve further treatment (Al-Shayah and Mahmoud, 2008). It is not clear if the high CODdis and VFA in the effluent of both reactors was due to low sludge activity and/ or due to poor contact between influent wastewater and sludge as a consequence of low upflow velocity and low biogas production.

The enhancement of sludge bed methanogenic activity by inoculating the reactor with well adopted sludge might further improve the reactors performance. In fact, reactor start-up is very important process step and particularly the quality of the seed sludge, microbial diversity and activity, is very important for successful start –up and might be essential for advancing reactor stability and performance (Show *et al*., 2004; Calli *et al*., 2006). Álvarez *et al*. (2006) emphasized the need for conducting more research on the start-up of pilot and full-scale anaerobic digesters for the moderately cold weather countries. In addition to inoculation of the UASB-septic tank with well adopted sludge, the reactor performance might be improved by modifying it to an Anaerobic-Hybrid (AH)-septic tank. The AH- septic tank consists of a sludge bed in the lower part and an anaerobic filter in the upper part, thus combines advantages of a UASB and AF reactors while minimising their limitations (Büyükkamaci and Filibeli, 2002; Elmitwalli *et al*., 2003).

The main goal of this research was to asses the possibility of enhancing the process performance of the UASB-septic tank treating strong sewage under fluctuating temperature by (1) adding a packing media to the upper part of the reactor, thus converting the UASB-septic tank to an AH-septic tank; and (2) by inoculating the reactors with well adopted anaerobic sludge. To achieve those objectives, a UASB-septic tank and AH-septic tank reactors were operated in parallel under ambient conditions in Palestine at HRT of 2 days for eight months covering the cold and hot periods of the year.

2. Methods

2.1. Experimental set-up

Two pilot scale UASB-septic tank and AH-septic tanks were installed and operated in parallel at the main sewage treatment plant (STP) of Al-Bireh city/ Palestine. Each of the reactors was made of galvanized steel with a working volume of 0.8 m^3 (height 2.50 m; diameter 0.638 m). Nine sampling ports were installed along each of the reactors at 0.25 m for sludge sampling, with the first port at 0.15 m from the bottom of the reactors. The influent was distributed in the reactors through polyvinyl chloride (PVC) tube with 4 outlets located 5 cm from the bottom of the reactors. Biogas was passed through a 16% NaOH solution for CO_2 scrubbing, and then methane quantity was continuously measured by wet gas meters. The media used in the AH-septic tank was reticulated polyurethane foam (RPF) sheets (type Filteren TM 10 from Recticel, Buren, The Netherlands) of 72 cm length oriented vertically in the top of the AH-septic tank above the solids –gas separator. Each sheet had knobs at one side, while the other side was flat. The characteristics of the used RPF sheets are presented in Table 1. The sheets were installed by fixing every two sheets back to back on a metal sheet amid. 10 metal sheets were used with 20 RPF sheets. Schematic diagram of the experimental set-up is presented in Fig. 1.

Table 1. Characteristics of the RPF sheets used in the AH-septic tank reactor

Parameter	Unit	Value
Total sheet thickness	Mm	25
Knob thickness	Mm	15
Base thickness	Mm	10
Specific surface area	m2/m3	500
Pore size	Mm	2.5

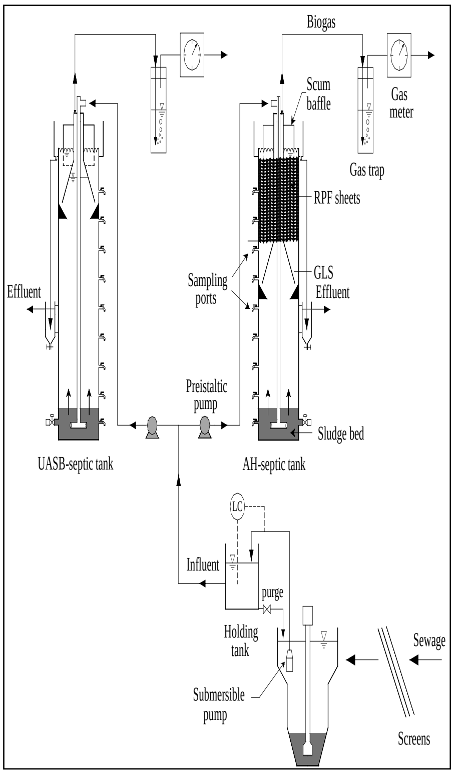

Figure 1. Schematic diagram of the experimental set-up (not to scale). GLS = Gas-liquid-solids separator; LC = Level controller

2.2. Pilot plants start-up, operation and monitoring

The UASB-septic tank and AH-septic tank were started up in January, the coldest month in the year, and operated in parallel for a period of around eight months. The reactors were operated at ambient temperature fed with domestic sewage pre-treated with screens and grit removal chamber. The sewage was pumped every five minutes to a holding tank (200 L plastic container), with a resident time of about 5 minutes, where the reactors were fed and the influent was sampled. The reactors were inoculated with 50 litres of anaerobic sludge (TS: 43 g/L; VS: 29g/L; VS/TS: 67) obtained from two pilot scale UASB-septic tank reactors (50% from each reactor) operated at 2 and 4 days HRT at the same research site and fed with sewage from the same source as in this research for more than one and a half year. Daily monitoring was started since the onset of the experiment including wastewater and ambient temperature and biogas production measurements. Grab samples of raw sewage and reactors effluents were collected and analysed two to three times a week (1 L for each) for CODtot. Over the last 50days of operation, the reactors influent and effluent were analysed six times for CODtot and fractions (CODsus, CODcol, CODdis), VFA, ammonia, phosphate and faecal coliform. The atmospheric pressure was measured *in situ.*

2.3. Analytical methods

Total solids (TS), volatile solids (VS), ammonium (NH_4^+), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and dissolved PO_4^{3-}-P were measured according to standard methods (APHA, 1995). Raw samples were used for measuring total COD (CODtot), 4.4 µm folded paper-filtered (Schleicher and Schuell 5951/2, Germany) samples for paper filtered COD (CODp) and 0.45 µm membrane - filtered (Schleicher and Schuell ME 25, Germany) samples for dissolved COD (CODdis). The suspended COD (CODsus) and colloidal COD (CODcol) were calculated as the difference between CODtot and CODp and the difference between CODp and CODdis, respectively. The volatile fatty acids (VFA) analysis was carried out as described by (Buchauer, 1998). All samples were analysed in duplicate except VFA in single. Sludge stability was measured once in triplicate after three months of staring up the reactors as described by Mahmoud (2002).

2.4. Calculations

Nomenclature

COD_{tot}: amount of total COD in the tested sample (mg COD/l)

$COD_{tot, inf}$ and $COD_{tot, eff}$: amount of total COD in influent and effluent (mg COD/l)

$COD_{dis, inf}$ and $COD_{dis, eff}$: amount of dissolved COD in influent and effluent (mg COD/l)

$COD_{VFA, inf}$ and $COD_{VFA, eff}$: amount of VFA in influent and effluent (mg VFA as COD/l)

COD_{CH4}: amount of produced $CH_{4\ (liquid\ form\ +\ gas\ form)}$ (mg CH_4 as COD/l); $CH_{4\ (liquid\ form)}$ was calculated according to Henry's law assuming 70% of the biogas is CH_4

$COD_{accumulated}$: amount of accumulated COD in the reactor (mg/l)

Sludge stability

$$\text{Stability (\%)} = 100\ (COD_{CH4} / COD_{tot,\ t=0\ days}) \qquad (1)$$

or

$$\text{Stability (\%)} = 100\ (COD_{tot,\ t=0\ days} - COD_{tot,\ t=t\ days}) / COD_{tot,\ t=0\ days} \qquad (2)$$

Hydrolysis, Acidification and Methanogenesis

Percentage of hydrolysis (H), acidification (A) and methanogenesis (M) were calculated according to equations 3, 4 and 5, respectively.

$$H(\%) = 100\,\frac{COD_{CH_4} + COD_{dis,eff} - COD_{dis,inf}}{COD_{tot,\ inf} - COD_{dis,inf}} \qquad (3)$$

$$A(\%) = 100\,\frac{COD_{CH_4} + COD_{VFA,eff} - COD_{VFA,inf}}{COD_{tot,\ inf} - COD_{VFA,inf}} \qquad (4)$$

$$M(\%) = 100\,\frac{COD_{CH_4}}{COD_{tot,\ inf}} \qquad (5)$$

2.5. Statistical data analysis

Statistical comparisons of means was followed by "Paired samples t-test" for the measured parameters of the two reactors using the SPSS program for windows- Release 11.0.0, SPSS® Inc. (2001), with p value <0.05 considered significantly different.

3. Results and discussion

3.1. Sewage characteristics

The results of sewage characteristics presented in Tables 2 and 3 confirm that sewage in Palestine is characterised with high concentration of pollutants as compared with sewage characteristics in several European, Asian and Latin American countries (Mahmoud *et al*., 2003; Metcalf and eddy, 2003). The high sewage strength in Palestine is postulated to low water consumption and people's habits (Mahmoud *et al*., 2003). The influent COD was mainly in the suspended form followed by dissolved then colloidal of respectively 65%, 25.8% and 9.2% (Table 3). Around 40% of the influent dissolved COD was in the VFA form. The CODtot concentration during winter was less than during summer most likely due to dilution with rainwater. The mean CODtot over the whole period of operation was 1081 mg/l.

3.2. Organic loading rate

The reactors were operated at a rather low organic loading rate of 0.54 gCOD/l.d during the whole period of operation. The organic loading rate during the cold period was relatively lower than during the hot period of respectively 0.52 and 0.57 g COD/l.d.

3.3. Removal efficiency

The results presented in Fig. 2 and Table 2 reveal that the UASB-septic tank and AH-septic tank have both performed equally well with no significant difference during the first three months of operation coinciding the winter period. During the subsequent summer period, the UASB-septic tank reactor achieved significantly ($p<0.05$) higher CODtot removal efficiencies as compared to the AH-septic tank reactor. This is attributed mainly to the rather higher fraction of suspended COD in the AH-septic tank effluent as presented in Table 3.

The achieved CODcol and CODdis removal efficiencies in both reactors were relatively high with no significant difference ($p>0.05$). The rather low VFA concentration in the effluent of both reactors indicates good methanogenic conditions in both of them (Table 3).

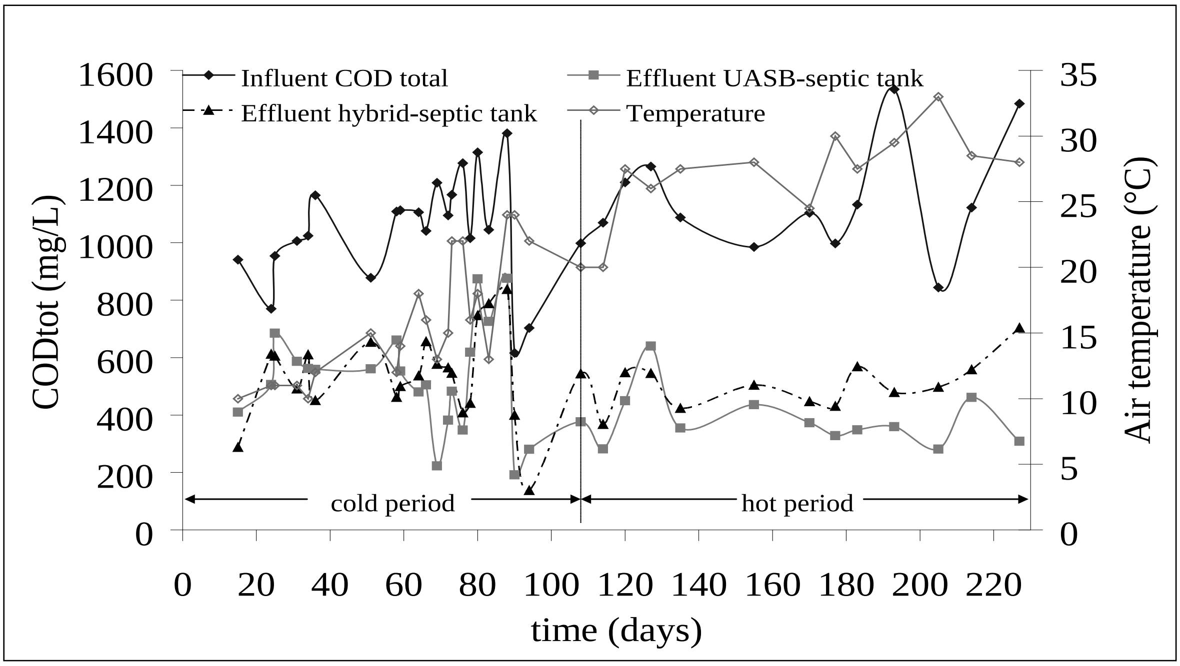

Figure 2. Influent and effluent CODtot and air temperature during the anaerobic treatment of domestic sewage from Al-Bireh City/Palestine in a UASB-Septic tank and an AH-septic tank. 0 day stands for 8th of January

Table 2. Influent and effluent CODtot and removal efficiencies (%) during anaerobic sewage treatment in a UASB-septic tank and an AH-septic tank operated during the cold and hot parts of the year in Palestine

		Cold period From day 15 to day 108 n = 22			Hot period From day 108 to day 227 n = 13		
		Influent	**UASB-Septic tank**	**AH-Septic tank**	**Influent**	**UASB-Septic tank**	**AH-Septic tank**
CODtot (mg/l)	Average	1042.23 (187.6)	520.41(182.5)	539.05(158.3)	1141.27(194.9)	384.63(96.2)	509.04(84.6)
	range	616-1381	192-876	138-838	845-1535	282-640	368-704
CODtot removal (%)	Average		50.07(14.7)	47.87(15.1)		65.78(8.2)	54.73(7.9)
	range		28-82	21-80		49-79	41-69
Tair (°C)	Average	15.86(4.7)			26.92(3.7)		
	range	10-24			20-33		

Standard deviations are shown in parenthesis

Table 3. Influent and effluent characteristics and removal efficiencies (%) in a UASB-septic tank and AH-septic tank treating domestic sewage in Palestine under ambient conditions. Results are average values of 6 samples measured over a 50 days period during the period 177-227 days of starting the reactors

Parameter		UASB-septic tank (HRT = 2 days)		AH-septic tank (HRT = 2 days)	
	Influent	Effluent concentration	Removal efficiency (%)	Effluent concentration	Removal efficiency (%)
	concentration	average		average	
COD Total	1186(272)	348(62)	69.61(7.4)	540(95)	53.23(9.2)
Suspended	767(162)	209(43)	71.95(7)	339(57)	53.71(12)
Colloidal	111(76)	18(7)	77.08(14)	22(15)	78.11(12)
Dissolved	308(83)	121(19)	54.92(9)	179(50)	45.36(9)
VFA as COD	110(25)	15(16)	88.19(9)	21(13)	81.71(10)
NH4+ as N	84(4.9)	80.12(17.8)	-0.06(13.83)	83.15(6.4)	1.18(4.79)
PO43- as P	14.3(1.48)	12.3(1.8)	13.79(9.5)	10.8(0.95)	23.69(8.5)
TSS	1125(631)	44.7(29)	94(4.9)	58.7(73)	95(4.5)
Fecal coliform	8.40E+09 (4.5E+09)	3.37E+07 (2.51E+07))	99.33(0.7)	3.80E+07 (2.35E+07)	99.16(1.1)
Tair	29.42 (2)				
Patm.	0.923 (0.008)				

Standard deviations are shown in parenthesis; all parameters are in mg/l except: faecal coliform: CFU/100 ml; ambient air temperature: °C; atmospheric pressure: atm.

3.4. Sludge profile

The course of sludge bed development during the whole period of operation is depicted in Fig. 3. The results clearly reveal a stable sludge bed development and rather stable sludge hold up in both reactors. The quantity of sludge in the sludge bed of the UASB-septic tank is more than the AH-septic tank sludge bed (Table 4). The sludge stability of both reactors assessed during the cold period was rather poor with 68% and 66% for respectively the UASB-septic tank and AH-septic tank. However, the results presented in Fig. 3 clearly show an apparent better sludge stabilisation trend expressed as VS/TS ratios in the UASB-septic tank as compared with the AH-septic tank. The VS/TS ratio of sludge in the UASB-septic tank and the AH-septic tank were reduced respectively from 72 (7.55) and 71(3.5) during the cold period to 62 (6) and 66 (3.8) during the hot period. According to Wang (1994) a (VS/TS) ratio of 63% can be considered a well-stabilized sludge. The excess sludge in both reactors over the whole period of operation was marginal.

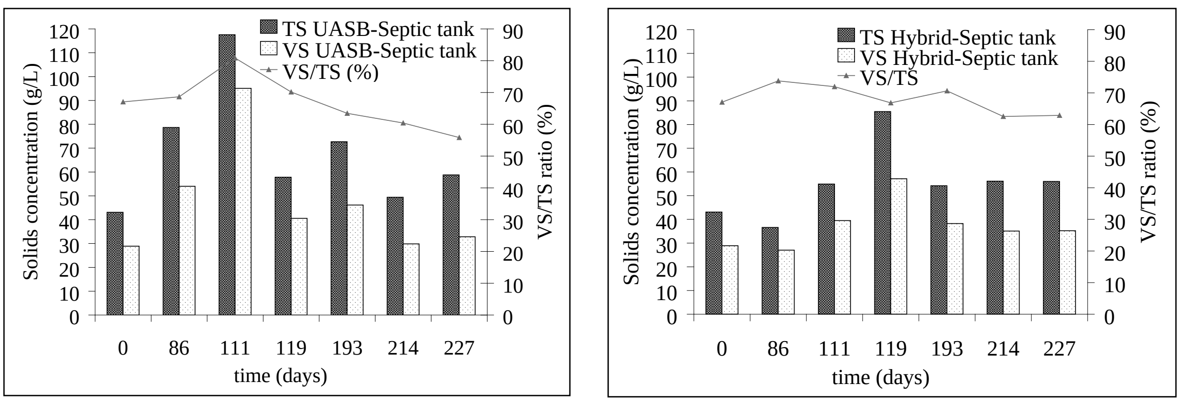

Figure 3. Course of sludge bed development in a UASB-septic tank and Anaerobic-Hybrid-septic tank reactors treating domestic sewage. Solids concentration at days 0 stands for inoculum

Table 4. Average VS, TS, and VS/TS ratios of the sludges retained in the UASB-septic tank and Hybrid-septic tank over the whole period of operation (day 0 - day 227)

	TS	VS	VS/TS
UASB-septic tank	68.28 (25)	46.75(23.19)	66.63(8.01)
Hybrid-septic tank	55.19 (15.34)	37.31(9.88)	67.97 (4.37)

Standard deviations are shown in parenthesis

3.5. Hydrolysis, Acidification and Methanogenesis

The percentage of COD hydrolysis (H), acidification (A) and methanogenesis (M) in the UASB-septic tank assessed over the last 50 days of operation, viz. after 6 months of starting up the reactor, were respectively 29.3(12.7), 29.6(8.2) and 35.7(8.6). Those results are remarkably higher than the H, A and M reported by Al-Shayah and Mahmoud (2008) who also operated UASB-septic tank at the same wastewater treatment plant during the hot period of the former year. The difference is postulated to the better quality of the inoculums sludge used in this investigation. In this research, the reactors were inoculated with well adopted sludge brought from UASB-septic tanks that had been in operation for more than a year, while Al-Shayah and Mahmoud inoculated the UASB-septic tanks with sludge from a cesspit.

The achieved rather high percentage of methanogenesis indicates the stabilisation of accumulated sludge. Moreover, the results clearly reveal that the hydrolysis was limiting the overall conversion of organic matter to methane as the effluent contained a low amount of CODdis and VFA (Table 3). The occurrence of methanogenic conditions is crucial for enhancement of lipids hydrolysis and acidification which is also affected by the degree of methanogenesis (Mahmoud *et al*., 2004). The VFA/CODdis had remarkably reduced from 40% in the influent to 12% in the effluent of both reactors, with a substantial decrease of VFA concentration in the effluent.

3.6. Discussion

The researched two reactors had performed rather equally well during the cold period of the year. But this trend was significantly changed during the hot period. During the hot period, the UASB-septic tank achieved significantly better CODtot removal efficiency as compared to the AH-septic tank of respectively 65 and 54%. This result was rather surprising as it disagrees with our hypothesis that the packing media will enhance the removal efficiency. The more thorough analysis of the distinguished COD fractions removal efficiencies revealed that the CODss removal efficiency was the only significantly better removed COD fraction in the UASB-septic tank in comparison with the AH-septic tank. This might be due to accumulation of CODss beneath the packing media during the cold period which probably had started to erupt gradually during the subsequent hot period. Moreover, short circuiting and dead zones are popular drawbacks of the AH reactors. Wu *et al*. (2000) found that increasing the packing ratio in AH reactors increases the by-pass flow rate due to short- circuiting and the dead space volume. They also reported that the sludge bed height decreased with increasing the packing ratio. Interestingly they also showed that the packing ratio did not cause much difference on the reactors performance at low organic loading rates (OLR) of 1 and 2 gCOD/l.d which are higher than the imposed OLR to the here investigated UASB-septic tank and AH-septic tank.

The performance of the UASB-septic tank was not only significantly better than the simultaneously operated AH-septic tank but also superior to formerly attained removal efficiencies in UASB-septic tank reactors operated at 2 and 4 days HRT over a whole former year in Palestine (Al-Shayah and Mahmoud, 2008; Al-Jamal and Mahmoud, 2009). This strongly indicates that the inoculum quality is of vital importance to attain the maximum achievable performance of the UASB-septic tank reactors. The CODtot removal efficiency by the previously operated UASB-septic tank reactors by Al-Shayah and Mahmoud (2008) during the hot period of the year and by Al-Jamal and Mahmoud (2009) during the cold part of the year were respectively for the reactors operated at 2 and 4 days HRT "54% and 58%" and "51% and 54%". This proves the reliability of the anaerobic technologies for domestic sewage treatment in extreme situation of high strength and temperature fluctuation that was questioned in literature (Leitão *et al*. (2006).

4. Conclusions and recommendations

The performance of the UASB-septic tank reactor was substantially improved by starting up the reactor with well adopted anaerobic sludge. The UASB-septic tank reactor is more efficient as compared to the AH-septic tank reactor. Mean removal efficiencies for CODtot in the UASB-septic tank and AH-septic tank during the cold and hot periods of the research were respectively "50.07(14.7) and 47.87(15.1)" and "65.78(8.2) and 54.73(7.9)", respectively. The difference in the performance of the UASB-septic tank and AH-septic tank was significant during the hot period of operation, viz. after rather long period of operation. The difference in the CODtot removal efficiency was mainly due to the better CODss removal efficiencies in the UASB-septic tank reactor as compared to the AH-septic tank reactor. The achieved mean removal efficiencies during the last 50 days of operation for CODtot, CODss, CODco and CODdis in the UASB-septic tank and the AH-septic tank were "70, 72, 77 and 55%" and 53, 54, 78 and 45%" respectively.

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Domestic Wastewater Treatment and Its Reuse for Irrigating Home Gardens (Case Study)

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Abstract

As an environmental solution to face water scarcity and threat coming from untreated domestic wastewater, the Applied Research Institute – Jerusalem (ARIJ) has put huge efforts in developing locally made wastewater treatment plants to be utilized at domestic level to help promote sustainable development and combat desertification in the occupied Palestinian territory. Developed wastewater treatment plants adopted activated sludge technology as biological process, followed by mechanical filtration as advanced treatment. This provided an environmental friendly solution to the problem of the generated wastewater at household level (ARIJ, 2010). The adoption of such approach resulted in: (1) Protecting the environment from pollution caused by the improper wastewater disposals (use of cesspits), mitigating and reducing of the environmental and health problems and risks; (2) Providing a better management of the wastewater resources by reusing the treated wastewater for irrigation purposes economizing in domestic drinking water volumes used for irrigation, (3) Contributing in an increase of the agricultural areas as result of the new water resource, (4) Contributing in the family economy and sustainability, this was achieved by economizing the monthly expenses that benefited families used to have as concept of hiring wastewater vacuuming services and which was provided by vacuum tankers, (5) The new planted fruit trees and which are currently irrigated with treated wastewater are expected to contribute in the family food security, (6) Protecting the surface and ground water resources.

Keywords: Environmental Solution, Wastewater, Reuse of Treated Wastewater, Small Scale Onsite Wastewater Treatment Plant, Activated Sludge.

1. Introduction

Despite that the sewage collection coverage has been increased in the last few years in the occupied Palestinian territory (oPt), there is still a lot of work to be done. The sewage collection systems in the absence of available wastewater treatment infrastructure used to transport the problem rather than solving it. Only 6.33% (2.836 MCM) of the generated wastewater in the West Bank is treated in centralized and collective wastewater treatment plants, the remaining 93.7% is discharged untreated into the environment using cesspits, septic tanks and sewage collection networks that are not connected to any wastewater treatment infrastructure(ARIJ, 2011). Cesspits are purposely designed and constructed without a concrete lining in order to allow seepage into the ground. With time, cesspits are filled with wastewater which necessitates periodical emptying by vacuum tankers. The collected wastewater in the tankers is often released in the nearby valleys. However, septic tanks are environmentally preferable to cesspits as their design prohibits wastewater leakage to the ground. Vacuum tankers whether with sewage from septic tanks or cesspits, if there is not close available infrastructure to receive this sewage, those pollutants are discharged into the environment. Hiring the service of vacuum tankers despite of not being a real solution to the problem is a costly service that in many cases goes beyond citizens' affordability. In the Gaza Strip, there are also discharges of untreated wastewater into the Mediterranean Sea (ARIJ, 2011).

The Applied Research Institute-Jerusalem (ARIJ) considers that the generated wastewater in the oPt; shall be treated and reused within the oPt. The adoption of such approach, will contribute in avoiding elevated costs paid to Israel as wastewater treatment concept, providing at the same time a non-conventional water resource that can be utilized for irrigation, contributing in alleviating the water scarcity problem.

On-Site small-scale wastewater treatment plants, which often serve a single house or building, respond to the needs and conditions especially in rural localities. They can solve the wastewater collection and disposal problems in such communities, along with the benefit of generating a water resource that can be utilized for irrigation purposes as land and agriculture are available (ARIJ, 2010). Working in this direction ARIJ implemented a project of 180 household wastewater treatment and reuse systems, this project was entitled "*Introducing Small Scale Activated Sludge Filtration System of Wastewater Treatment in the Rural Areas of Bethlehem and Hebron Governorates in the West-Bank* " this project was funded by The Mennonite Central Committee (March 2007 - September 2010). Through this paper will be discussed some obtained results from a Midterm Evaluation (MTE) that took place in September - 2009, as well will discuss obtained results and conclusions after project completion, adopting the aforementioned implemented project as Case Study.

2. Methodology

2.1. Case Study Project Wastewater Treatment Process Methodology Description

Each installed wastewater treatment plant in the case study project, was planned to serve a single small family of six members as maximum recommended, with a hydraulic daily flow that does not exceed one cubic meter. The adopted material utilized for the construction of the installed WWTPs was polyethylene, avoiding in this manner risks of corrosion. The aeration device utilized has a power consumption average at full time operation of 65 Watts; the water pump utilized has a power consumption average at full time operation of 1 HP, both devises connected to one control panel. The treatment process starts with screening of certain suspended solids present in the wastewater; these suspended solids are filtered using a removable screen basket with filtering slots of 5-8 mm. With the help of a set of pipes, the recycled activated sludge is brought to just underneath the basket from the separation zone, and is mixed with the incoming wastewater. After the screening, the de-nitrification and activation/nitrification processes take place. In the de-nitrification zone, oxygen is removed from nitrate and nitrite to form nitrogen gas and water. From the de-nitrification zone, wastewater overflows into the aeration (nitrification/activation) zone, which is the largest zone and provides a space where the bacterial mass is aerated and maintained for the longest period of time. This allows for the maximum utilization of nutrients and conversion of the contaminants in the raw sewage into less harmful compounds; carbon oxide and water in the process of oxidation, and nitrite and nitrate in the process of nitrification. The aeration system goal was to maintain the dissolved oxygen at 2-3 mg/l, and to maintain solids in suspension and ensure proper recirculation of the activated sludge. Air was diffused from the bottom of the aeration zone. It is important to mention that the typical wastewater does not contain nitrate which means that no de-nitrification process can occur unless a nitrification process is preceded. For this reason, the de-nitrification of the treatment plant was accomplished through the use of a circulating pipe that returns the flow to the screen and therefore to the de-nitrification compartment, assuring that the de-nitrification process occurs. The half conical shape of the separation zone in the installed system ensured that the upward velocity of the sludge flocks decrease as the flocks rise until they form a stationary sludge blanket as gravitational and uplift forces reach equilibrium. As Wastewater passes through the sludge blanket, fine suspended solids are retained and the filtered effluent rises above it. The effluent is then discharged out of the system. The growing flocks of the sludge at the bottom of the separation zone are recycled by means of an air lift pump back to the screen and de-nitrification zone of the bioreactor. Also located in the separation zone is a device to skim and remove flocks of sludge occasionally breaking away and floating on the surface of the separation zone. The running of the treatment facility was controlled completely automatically, including: steering, recirculation of activated sludge, injected oxygen volumes and treated wastewater pumping. Figure 1 illustrates the wastewater treatment plant process (ARIJ, 2005).

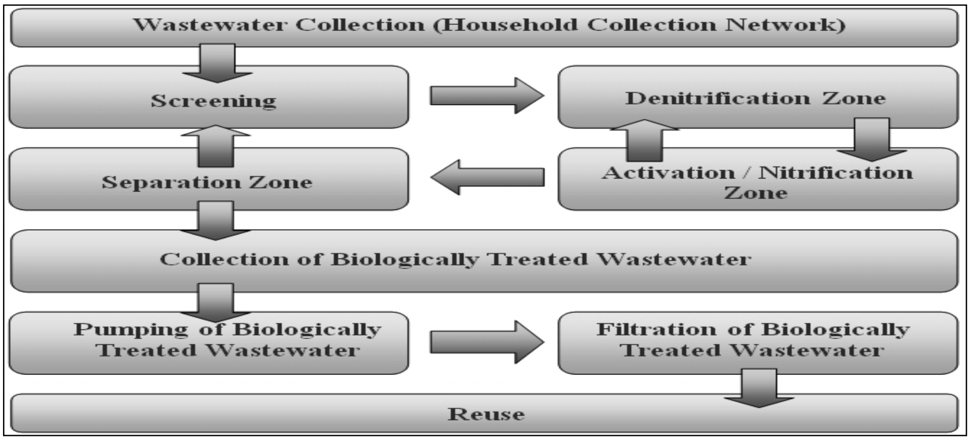

Figure 1. Illustrates the path of the wastewater and wastewater treatment plant process (ARIJ, 2005).

The secondary treatment achieved through the biological treatment afore described was followed by a sand filter that contributed in further treating the biologically treated wastewater mechanically; later on the treated effluent is pumped to irrigate trees ,of course after the adoption of the local reuse standards and recommendations (ARIJ, 2005).

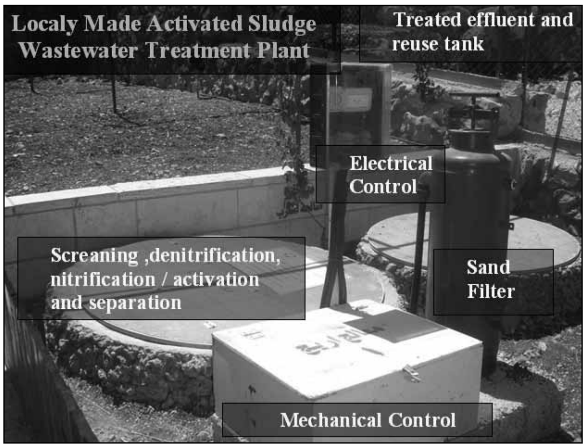

Figure 2. Description of the different components of a locally made onsite wastewater treatment system(ARIJ, 2005).

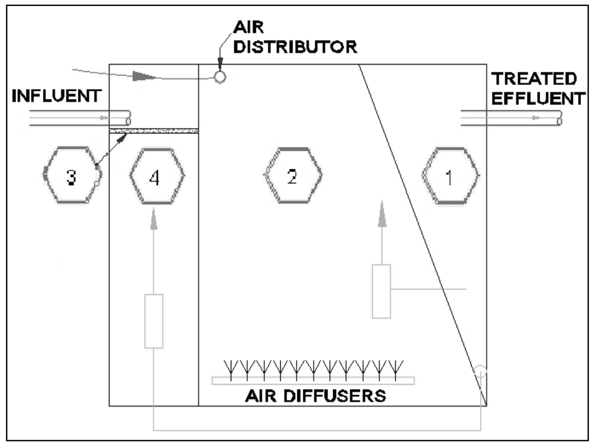

Figure 3. A cross Section of the Biological Treatment Reactor, (ARIJ, 2005).

The illustrated numbers in (Figure 3) refer to the compartments of the wastewater treatment reactor, but they do not indicate the sequence of the wastewater flow:

1) The separation zone.

2) The activation/nitrification zone.

3) The mechanical debris screen Basket.

4) The de-nitrification zone.

2.2. Methodology adopted for the Project Midterm and End Project Evaluation

The methodology adopted for this project midterm evaluation was based on a special questionnaire that was prepared to collect information on the effectiveness of the installed units and to evaluate beneficiaries' satisfaction of the project activities. The questionnaire was filled by the evaluator during field visits and by interviewing the beneficiaries, observing the gardens and functionality of the installed units and effluent evaluation utilizing for this task the BOD5 (Biological Oxygen Demand) parameter. All gathered information was then entered on SPSS and analyzed. The sample size was 29.27% of the total installed units (36 units out of a total of 123 installed units at that stage). The evaluated units were chosen randomly from the first targeted localities. Those localities included Al-Walaja, Al-Khader, Battir, and Beit-Ummer. Most of the interrogated beneficiaries were with installed units for more than one year (ARIJ, 2009).

This mid-term evaluation was conducted to assess the effectiveness and efficiency of small-scale activated sludge installed systems. The MTE was designed to provide midterm feed back to the project team from benefited families, and as a project management tool with the goal of identifying, and reinforcing initiatives that demonstrate the potential for success and as evaluation tool to do corrections if needed

The special questionnaires that were utilized in the MTE included several main points that can be summarized in the followings:

a) Personal information about the beneficiary.

b) Information about the beneficiary environmental understanding, involvement and knowledge on his own treatment system.

c) Information about the installed unit, maintenance, safety measurement and effluent quality.

d) Evaluation to what degree the beneficiary has been benefited from the installed unit.

e) Beneficiary perception of installed unit and satisfaction degree. (ARIJ, 2009).

In March of 2011, after three years of operation of the first project installed WWTPs another evaluation took place (Evaluation after project completion), the evaluation procedure at this stage was the same adopted at the MTE, but with some differences in the parameters that were evaluated. The sample size at this time was of 34 WWTPs different users, approximately 19% of a total of 180 installed systems (ARIJ, 2011).

3. Results and Discussion

3.1. Results related to the wastewater treatment technology adopted

The Project adopted prototype was first tested in 2005; the selected parameters were analyzed to study the efficiency of the small scale wastewater treatment prototype, and whether this effluent is suitable for irrigation purposes. These parameters are the Biological Oxygen Demand (BOD_5), the Chemical Oxygen Demand (COD), the Total Suspended Solids (TSS), Ammonium Nitrogen (NH_4-N), the Total Phosphorus (TP) and the measure of acidity or alkalinity (PH) (Table 1).

Table 1. Comparison table between effluents obtained from the WWTP on evaluation and PSI standards

	Quality Parameter (mg/l)		BOD5	COD	TP	TSS	NH4-N	PH
Recommended guidelines by the Palestinian Standards Institute For Treated Wastewater Characteristics According to Different Applications	Fodder Irrigation	Dry	60	200	-	50	-	6-9
		Wet	45	150	-	40	-	6-9
	Gardens, Playgrounds, Recreational		40	150	-	30	50	6-9
	Industrial Crops		60	200	-	50	-	6-9
	Ground Water Recharge		40	150	-	50	10	6-9
	Seawater Outfall		60	200	-	60	5	6-9
	Land Scapes		60	200	-	50	-	6-9
	Trees	Citrus	45	150	-	40	-	6-9
		Olive	45	150	-	40	-	6-9
Average of effluent quality obtained from the Tested WWTP			<20	22	4.35	172	5.15	7.25

Note: In this evaluation the samples were taken from the separation zone without any further treatment
Sources: (PSI, 2005; Al Quds University, 2005).

According to the Palestinian Standards Institution for treated wastewater, characteristics of which are shown in Table 1, the results of the effluent parameters show that the quality of treated wastewater from local small scale wastewater treatment units is acceptable for irrigation purposes without any hazardous impacts. However, the TSS concentrations were generally high, (PSI, 2005).

To improve the TSS value, was added to the process sand filtration, to improve the effluent to an acceptable treatment level that complies with reuse for irrigation purposes of course after taking into consideration the local reuse standards and recommendations (ARIJ, 2010). Later on a composite sample of raw wastewater was done by mixing collected samples obtained from five representative households in the rural areas of Bethlehem; this composite sample was used to determine an estimated BOD_5 value for the raw wastewater in the rural areas of Bethlehem, the obtained value of this composite sample approximated the 362 mg/l (ARIJ, 2005), this value later on was used to assess the removal efficiency of the wastewater treatment plants that were installed in the rural areas of the Bethlehem Governorate (Table 2).

3.2. Results obtained at the project MTE

During this study, the number of installed WWTPs was 123 out of 180 planned to be installed. The average efficiency of the BOD removal in the WWTPS during the MTE varied from locality to another. An example is shown in Table 2.

Table 2. Evaluation of the Wastewater Treatment Plants efficiency in both Al Walajah and Al Khader village – Bethlehem

No. of tested plant & location	WWTP BOD5 Test Result (mg/l)	Efficiency obtained in the removal of BOD
Al Walajah-1	8	E (%) = [(BOD5 influent – BOD5 effluent) / (BOD5 influent)] x 100 = [(362 mg/l –14 mg/l) / (362mg/l)] x 100 = 96.1 %
Al Walajah-2	11.6	
Al Walajah-3	20.4	
Al Walajah-4	16	
BOD5 Test Average (Al Walajah)	14	
Al Khadr-1	23.4	E (%) = [(BOD5 influent – BOD5 effluent) / (BOD5 influent)] x 100 = [(362 mg/l –18.8 mg/l) / (362mg/l)] x 100 = 94.8 %
Al Khadr-2	21.6	
Al Khadr-3	15.6	
Al Khadr-4	14.8	
BOD5 Test Average (Al Khadr)	18.8	
Source: (ARIJ, 2009)		

The results obtained through the lab tests at this stage were very acceptable and fit with what was planned for.

At that stage was needed also to evaluate the beneficiaries' involvement in the project, perception of project activities, degree of satisfaction among the beneficiaries and impact of the installed systems. To do so, the 29.27% of the total installed WWTPs at that stage were visited and information from beneficiaries was collected. Some of the result of this stage of the MTE can be summarized in Table 3.

Table 3. Some obtained results from the case project midterm project evaluation

Aspect , Subject or Indicator	%
Knew about wastewater, possibility of wastewater treatment and reuse, from school literature, TV programmers; others get some information while working in Israel	41
Aware of the negative impact of cesspits to the environment	97
WWTPs users that considered that they give periodic maintenance to the system sand filter	89
Considers that the onsite wastewater treatment plans has positive impact on the environment.	86
WWTPs users who considered that their wastewater treatment plants are working in excellent conditions (based on their own monitoring and perception of the installed Systems).	86
Beneficiary follow up of recommended safety guidelines	67
Percentage of beneficiaries that used to irrigate from time to time their home gardens before installing the WWTPs.	23
Beneficiaries that considered that they don't face bad odors problem in their installed systems	75
Percentage of beneficiaries that used to utilize cesspit as wastewater disposal method , before installing the Wastewater treatment and reuse system	83
Percentage of beneficiaries that used to hire the service of vacuum tanker to dispose the collected wastewater	27.6
Source: (ARIJ, 2009).	

From Table 3 some positive impacts of the installed wastewater treatment plants can be concluded:

1) Installed units put a stop to pollution of cesspits to the environment, as was stated by 83% of the WWTPs interviewed users (by replacing cesspits with wastewater treatment plants).

2) Economize in the economic resources that are used for paying for the service of vacuuming filled cesspits or septic tanks, in accordance to the MTE 27.6% of interviewed users were hiring the service of vacuum tanker to dispose the collected wastewater.

3) Installed systems have provided an environmental solution to the disposal of the households generated wastewater, at the same time has provided a non-conventional water resource that can be reused for irrigation. (ARIJ, 2005).

Also in accordance with the MTE, 42% of the WWTPs users said that there is some saving in their water bill, this saving was attributed to the use of treated wastewater for irrigation of trees, economizing in this manner in the volumes of domestic tab water used for that purpose previous to the installation of the wastewater treatment and reuse systems. WWTPs users considered that this saving in the water bill can be estimated at about 30% of the total value of the water bill, but at the same time they expressed that it is hard to measure it more precisely; The remaining 58% of users could not provide information on savings as most of them were not paying their water bill regularly (ARIJ, 2009).

Based on the MTE (at that stage), was estimated a total of 78 dunums utilizing treated wastewater as irrigation water resource.

According to agronomist's estimations at ARIJ, each household can increase the production of its home garden from 220 kg/year to 722 kg/year by the periodic irrigation that can result from the household reclaimed water, obtaining an approximate increase in the home garden production of 502 kg/year. This increase in production is estimated to be equivalent to approximately 134 USD for typical home gardens that don't irrigate frequently to 440 USD for home gardens that utilized reclaimed water permanently in irrigation (ARIJ, 2010), this potential to increase in home garden production can be considered as another positive impact of installed WWTPs.

In this MTE also was stated 69.4% of WWTPs users were 100% satisfied with the idea of having the wastewater treatment plants. The remaining 30.5% were 75% satisfied for having those units. Regarding the guidelines and workshops done at that project stage, 88.9% of users considered that guidelines and workshops were enough, while the remaining 11.1% demonstrated a partial satisfaction (ARIJ, 2009).

3.3. Results obtained after three years of operation of the first project installed WWTPs

At this time the same evaluation procedure that was utilized at the MTE was adopted, but with some differences in the parameters that were evaluated. The sample size at this time was of 34 WWTPs different users, approximately the19% of the total of 180 installed systems (ARIJ, 2011). The data compiled through the questionnaires was entered into the Statistical Package for Social Sciences (SPSS) and then analyzed. At that stage the status of the onsite WWTPs was as follow:

Around 59% of the interviewed WWTPs users stated that the onsite WWTP is operating well with high efficiency (Figure 4).

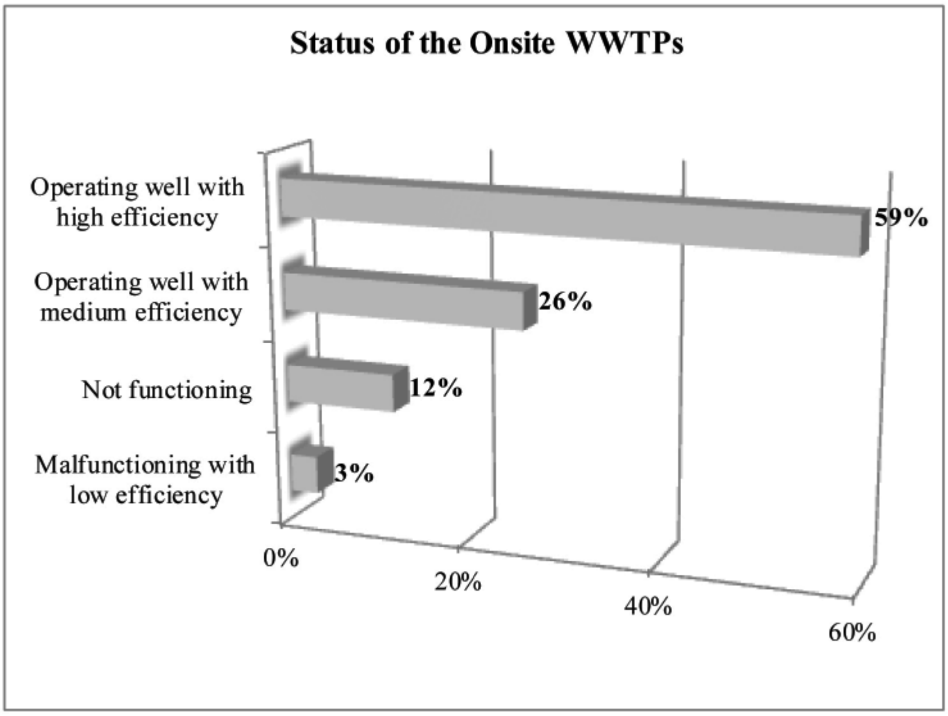

Figure 4. Status of the Onsite WWTPs (ARIJ, 2011).

Around 26% of the evaluated units were operating well with medium efficiency; variation in efficiencies from system to another could be result of:

- Systems adjustments,

- Variation in volume and composition of chemicals that the system is exposed to (Cleaning detergents, shampoos, washing machine softeners, soaps, etc.).
- Variation in the number of individuals at the household (Example (1): a household with tree persons is expected to generate half liquid waste than the expected of a household of six persons. Example (2) The WWTPs if assigned to serve a number of persons that exceeds what was originally planned for; this can lead the WWTP to operate under overloaded conditions and which can be reflected negatively in the effluent obtained).
- Variation in the concentration of pollutants in the wastewater inlet pipe and water consumption behaviors (The concentration of pollutants in the wastewater is directly linked to the water consumption behavior (for example a household inhabited of five persons that have an average water consumption of 60 liter / person /day, will have a more concentrated wastewater than if the average water consumption of the inhabitants of the same household was 250 liter / person/day). As well the real hydraulic retention time of the wastewater treatment phases will be subject to the variation in the water consumption behavior, since the reactor volumes are constant values, and the wastewater that enters the system is variable. (ARIJ, 2011).

Around 12% of the evaluated units were not functioning, to assess the reason behind this; a technical evaluation was done and the following aspects were considered that can lead users to stop operating their WWTPs:

- WWTPs users can consider that at winter time no need to reuse the treated wastewater, since at winter time they may rely on rain water for irrigation instead of treated wastewater, users thinking in this manner could be capable of cutting the source of power (electricity) especially in wintertime, and that is needed for both wastewater treatment and reuse process.
- WWTPs users' with lack of environmental commitment, in the absence of the enforcement of environmental practices.
- WWTPs users 'neglection to the installed systems and their lack of willingness to comply with what they were trained for in what regards the WWTPs periodic maintenance needed.
- WWTPs users may lack of willingness to invest in maintenance to the installed system, despite that the installed systems were made a manned that the needed maintenance is minimum.
- WWTPs users may face change in their willingness of having home gardens and in the absence of enforcement to the environmental practices there is a potential risk of users end operating their wastewater treatment and reuse system.
- WWTPs users lack of maintenance provided to the system ,and their lack of commitment in following the maintenance instructions can lead the WWTPs users to think that their systems are not efficient (Example : The used technology is activated sludge , therefore needs periodic wasting of sludge. Neglecting sludge removal can lead WWTPs users to think that the installed system is not efficient and this can encourage the WWTP user to stop operating the installed WWTP). (ARIJ, 2011).

3% of the installed units were malfunctioning with low efficiency, to assess the reason behind this; another technical evaluation was done and the following notes were obtained:

- Some WWTPs users' willingness to get benefit of bigger volumes of treated wastewater can lead them to connect neighboring households drainage line to the installed systems, exposing in this manner the WWTP to overloading working conditions leading at the end to effluent of low quality.

- Some WWTPs users' fears of technology and of reusing treated wastewater can encourage them to utilize a WWTP with gray water inlet instead of wastewater, altering in this manner what the wastewater treatment plant was originally designed for, and affecting in the expected system effluent (ARIJ, 2011).

3.4. Feasibility discussion related to the adopted wastewater treatment technology

Each installed wastewater treatment plant in the project was planned to serve a small family of six members at maximum as recommended, with a hydraulic daily flow that does not exceed one cubic meter. In accordance with the information provided through the MTE activities, the following was obtained: The daily wastewater generation in each household with installed WWTPs is estimated to range between (200 – 800) liters / day. Assuming an average of 500 liter / day, multiply this value with 365 days (the number of days of the year), then each installed wastewater treatment plant is estimated to treat an approximate of 183 cubic meters of wastewater per year.

The running cost of a single installed WWTP is estimated to be as follow: (1) Electricity cost is estimated to range between NIS 25 and NIS 35 per month, then assuming the average cost of electricity is 30 NIS / month, then the annual electricity cost will be NIS 360. (2) Equipment maintenance cost and / or replacement of parts if needed is estimated at NIS 330 / year. (3) Sludge removal cost: the excess sludge is needed to be periodically removed and the frequency of removal depends at the end on the plant loading; the adopted sludge removal frequency ranged between six and eight months, assuming that each time the excess sludge is removed, a vacuum tanker will be hired for that purpose *(According to information gathered trough the MTE, the costs of vacuuming an approximate of seven cubic meters of wastewater (a typical full load capacity of a common vacuum tanker used in the area on evaluation) ranged between 70 and 150 NIS depending at the end on the locality, distance of the household and distance of discharge point). By* adopting that, the average cost of hiring a vacuum tanker will be NIS 110 per load and by adopting the abovementioned sludge removal frequency, we will need to hire every two years the service of a vacuum tanker between 3 and 4 times, that means that every two years we will have to spend between NIS 330 and NIS 440. Taking the average cost of sludge removal every two years, we can estimate an approximate of NIS 193 / year spent as concept of annual sludge removal cost. Adding the three main operating costs together, we will find that the total cost of the alternative of treating the wastewater onsite, approximates NIS 883 / year (Electricity 360 NIS/year plus maintenance 330 NIS/year and periodic sludge removal 193 NIS/year).

If we assume that to prevent pollution, a household of the same aforementioned characteristics (with an approximate annual wastewater generation of 183 cubic meters) will utilize a septic tank to collect the generated wastewater instead of a cesspit, and later on this collected wastewater will be vacuumed by a vacuum tanker to an assigned accorded discharge point; adopting the vacuum tanker of the same abovementioned characteristics (tank capacity of seven cubic meters per load) and with the same average cost per load of NIS 110, then we can estimate that the frequency needed to hire the services of a vacuum tanker approximates 26 times/ year (183 cubic meters of wastewater generated annually divided by 7 cubic meters, that is the maximum load of adopted vacuum tanker); translating this into costs, we will have an annual approximated cost of 2860 NIS needed as annual vacuuming household cost. Comparing both approaches (Onsite wastewater treatment & Vacuuming of generated wastewater), we find that onsite wastewater treatment is more feasible than adopting vacuum tankers to dispose the generated wastewater and the annual difference between the two approaches is estimated to be NIS 1977 in favor of onsite wastewater treatment; this is done without considering the additional benefit of the generated treated effluent that will be generated and can be reused for restricted irrigation.

4. Conclusion and Recommendation

The results obtained after evaluating the effluent of the installed activated sludge wastewater treatment plants, indicates that: (a) the quality of the effluent can be improved to an acceptable degree, (b) the onsite wastewater treatment is more feasible than adopting the use of vacuum tankers as wastewater disposal method. The adoption of such technology in the oPt, can contribute in: (1) generating a new water resource that can be reused in restricted irrigation (2) solving a big portion of the problem resulting from the disposed volumes of untreated domestic wastewater, preserving the environment by protecting the ground water and surface from pollution due to disposed wastewater collected in cesspits and other non-environmental wastewater disposal practices, (3) economizing in the volume of the consumed drinking water used in irrigation, by replacing it with treated wastewater, contributing in improving the water resources management, (4) the household economy and sustainability by economizing wastewater vacuuming expenses and contributing in an increase of home gardens production by providing treated wastewater that can be reused after the adoption of local standard reuse recommendations ,(5) increasing of the agricultural areas as result of the non-conventional water resource that can be obtained, (6) provide an alternative solution to solve the wastewater problem especially in localities where buildings are dispersed and is unfeasible to construct wastewater collection networks ,(7) mitigating and reducing of the health problems and risks resulting from bad wastewater disposal practices. Laws enforcement, law legislations, water utilities and authorities' encouragement to WWTPs users, subsidies and awareness campaigns can contribute in a more sustainable wastewater sector. Huge efforts are needed to increase the public awareness and involvement and that can contribute in enhancing the public attitude and behavior in what regards to the environment. From this study, it can be concluded that wastewater treatment and reuse is possible in the oPt, but special attention and efforts shall be done to guarantee an environmental involvement of the onsite WWTPs end users to guarantee a proper use of installed systems and its sustainability.

5. Acknowledgment

This research has been done with the contribution of different departments at the Applied Research Institute –Jerusalem (ARIJ), among them: 1) The Water and Environment Research Department (WERU) 2) Monitoring and Evaluation Department (M&E) 3) Biodiversity and agriculture Department (BARU).The contribution of different donors as The Mennonite Central Committee (MCC), The Spanish Agency for International Cooperation and Development (AECID) and The Ministry of Education and Higher Education (MoEHE) are also appreciated.

6. Nomenclature

(BOD_5): Biological Oxygen Demand; amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period.

(COD): Chemical Oxygen Demand; a test commonly used to indirectly measure the amount of organic compounds in water.

(TSS): Total Suspended Solids; a water quality measurement.

(NH_4-N): Ammonium Nitrogen; a primary indicator of water quality.

(TP): Total Phosphorus; the sum of all phosphorus components.

(PH): Measure of Acidity or Alkalinity

(E (%)): Efficiency percentage.

(HP): Horse Power; 1 HP equals approximately to 745.7 Watts.

(WWTPs): Wastewater treatment Plants

(MTE): Mid Term Evaluation

(oPt): occupied Palestinian territory

(PSI): Palestinian Standards Institute

(SPSS): Statistical Package for Social Sciences.

(NIS): New Israeli Sequel

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Application of Different Water Harvesting Techniques as a Tool to Maximize the Plant Crop Water Requirements and Better Manage the Water Resources

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Abstract

The scarcity of the Palestinian Agricultural land which is usually located in the arid or semi-arid belts where rain falls irregularly and much of the precious water is soon lost as surface runoff. The climate change and the recent droughts have highlighted the risks to the Palestinian agriculture, which occur when rains falter or fail. The scarcity of water resource as well as the missing control over the Palestinian water resources is considered as the main factor responsible for the limited productivity of the local agriculture as it is in dry land worldwide.

The Palestinian agricultural lands are classified mainly as a semi arid land, with limited precipitation and high evaporation rates, water scarcity is considered to be a more limiting factor to production than land. Any national strategies for efficient water resources management and feasible agricultural production, must take into consideration the limited water resources, the impact of unmanaged runoff water which is soil erosion and the high competition on these resources especially when it comes to the Palestinians case where they have no control over their water resources.

Rainfall in the southern parts of Palestine mainly Hebron Governorate is characterized by high variability in time and space which is reflected on the productivity of these lands which is the result of insufficient amount or improper distribution. The effectiveness of rainfall as a future water supply for plant growth is a function of depth and timing of occurrence. Most rainfall can be lost by evaporation when only small (2mm- 3mm) amounts occur. If the rainfall is in excess of about 12 mm, some of this water will be stored and be available later to meet plant water requirements (Ayars, 2003). For maximize benefits of the limited water resources available in Palestine, many research studies tackled the issue of water harvesting techniques, as a method for increasing the availability of the stored water within the soil profile in order to meet the crop water requirements, and will reduce the risk of soil erosion as a result of water runoff.

This study aims at addressing the potentiality of using water harvesting techniques in the southern parts of the West Bank mainly (Hebron District) within the Palestinian context. Results of many studies will be presented and a set of measures along with recommendations will be offered in this paper.

1. Introduction

With growing population and limited water resources, there is an increasing need worldwide to manage water resources better. This is especially true when all or nearly all water resources in a basin are allocated to various uses and are out of the national control like in our Palestinian Case. Stone mounds and water conduits dating from the Nabatean, Roman and Byzantine periods (4th century B.C. to 7th century A.D.) can be found on hillslopes over hundreds of kilometres square in the Negev Desert, as well as in other parts of North Africa and the Middle East (Hanoch, et al.1996) .

The scarcity of the Palestinian Agricultural land which is usually located in the arid or semi-arid belts where rain falls irregularly and much of the precious water is soon lost as surface runoff. The climate change and the recent droughts have highlighted the risks to the Palestinian agriculture, which occur when rains falter or fail.

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The Palestinian Agricultural lands are classified mainly as a semi arid land, with limited precipitation and high evaporation rates, water scarcity is considered to be a more limiting factor to production than land. Any National strategies for efficient water resources management and feasible agricultural production, must take into consideration the limited water resources, the impact of unmanaged runoff water which is soil erosion and the high competition on these resources especially when it comes to the Palestinians case where they have no control over their water resources.

Rainfall in the southern parts of Palestine mainly Hebron Governorate is characterized by high variability in time and space which is reflected on the productivity of these lands which is the result of insufficient amount or improper distribution. “The effectiveness of rainfall as a future water supply for plant growth is a function of depth and timing of occurrence. Most rainfall can be lost by evaporation when only small (2mm- 3mm) amounts occur. If the rainfall is in excess of about 12 mm, some of this water will be stored and be available later to meet plant water requirements” (Ayars, 2003).

For maximize benefits of the limited water resources available in Palestine, many research studies tackled the issue of water harvesting techniques, as a method for increasing the availability of the stored water within the soil profile in order to meet the crop water requirements, and reduce the risk of soil erosion as a result of water runoff.

2. What is Water Harvesting, its Techniques and Types

The main goals of different water harvesting techniques are to store the runoff water directly in the soil profile of the planted areas, or to store the runoff water indirectly in tanks, reservoir or other means.

Wide ranges of indigenous water harvesting techniques were used in the arid and semi-arid regions of the world. In their publication, Siegret and Critchley (1991), differentiated the following types of water harvesting techniques that are widely used worldwide:

1. Contour ridges: (Contour furrows), it is a microcahment techniques constructed by creating earth ridges along the contour, soil is excavated and placed downslope to form ridge, ridges follow the contour at spacing of usually 1 to 2 meters depending on plantation type,

rainfall and topography. The technique is mainly suitable for different field crops, shrubs and trees.

2. Diamond shape microcatchment: it is a network of diamond shape or open ended of V formed by earth ridges with infiltration pits in the down slope end. The technique is suitable and functioning for regions of 100-200 mm rainfall. It is recommended for trees plantation of different species. The soil should be at least 1.5 to 2 m deep in order to ensure enough storage of harvested water and therefore providing adequate root development.

3. Semi-circle bound: this type of water harvesting structure is classified as microcatchment technique. Semi-circle bounds are earth embankments in the shape of a semi-circle with the tips of the bunds on the contour, the system should be implemented in a staggered orientation, and the soils are not too shallow or saline. Semi-circle bounds are mainly used for rangeland rehabilitation or fodder production, also it is useful for growing trees and shrubs. Such system is used in many parts of the world, in West Bank as in (Daherya, Hebron) the farmer built this system to support olive trees (MPO, 2002).

4. Stone terracing: terracing are constructed a long with the slope using small stones, to slow down runoff, increasing the infiltration and capturing the sediment. The technique is widely used in the mountainous area, which have adequate supplies of stones can be implemented quickly and cheaply. The Jessour system is a type of stone terracing, which constructed in the wadi with earth dikes (tabia) which is often reinforced by stone walls, the sediments accumulating behind the dikes are used for cropping (Prinz, 2003). In the central mountains of Palestine stone terraces have been developed by farmers in the ancient times thousands of years ago, these terracing are cultivated with different types of cereals and trees.

3. Problem Statement

The Palestinian Lands are classified mainly as a semi arid land, whereas limited precipitation and high evaporation rates, that induce water scarcity are dominant and subsequently limiting the productivity of the land, which must be considered as a higher priority in the national strategies for water management, also bearing in mind the limited water resources in term of quantity and quality and the increased competition on these resources especially when we consider no control over our water resources.

The study aims at addressing the potentiality of using water harvesting techniques in the southern parts of the West Bank mainly (Hebron District) within the Palestinian context. The results of many studies will be presented and a set of measures along with recommendations will be offered in this paper.

4. Study area

The study area is located in southern-west and north-west parts of Hebron District, between the villages (Sourif, Aldahryeh, Doura, and part of Bani Naem). This transect, extending over a distance of 60 km, illustrates a very sharp rainfall gradient running from a mean annual rainfall of 250–350 mm, to an arid climate, with less than 150 mm Bani Naem and Adahryeh.

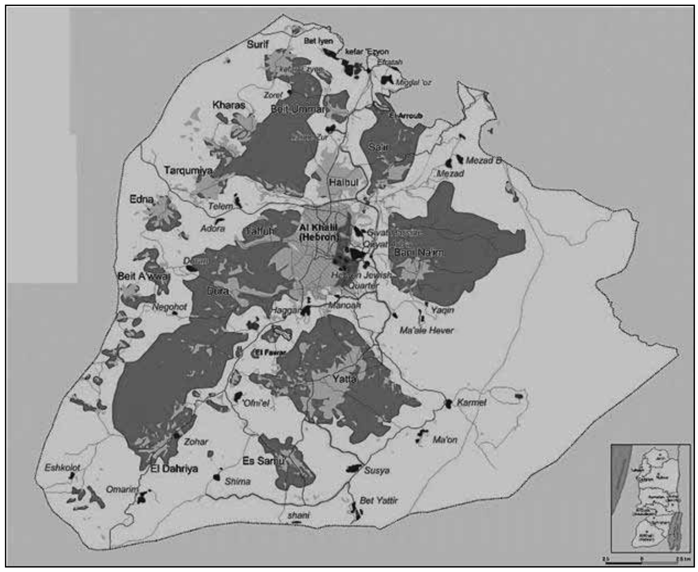

Figure 1. Hebron Governorate Map MOPIC. 2000

5. Study Resources

Many studies tackled this issue from various point views, but with one common goal, aiming at increasing the availabilities of water for fulfilling the different plant water requirement.

In their study (Hanoch, et al., 1996), proved that ancient farmers were very efficient in harvesting water. A comparison of the volume of stones in the mounds to the volume of surface stones from the surrounding areas indicates that the ancient farmers removed only stones that had rested on the soil surface and left the embedded stones untouched. Ancient stone mounds and water conduits are found on hillslopes over large areas of the Negev desert.

In his study (Katbeh-Bader, 2006) were Stone Walled Terraces (SWT) and Diamond Shape Micro Catchments (DSMC) tested in seven sites, in Two ways; the first is to test WHT in newly planted fields, while the second is to test these techniques in an already established Nabali olive fields. The concluded that:

1. Soil moisture content increased significantly when WHT were implemented in old olive fields especially in SWT experiment;
2. Increased water content was reflected in olive tree productivity in kg/tree; this increase was up to three folds in one site for the growing season 2003/2004 and 2004/2005.
3. Plant growth parameters, for new seedlings showed no positive effect of WHT.

A study By (AL-Seikh, 2006), Field experiment were conducted in three sites at Hebron district (Soreif, BanNoeim, and Dura), which represent different environmental conditions, to assess the effects of different WHT on runoff, sedimentation, and soil properties.

The results indicated that WHT are efficient in reducing surface runoff and sedimentation and increase the soil moisture storage compared to untreated area. Stone terraces, semi-circle bunds, and v-shape have higher soil moisture storage compared to the control. The study concluded that:

1. Water harvesting techniques (semi-circle bunds, stone terraces, contour ridges) were efficient in

increasing soil moisture storage compared to untreated area (control).

2. Water harvesting significantly reduce the amount of soil erosion and runoff compared to natural areas without any treatments (control).

3. WH Higher plant growth of fruit trees (olive and almond) grown inside water harvesting techniques (semi-circle bunds and v-shape) compared to those planted without these techniques (controls).

A study by (Al-Joaba, 2006), conducted in three different sites (Massafer Bani-Noe'm, Sorif and Dura) in Southern part of West Bank; to study the influence of environmental factors, grazing and water harvesting techniques on the vegetation attributes (dry plant biomass, plant density, ground cover and frequency). Results indicate that plant dry biomass and species plant density increased, and new plant species appeared when water harvesting were constructed which indicates that the rangelands of West Bank have the potential for natural re-vegetation when suitable management used, but it needs time specially in dry area.

A study (Alqouqa, 2006), concluded that different water harvesting techniques increased productivity and subsequently increase gross margin from production and reduced the risks of negative profits.

6. Problems and Constraints Hindering the Use of Water Harvesting

We think that the significant potential problems and constraints hindering the integration of water harvesting as a tool to maximize the plant crop water requirements and better manage the water resources of the southern parts of Palestine:

1. Technology inadequate to the requirements of the area;
2. Lack of acceptance, motivation and involvement among beneficiaries;
3. Lack of adequate hydrological data and information for confident planning, design and implementation of water harvesting techniques;
4. Insufficient attention to social and economic aspects such as land tenure, unemployment, and return of water harvesting system;
5. Lack of effective involvement of the national research centers and extension services;
6. Inadequate institutional structures, beneficiary organizations (associations, cooperatives) and government training programs for farmers, pastoralists and extension staff;
7. Absence of a long-term government policy.

7. Conclusion and Recommendations

1. Agricultural Practitioners have to utilize the available water resources, in order to sustain their Agricultural practices and secure their food needs;
2. RWHTs, are excellent tool to maximize the plant crop water requirements
3. Long term studies are recommended.
4. Attention and considerations must be given to the above mentioned potential problems and constraints.

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Annual Variation in Spring Water Quality and Discharge in the West Bank

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Abstract

Springs are the major source of water for both domestic and agricultural purposes. Continuous supply of high quality and adequate quantity of water is essential for economic, industrial, social and environmental sustainability and survival. This paper studies the annual variation in spring water quality and discharge throughout the West Bank profile. Data for spring water quality and quantities discharged was obtained from PWA, PNA, PCBS and Palestinian MoH. On one hand, the majority of springs in the West Bank are considered suitable for drinking from the chemical point of view since mean values of tested parameters are below the recommended Palestinian Standards and WHO Guidelines. However, water from those springs is contaminated with coliform bacteria and can't be used unless properly disinfected. On the other hand, most of the springs are suitable for irrigation expect those which suffer from high salinity as in the case of some Jericho springs. Variation in the water quality of the springs throughout the West Bank can be attributed to the chemical and mineralogical compositions of the aquifer from which the spring is discharged, to the agricultural activities and to the improper or illegal disposal of raw wastewater near recharge areas. Annual quantity supply of spring water discharge represents 5.5 and 23.9 mcm/y for both domestic and agricultural sectors, respectively. Fluctuation in discharge quantities may be due to factors such as occupation water-related activities, annual rainfall, temperature and evaporation rates, which directly affect groundwater recharge, spring discharge and eventually water supply for domestic and agricultural sectors. It is important to resolve current unsustainable water practices, particularly aquifer over pumping and lack of pollution control through legislation, institutional reform, rehabilitation of springs, modernizing agriculture, establishment of wastewater collection systems, treatment facilities and wastewater reuse.

Key words: Water scarcity, Groundwater, Spring discharge, Rainfall, Contamination.

1. Introduction

Water is vital to life. It promotes the economic and the general wellbeing of the society through its diverse and beneficial uses. "The human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses" (UN Economic and Social Council, 2002).

The available water resources in the Middle East are scarce, limited, threatened and are already exploited especially in Palestine. Palestine belongs to the arid and semi arid areas that are normally characterized by low rainfall and high temperature and evapotranspiration (Ikhlil, 2009). The shortage of water in the area is not only caused by scarcity of naturally available water resources, mismanagement and pollution of these water resources and rapid increasing demand due to the rapid population growth, but also because of lack of control over these resources (Smith, 2011; Ikhlil, 2009; Daghrah, 2005; Isaac, 2005; Sabbah *et al.,* 1998). The average per capita availability is extremely low, a large proportion of the water resources are transboundary and final arrangements on water resources allocation between Palestinians and Israelis have not yet been achieved (Ikhlil, 2009).

The principal and conventional water resources available to Palestinians include groundwater, surface water, and harvested rainwater (UNEP, 2003). Whereas the unconventional resources include treated wastewater and desalinated water (Anayah, 2006), where growing water scarcity has resulted in the increasing interest in and use of the latter water sources (UNEP, 2003).

Nowadays, the major two sources accessible to the Palestinians are groundwater of water pumped from wells and undeveloped springs, and water purchased from Israeli Water Company (Mekorot) (PCBS, 2009f), where the total amount of water available from these two sources was 315.99 million cubic meter/year (mcm/y) in 2009 (PCBS, 2009a) both in the WB and Gaza Strip.

Restrictions on Palestinian movement and access due to the Israeli separation wall, Israeli checkpoints, barriers and roadblocks as well as bypass roads, closed military areas, nature reserves and area C zoning, have cut many Palestinian communities off from their water resources (EWASH Advocacy Task Force, 2009). The amount of water utilized by Palestinians from ground water aquifers is very little since 85% is being exploited by both Israelis and settlers (PCBS, 2011b). Average West Bank Palestinian water consumption is 70 liter/capita/day (l/c/d) which is less than the minimum global standards set by the World Health Organization which stands at 100 l/c/d. Israeli usage of West Bank groundwater sources has been estimated at approximately 483 mcm/y while Palestinian use was estimated at 120 mcm/y. In addition, Palestinians are forbidden from using the Jordan River, which would provide 250 mcl/y (Maan Development Center, 2010).

The West Bank Resources are finite; the pressure on natural resources is increasing as both Palestinian and settler populations expand (OCHA, 2007). Groundwater is considered to be the main fresh water resource in the West Bank (Hilou, 2008; Anayah, 2006; Daghrah, 2005; Ghanem, 1999), where springs are being counted on to cover part of the water demand in the domestic and agricultural use (PCBS, 2009f). There are 120 springs in the West Bank with a total annual discharge of 30.6 mcm (PCBS, 2009c), and usual fluctuations in their yield depend on the rainfall quantities, and thus the recharge to the groundwater (Ikhlil, 2009). Figure 1 illustrates the springs in the West Bank along the Eastern, Western and North Eastern Basin according to the spring use.

The hydrochemical parameters are the main indicators of water quality for the springs. The hydrochemistry of the springs will indicate to which extent the spring water is suitable for drinking or agricultural purposes (Ghanem and Ghannam, 2010) in comparison of the results of water quality analysis with WHO guidelines and/or Palestinian standard.

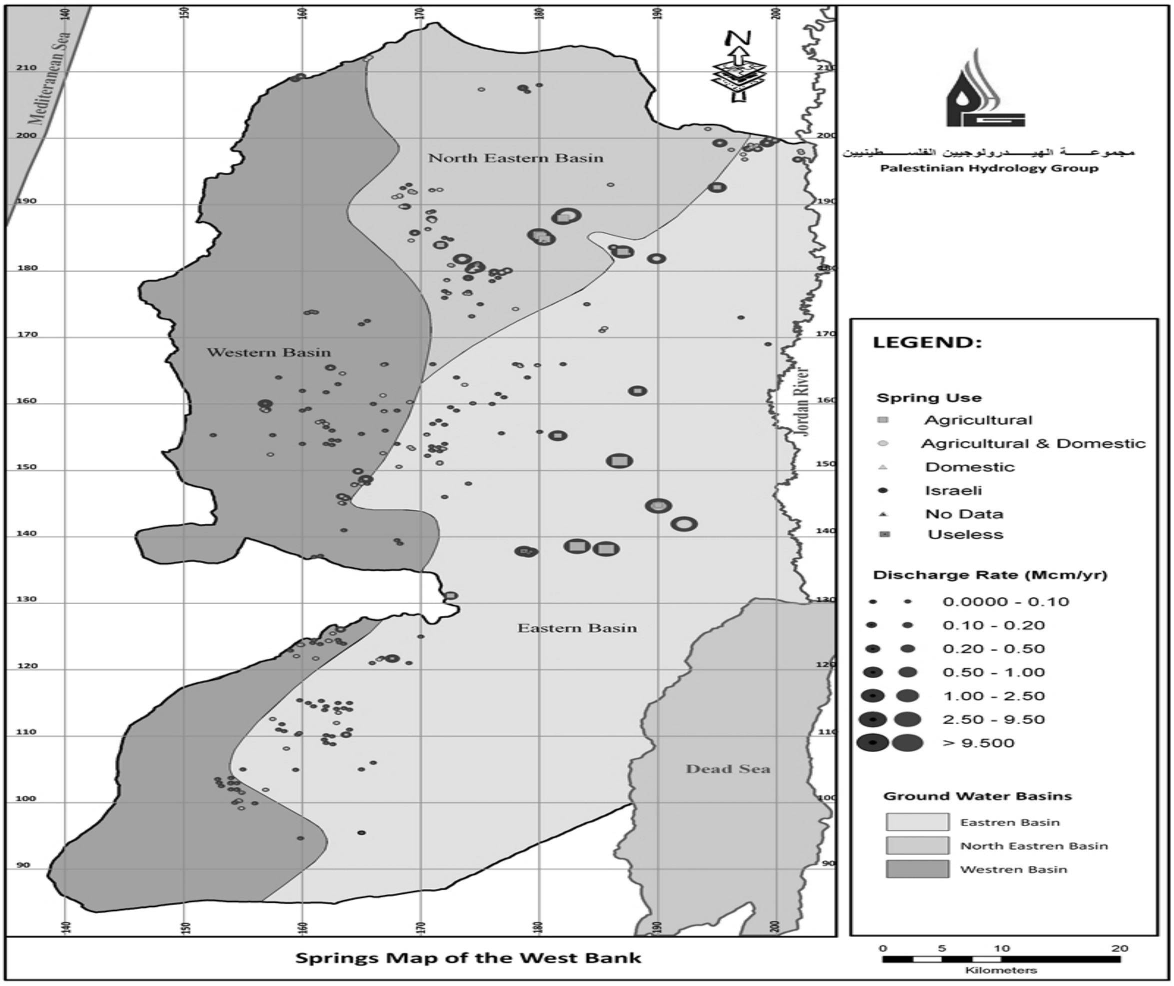

Figure 1. Springs Map of the West Bank (PHG, 2010)

Spring water quality is influenced by the quality of its source, and any change in groundwater recharge or degradation in water quality may seriously impair the quality of groundwater and spring water (Anayah, 2006).

The majority of the springs in the West Bank are suitable for drinking from the chemical point of view; the concentrations of various health hazard parameters such as nitrate and heavy metals are within the acceptable limits of WHO guidelines for drinking water. In addition, except for few, all springs in the West Bank are suitable for agriculture purposes (Abed Rabbo, *et al.*, 1999). However, springs are susceptible to pollution, mainly due to agricultural practices, industrial activities and improper disposal of solid waste and wastewater (Ghanem, *et al.*, 2011). There is no advance treatment of water in the west bank except for using chlorine to disinfect domestic municipal wells and springs, which is not even carried out regularly (Anayah, 2006).

The continuous supply of high quality water is essential for economic growth, quality of life, environmental sustainability and survival (Shalash and Ghanem, 2008). Many previous studies interested in the quality and quantity disciplines of the groundwater and springs discharge are available. Some of these studies were carried out in the West Bank and others abroad.

Ghanem, *et al.* (2011) determined the quantitative effect of pesticides and heavy metals on groundwater quality due to agricultural practices in Jenin and Tulkarem. The concentration of pesticides in Jenin was found to be higher than those in Tulkarem. Also, Jenin showed significant pollution from the trace elements mainly Pb, Cd and Cr. Studied wells showed unsuitability for domestic consumption due to the uncontrolled industrial and agricultural activity and lack of monitoring.

Daghrah (2009) examined the quality of water discharged from Wadi Al Qilt drainage basin springs. Physiochemically, water flowing from the springs is considered a good source for domestic, industrial and agricultural purposes. Microbiologically, except Ein el Fawwar and Ein Al Qilt, all other springs are fecal-coliform free.

Badrakh, *et al.* (2008) assessed the quality and hygienic conditions of spring water in Mongolia in 2004. The majority of springs studied had poor hygienic conditions such as low flow rate, turbidity or pollution sources in the springs surroundings. Different levels of contamination using both microbiological and chemical tests were found in studied springs. Thus, awareness should be considered among communities and local authorities for further protection and upgrading of spring water sources.

Mazibuko, and Mwendera (2006) assessed the impacts of uses of thermal springs in Swaziland on water resources quality. The results indicated that the used water from the hot springs had levels of quality parameters significantly much higher than the recommended Swaziland, South African and WHO standards. Monitoring of these parameters and regulation of hot springs usage are needed to reduce the negative impacts on the water resource.

Risk from spring water bacterial contamination for Kampala city in Uganda was examined by Haruna, *et al.* (2005). Sanitary risk assessment score was used as a tool for predicting the levels of bacterial contamination. The results showed that the water is unsuitable for drinking as 60%, 90% and all samples in regard to nitrate, *fecal coliform* and *total coliform*, respectively, had levels above the WHO recommended limit.

Negi, and Josh (2004) studied the relation between rainfall and spring discharge in the western Himalayan Mountains in India. Regardless topography, which affects water yield and nature of the springs, the study showed a strong positive relationship between rainfall and spring discharge. Some springs could be suitable for tapping water for household consumption; however, their water quality needs further investigation.

Faniran, *et al.* (2001) investigated the physico-chemical properties of Isinuka springs in South Africa over three seasonal regimes. The study indicated that the springs are unsuitable for drinking, hard, salty, turbid, fairly neutral, have very high concentrations of TDS, Cl^- and NH_4^+-N. The concentrations of $SO4^{2-}$ and phenol are high enough to cause serious health risks after prolonged intake. However, no occurrence of blue baby syndrome was noticed due to the presence of low levels of $NO2^-$.

The quantity and quality of available water varies over space and time, and is influenced by natural and manmade factors including climate, hydrogeology, management practices and pollution. The objective of this study is to review a time series of statistical data related to the water status in the West Bank to cover water quality and quantity of water discharged from springs and highlights the fluctuation in water quality and yield as a result of different pollution sources and annual rainfall quantities, respectively.

2. Methodology

This paper provides briefs on all springs in the West Bank with regard to spring water quality and quantity in terms of discharge. Data about springs water quality and discharge are second hand data collected from the records of the Palestinian Water Authority (PWA) and Ministry of Health (MoH). Data of springs' water physical and chemical properties were obtained from PWA only for the years 2007 and 2008, while data about springs discharge was for the years between 2005-2009. Whereas, only data for microbiological properties obtained from MoH was for the year 2010. Results would have been stronger if data for a series of years was available.

Data screening, sorting, and processing were conducted for the obtained spring water quality and discharge data. Data was also assembled and sorted with regard to the districts' spring type of usage.

Despite the fact that the PWA database on springs water quality in the West Bank is limited, it includes measurements of a variety of parameters; available chemical parameters are chloride, sulfate, nitrate and bicarbonate. Physical parameters include pH, temperature, turbidity and electric conductivity. Whereas, microbiological parameters include Total and Fecal *Coliforms*.

All available spring water data was assembled into a single composite database to facilitate the analysis. Previous publications and reports have been joined to the data in order to highlight the annual variation of springs in terms of water quality and discharge during previous consecutive years till the time being. Quality data was compared with WHO guidelines and Palestinian Standards to assess suitability for domestic and agricultural practices. While discharge data was checked for annual fluctuations and its relation to temperature and evaporation rates, total water supply and domestic/agricultural water supply amounts for Palestinians in the West Bank.

Finally, the main conclusions were set as a brief summary of the whole status, followed by major recommendations for both public and professionals.

3. Results and Discussion

Collected data was separated and tabulated in order to facilitate the analysis of the various properties and parameters.

The purpose of water analysis is to determine the level of pollution of spring water in the West Bank by measuring water quality parameters; chemical, physical and microbiological properties.

3.1. Physiochemical Properties

The descriptive statistics (minimum, maximum, average and standard deviation) along with water quality standards (Maximum Allowable Concentrations "MAC") of Palestinian and WHO for the different parameters are illustrated in Table 1.

The pH values of springs ranged between 6.5 – 8.1 and 6.9 - 8.6 with a mean value of 7.3 and 7.4 for the years 2007 and 2009, respectively. Results from all tested samples are within the MAC established by Palestinian and WHO standards except for 1 value of 8.6 in Jericho in 2009. This high pH value reflects dolomite and limestone dissolution from the Pleistocene age-aquifer system geological formation of both Lisan and Samara layers (Khayat, et al., 2006).

Table 1. Physiochemical Properties for Spring Water in the West Bank – 2007, 2009

Parameter	2007				2009				Palestinian Standardsc	WHO Guidelinesd
	Range	Mean	Samples above MACa	Standard Deviation	Range	Mean	Samples above MAC	Standard Deviation		
T (0C)	2.0 – 29.0	22.7	---	2.35	17.0 - 27.5	22.5	---	1.94	NAb	NA
pH	6.5 - 8.1	7.3	---	0.27	6.9 - 8.6	7.4	1	0.34	6.5 – 8.5	6.5 – 8.5
Turbidity (NTU)	0.3 - 16.9	1.3	4	1.66	0.8 - 171.0	4.2	7	17.65	5	5
EC (ms/cm)	51.0 – 4560.0	733.3	5	490.46	434.0 – 5900.0	1366.8	14	1236.10	NA	2000
HCO3 (mg/l as CaCO3)	98.5 - 373.3	200.2	---	52.81	180.8 - 442.3	312.8	---	50.76	500	NA
Cl- (mg/l)	19.0-1106.0	81.0	6	112.12	30.4 - 1520.8	243.5	17	358.27	250	250
SO4-2 (mg/l)	5.0-276.0	26.0	1	27.41	0.6 - 573.0	48.8	4	77.08	200	NA
NO3- (mg/l)	2.0-496.0	32.0	16	47.96	3.5 - 180.9	41.5	12	32.14	50	50

[1] (PWA, 2011a)

[a] MAC= Maximum Allowable Concentration

[b] NA= Not Available

[c, d] (Al-Salaymeh and Al-Khatib, 2009; Daghrah, 2005)

Values of turbidity increased with a mean of 4.2 NTU in 2009 compared to 1.3 NTU in 2007, especially in Jenin and Nablus districts, where turbidity was a result of rainstorms and rainwater runoff. According to PCBS (2007-2009b), rainfall quantity measured in Jenin station increased from 232.5 mm in 2007 to 593.1 mm in 2009.

The EC of the water depends on the water temperature; the higher the temperature, the higher the electrical conductivity would be. Mean values of EC are considered below the WHO guidelines. Samples of high EC values are located mainly in Jericho and they are directly proportional with the effect of temperature as stated above.

EC is directly related to the concentration of total dissolved salts and ions and a good indicator for salinity mainly occurring in Jericho spring water. Salinity makes spring water unsuitable for irrigation as it affects crop productivity (Khayat, et al., 2006).

Causes of salinity are derived from the discharge source of these springs resulting from: upwelling from deep underlying brine aquifers as a result of over extraction or fresh water aquifers containing salt-bearing rocks, *in-situ* dissolution of salts from Lisan and Samara layers and anthropogenic sources such as agriculture return-flow and domestic sewage (Khayat, *et al.*, 2006; Marie, and Vengosh, 2001). Wastewater facilities in the Jordan Valley are unlined or in need of repair, whereas, many communities lack connection to the sewerage network and families are forced to used septic tanks and holes (Maan Development Center, 2010).

There is relatively little information concerning the impacts of the Dead Sea on the salinity of the groundwater in the Jordan Valley (Anayah, 2006). However, a study showed that salinity of groundwater was due to Dead Sea brine (Anayah, 2006; Marie, and Vengosh, 2001).

Mean values of HCO_3, Cl^-, SO_4^{-2} and NO_3^- are below the Palestinian standards and WHO guidelines.

However, some individual values in Jericho springs water exceed the MAC for Cl^-, SO_4^{-2} and NO_3^-. Intensive evapotranspiration, excessive agricultural activities and irrigation applications of inorganic fertilizers are potential sources of chloride contamination of groundwater that is eventually discharged into springs (Anayah,2006).

The occurrence of SO_4^{-2} in Jericho springs is due to leaching of salts from the aquifers' Lisan formation (Khayat, *et al.*, 2006; Marie, and Vengosh, 2001). Whereas, HCO_3^- presence, suggest dolomite and gypsum/calcite weathering from the Samara and Lisan layers, respectively, along the water path (Khayat, *et al.*, 2006). Upon the collected data from PWA, unlike SO_4^{-2}, individual and mean values of HCO_3^- for all districts lay below the MAC of the Palestinian standards.

Water Quality towards the Jenin area tends to deteriorate due to over pumping and heavy irrigation activities (Aliewi, 2007), which results in chloride concentration reaching 435 mg/l, and nitrate concentration of 150 mg/l, which are highly above the recommended guidelines.

Elevated nitrate concentrations in the groundwater and spring water of the West Bank are of increasing concern due to the fact that it can cause methemoglobinemia in infants and stomach cancer in (Wolfe, and Patz, 2002). Results showed that the annual mean of nitrate values is below the MAC, however, 9% and 7% of samples in 2007 and 2009, respectively, contain nitrate concentrations above the MAC of 50 mg/L of Palestinian and WHO guidelines. Highest values were recorded in Ramallah 293 mg/L, Tubas 170 mg/L, Jenin 150 mg/L, Nablus 130 mg/L and Jericho 87 mg/L.

Nitrate values vary with agricultural/domestic activities and well location from which the springs discharge (Khayat, et al., 2006). The areas with the most elevated nitrate concentrations are areas characterized by heavy agricultural activities. Such activities are intense in Jenin, Tubas, Tulkarem, Qalqilya, and Jericho districts (Anayah, 2006). Other anthropogenic influences are from nitrogen fertilizers, pesticides, manure and animal farms (Khayat, et al., 2006). According to Anayah, and Almasri (2009), elevated nitrate concentrations in the groundwater correspond to agricultural practice, increasing rainfall and groundwater recharge. However, contamination in populated areas, where no agricultural activities exist, is attributed to leaking septic and sewer systems.

3.2. Microbiological Properties

The health concerns associated with chemical constituents of drinking-water differ from those associated with microbial contamination and arise primarily from the ability of chemical constituents to cause adverse health effects after prolonged periods of exposure.

Out of 377 water samples from spring water in the west bank for Total *Coliform* (TC) and Fecal *Coliform* (FC), 32.1% and 23.9% of the samples, respectively, were microbiologically contaminated as illustrated in Table 2.

These results indicate serious contamination, especially for spring used as an additional drinking water supply. As studied by Hind (2004), contamination originates from the absence of wastewater collection sewerage systems and the spread of unsealed and unlined septic tanks and cesspools, where wastewater percolates easily toward groundwater and is mixed with the water of the springs as in Nablus and Ramallah districts; 24.3% and 36.0% of tested samples were totally contaminated and 20.3% and 28.0% were fically contaminated, respectively. Al-Salaymeh and Al-Khatib (2009) and (ARIJ, 1995) stated the same reason for contamination in Hebron district and in some villages of Bethlehem district, respectively. Not to mention that contamination of springs results from percolation of wastewater from cesspits and open channels especially during winter season

In addition, households in Nablus and Hebron owns one or even few animals such as a cow, a donkey, goats and chicken, and the urine and feces of these warm blooded animals along with the human feces contribute further to the pollution of spring water.

As studied by ARIJ (2006), the source of contamination in Tubas is due to the disposal of wastewater in cesspits. And since 90% of the residents rear livestock, they might add a source for contamination as in Nablus and Hebron. However, providentially, according to the data obtained from Palestinian MoH (2011), all tested samples were clean of any contamination.

Table 2. Microbiological Properties for Spring Water in the West Bank – 2010*

District	No. of Tested Samples	Total Coliform (TC)		Fecal Coliform (FC)	
		No. of contaminated Samples	% TC	No. of contaminated Samples	% FC
Jenin	20	3	15.0	2	10.0
Ramallah	25	9	36.0	7	28.0
Nablus	148	36	24.3	30	20.3
Bethlehem	11	5	45.5	3	27.3
Hebron	8	4	50.0	2	25.0
Jerusalem	2	2	100.0	2	100.0
Salfit	12	6	50.0	3	25.0
South Hebron	74	17	23.0	6	8.1
Tubas	7	0	0.0	0	0.0
Jericho	70	39	55.7	35	50.0
Totals	377	121	32.1	90	23.9

* (Palestinian MoH, 2011)

Hind (2004) also observed that low maintained and Israeli-damaged wastewater networks, causing flooding during dry and wet weather conditions, add to the pollution in Jenin, which already suffer from groundwater pollution due to leachate from the solid waste Israeli dumpsite in the area.

As for the case of Salfit, untreated wastewater discharged from the nearby settlement of Areal is flowing to Wad Al Matwee, passing toward the town of Burqeen crossing it and flowing east word to Deir Balloot and Kufr Al Deek where it pollutes Ein Al Fawwar Spring in Jericho.

Four kilometers to the west of Salfit lays Bruqeen. According to Hind, highly polluted and uncontrolled industrial wastewater is being discharged from the industrial zone of Barkan settlement into Wadi Al Wadat, where it flows to Der Balloot causing Wadi Al-Qilt and its springs to be environmentally hazarded and polluted.

The same applies to villages of east Jerusalem, where Ein Al-Farrah spring is of low water quality resultant from sewage flowing from the settlement of Neve Ya'acov (ARIJ, 1996).

3.3. Spring Water Discharge

The population of Palestine (West bank and Gaza) is estimated at 3,702,218. The annual available water quantity in Palestine is 316.0 mcm/y including water purchased from Israeli Company Mekorot (includes pumped water from the wells which are located in the Palestinian Territory and controlled by Mekorot company for domestic and agricultural sectors), as stated in table 3. The annual available discharge of springs water is estimated at 30.6 mcm/y representing 9.7% of the total annual available water quantity in the region.

Table 3. Selected Indicators for Water Statistics in Palestinian Territory/ West Bank – 2009

Indicator	Palestine	West Bank
Population 1	3,702,218	2215402
Annual Available Water Quantity (mcm/y)2	316.0	146.3
Annual Available Discharge of Springs Water (mcm/y)2	30.6	30.6
Annual Quantity of Water Supply for Domestic Sector (mcm/y)1	182.2	86.5
Annual Quantity of Spring Water Supply for Domestic Sector (mcm/y) 3	5.5	5.5

[1] (PCBS, 2009d) [2] (PCBS, 2009a) [3] (PCBS, 2009e)

For a population of 2,215,402, the annual available water quantity in the West Bank is estimated to be 146.3 mcm/y, representing 46.3% of the annual available water quantity in Palestine. The annual water quantity available for Gaza is higher than in the West Bank, which is due to the fact that Gaza has no springs. This leads to having similar annual available discharge of springs water for Palestine and West Bank, but representing 21% of the total annual available water quantity in the West Bank.

Concerning the domestic Sector, annual quantity of water supplied to the Palestinians in the West Bank is estimated at 86.5 mcm/y which represents 59.1% of the annual available water, where 5.5 mcm/y (6.4%) is being supplied from springs, and the rest 37.2% and 56.4% are being supplied from wells and Israeli water company Mekorot, respectively.

As illustrated in Table 4, and depending on the water quality to be supplied for different uses, 22% of the springs in the West bank supply the domestic sector annually, with the majority of 19 out of 28 springs in Nablus district, and 60% supply the agricultural sector, where, in decreasing order, the majority of springs are located in Ramallah, Bethlehem, Nablus/Hebron and Tubas. In addition, 9.5% supply both sectors, whereas, 7.9% of the springs are not being used. In terms of annual quantity of spring water supply, 5.5 and 23.9mcm/y are being supplied for domestic and agricultural sectors.

Table 4. Spring Water Type of Usage in the West Bank – 2009*

District/Usage	Agriculture	Domestic	Both	Not Used	Total
Jenin	4	3	---	---	7
Ramallah	22	2	4	3	31
Nablus	11	19	4	2	36
Bethlehem	13	1	---	1	15
Hebron	11	---	---	1	12
Jerusalem	1	---	---	3	4
Salfit	---	3	1	---	4
Tubas	9	---	1	---	10
Jericho	5	---	2	---	7
Totals	76	28	12	10	126

* (PWA, 2011b)

Table 5 shows the annual spring water discharge in the West Bank between 2005 – 2009. Results obtained for the year 2009 mimic the results obtained above contributing to an annual discharge of springs water of 30.6 mcm/year

Table 5. Annual Spring Water Discharge (m3/y) in the West Bank by Governorate, 2005 – 2009*

District/Year	2005	2006	2007	2008	2009
Jenin	211588.05	231129.993	205170	152772	176839
Ramallah	1471050.19	1655378.45	1713782	984618	714152
Nablus	9109728.67	9650787.68	8780751	2382296	4879745
Bethlehem	681665	858394.657	550261	356869	2271398
Hebron	208820.5	279315.493	258345	147230	174003
Jerusalem	2107406.4	2834392.1	2645374	1476077	1161277
Salfit	278260.5	279788.53	245276	152460	188143
Tubas	7609974.33	8389602.45	4484542	2458195	1572333
Jericho	31962702	31452059.3	25931963	17127046	19492234
Totals	53641196	55630848.65	44815464	25237563	30630124

* (PWA, 2011b)

Plotting a graph of total annual spring water discharge (mcm/y) in the West Bank, versus the year, shows variation in springs discharge during different consecutive years. The total annual springs water discharge varies according to the intensity of precipitation (Sbeih, 2007). The average annual rainfall varied from 429.1, 494.9 and 354.1 mm for the years 2005, 2006 and 2007, respectively (PNA, 2008). While it varied from 328 mm (PCBS, 2009f) to 482.9 mm (PCBS, 2009b) for the years 2008 and 2009.

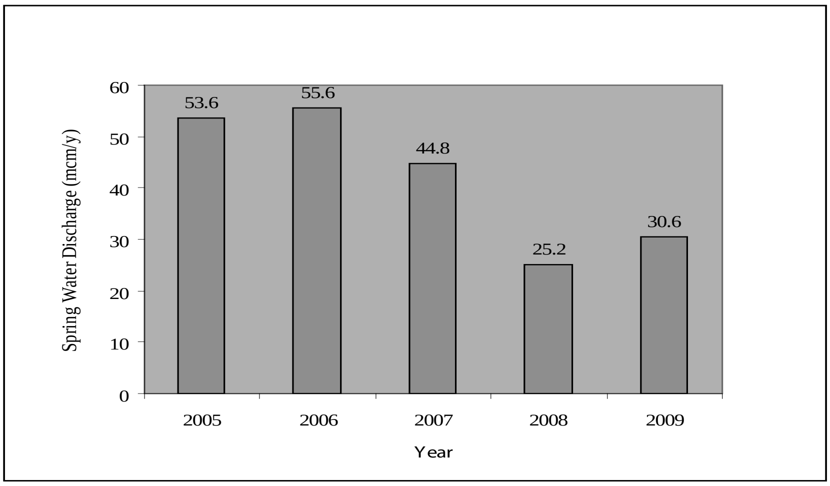

Figure 2. Annual Spring Water Discharge (mcm/y) in the West Bank, 2005 – 2009

This corresponds to varying annual spring water discharge as per figure 2 except for the latter in 2009. This results from climate change and elevated temperatures during the past years. The annual evaporation quantity ranged from 1820 mm in 2005 to 2065 mm in 2009 (PCBS, 2011a). Thus, the amount of spring water losses, due to evaporation contributes to a lower discharge amount, inversely correlates with rainfall.

4. Conclusions and Recommendations

In general, each human being has the right to access sufficient, safe, acceptable, physical accessible and affordable water. This is not the case in the occupied Palestinian territory (oPt), as it is one of the scarcest water availability in the world, due to both natural and man-made constraints. With time, water shortage will increase and become a greater problem as a result of population growth, higher standards of living, expected climate change, and Israeli practices and restrictions imposed on both the water resources and its sector's development. The current political negotiations do not include adequate provision for a fair and just distribution of water resources.

People living in the West Bank depend mainly on spring water, water pumped from Palestinian wells and water purchased from the Israeli water company Mekorot, to fulfill their domestic, agricultural and industrial needs. Despite the fact that springs are the major source of water for both domestic and agricultural purposes, in some areas in the West Bank, springs are the only source of water. However, no springs are known to occur in Tulkarem and Qalqilya districts (Abed Rabbo, *et al.*, 1999).

Physiochemically, mean values suggest that the majority of springs in the West Bank are of good quality and suitable for drinking as those values are below the recommended Palestinian standards and WHO guidelines. The water of some springs seriously exceeds the standards and guidelines for nitrate especially in Ramallah, Tubas, Jenin and Nablus districts, mainly as a result of extensive agriculture and use of fertilizers. There is no serious problem of high nitrate concentrations in the springs of the Jordan Valley, but rather salinity in some of them making them unsuitable for irrigation, unlike the other west bank springs that contain low to medium salinity. This problem is derived from intrusion of sea water into aquifers due to over extraction, dissolution of salts from aquifers rocks and layers, agricultural practices and domestic sewage. In addition, slightly high sulphate concentrations were recorded in some Jericho springs resulting from dissolution of salts from aquifers' layer formations.

The water of most of the springs of the West Bank is contaminated with *coliform* bacteria due to lack of wastewater networks, wastewater treatment plants, use of septic tanks and cesspits and illegal disposal of untreated industrial wastewater and solid waste from the Israeli settlements. No advance treatment of water in the West Bank is used except for chlorination to disinfect domestic springs - in order to reduce the risk of waterborne diseases - which is not even carried out regularly (Anayah, 2006). Nevertheless, the use of chlorine creates new potential risks, because it reacts and produces disinfection by-products such as Trihalomethan that is associated with cancer and reproductive disorders (Omar, 2010).

The most abundant water type among springs is the "earth alkaline with prevailing bicarbonate", where it originates from carbonate aquifers in recharge areas or rock interaction processes. Another water type is "earth alkaline with prevailing chloride" which is restricted to the Jordan Valley and characterized by high total dissolved solids as well as chloride for the above mentioned reasons.

Spring water in the West Bank is being distributed between domestic and agricultural sectors in addition to water pumped from wells under Palestinian control; however, due to the gap between supply and demand, additional water is being purchased from Israeli water company Mekorot. Variation in spring water discharge is a function of rainfall and evaporation. Increased rainfall compensates for water loss in aquifers which in turn increase water discharge, but unfortunately, due to climate change in the past years encompassing low precipitation and elevated temperatures, deterioration in spring water discharge is obvious.

Currently, all of the water resources in the West Bank are exploited up to the safe yield and some resources are overexploited which resulted in the deterioration of water resources in terms of quantity and quality. It is important to take steps in order to improve water quality and quantity of the available resources in terms of sustainability. This is done in several ways:

- Legislation to protect aquifers from illegal discharge of sewage.
- Monitor spring water quality, where analysis of water quality parameters such as heavy metals and pesticides must be conducted due to their hazardous effect on the health and environment.
- Reform and modernize agriculture.
- Rehabilitate the springs to provide safe drinking water sources, which could be used for agricultural land reclamation.
- Protect ground water by treating and reusing wastewater.
- Construct wastewater treatment plants in Nablus, Salfit, Jenin and other cities such as Hebron, Bethlehem and Jericho.
- Construct proper wastewater collection systems as well as renewing old and corroded networks across the West Bank.
- Monitor wastewater discharge from the Israeli settlements such as Areal and Burqan and conduct studies and environmental impact assessment to evaluate the impact of the discharge of untreated wastewater in Salfit.
- Creation of nonconventional water resources; treated wastewater and desalinated water, as additional supply for both domestic and agricultural sectors.
- Development of regional climate change adaptation strategy and programs.

To achieve sustainability in the water sector, the above mentioned should be joined with integrity, transparency, accountability, and equity in managing the sector.

One or more of the above mentioned recommendations were conformed by Fayyad (2011) in the conference of launching the report on the status of the Palestinian environment in terms of human rights organized by ARIJ.

Finally, when springs are NO_3- contaminated, and in the case of being the major or only water source for domestic purposes, supply for pregnant women and infants is not recommended. Nevertheless, in microbiologically-contaminated water, where disinfection isn’t possible, boiling water before disinfection is highly recommended.

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Tracing the Common used Agrochemicals Residues in the Groundwater System from Lower Jordan Valley Basin (Jericho/ West Bank)

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Abstract

The study is aims at tracing the effect of pesticides residues on the groundwater quality in the shallow Pleistocene aquifer in Jericho area. The Lithium and Bromide elements were also used to recognize the agrochemical pollution accompanied with pesticides residues in groundwater samples. Four Pesticides were followed in 25 water samples, these are: Decofol, Bromprophylat, Pyrazophos, and Cypermethrin. The Data shows a trace amount of pesticides in the groundwater were found, where the concentration of Dicofol was the highest, accompanied by a relatively higher concentration of bromide and lithium. Other high amount of Cypermethrin pesticide, reaches to 295µg/l in relatively deep well, was found in some agricultural wells in the study area. Cypermethrin has different half-life which reach 50 days in anaerobic groundwater conditions, thus the presence of this pesticide is mainly depends on the well environment. The presence of trace amount of residual pesticides indicate also that the higher amount of chemicals is retained by soil during infiltration, and only traces are washed out by floods from the upper mountains during raining seasons. The data also shows that the pesticides presence in the groundwater is mainly depend on the method of onsite application and the half-life of each agrochemical each well and the well depth.

Keywords: Jericho, Lower Jordan valley, groundwater quality, pesticides use.

1. Intoduction

Pesticides usage consist the major big virtual problem that threat the groundwater quality in many area. The degree of threaten always depends on the amount of pesticides added to the field and the environmental classification of the chemicals, as a function of time of persistence in the environment (WHO, 1967).

Jericho area is considered as a food basket for the west bank. The climate of the area is hot and dry in summer and mild in winter, supporting the growth of such crops as dates, bananas, and citrus fruits. The geological formation of Jericho is unique, it composed of Pleistocene to recent age, and most of the area covered with the sedimentary gravels, sand and clay which called Samra formation. The Samra formation is inter-fingering an elder formation of Lake Lisan remnant and alluvial formation that cover a wide range in the eastern part of Jericho (Fig.1). Most of Jericho's agricultural land is irrigated by small private wells that provide water throughout the year; the city draws its water for domestic use from an irrigation system originating at the Ein Sultan Spring, which has supplied Jericho with water since ancient times. The cultivated areas in the Jericho district cover approximately 2419.4 hectares with pesticides load reach 82 ton/y (ARIJ, 1995). Due to the limited rainfall amount which is about 150 mm/y, combined with the hot weather; irrigated agriculture is dominant in the district. The cultivated areas are concentrated in Jericho city, Dyouk, Nuwe'ma and Al-Auja.

An evidence of agricultural backflow and anthropogenic influence has been reported. The major indications show that the agricultural effects on groundwater have 3 main agricultural practices. These are: 1) Bromide which is injected as a fumigant to the land as a methyl bromide gas. 2) NO3 from nitrogen fertilizers, pesticides, and animal manure. 3) Some Potassium, Magnesium and Lithium compounds which might appear in surplus amounts due to irrigation back flow and infiltration with soil to the ground water (Khayat et al., 2006).

In the study, we try to trace the effect of adoption of common used pesticides in unaccountable amount to this agricultural, rich-water resources area, tracing the lithium, bromide and the residues of pesticides in groundwater.

2. Material and Method

Samples of groundwater for analysis of Pesticides were collected in 30ml HDPE bottles from 25 spring and wells (fig.1), and the other trace elements in 60ml PDE bottles. The samples were poisoning using HgCl2 to prevent any alteration from bacterial activates in the samples. A list of common used 4 pesticides was taken from the farmers in the field. These namely are: Dicofol, Brompropylat, Pyrazophos and Cypermethrin. Lithium was analyzed using ICP-MS while Br^- was analyzed using HP liquid chromatography.

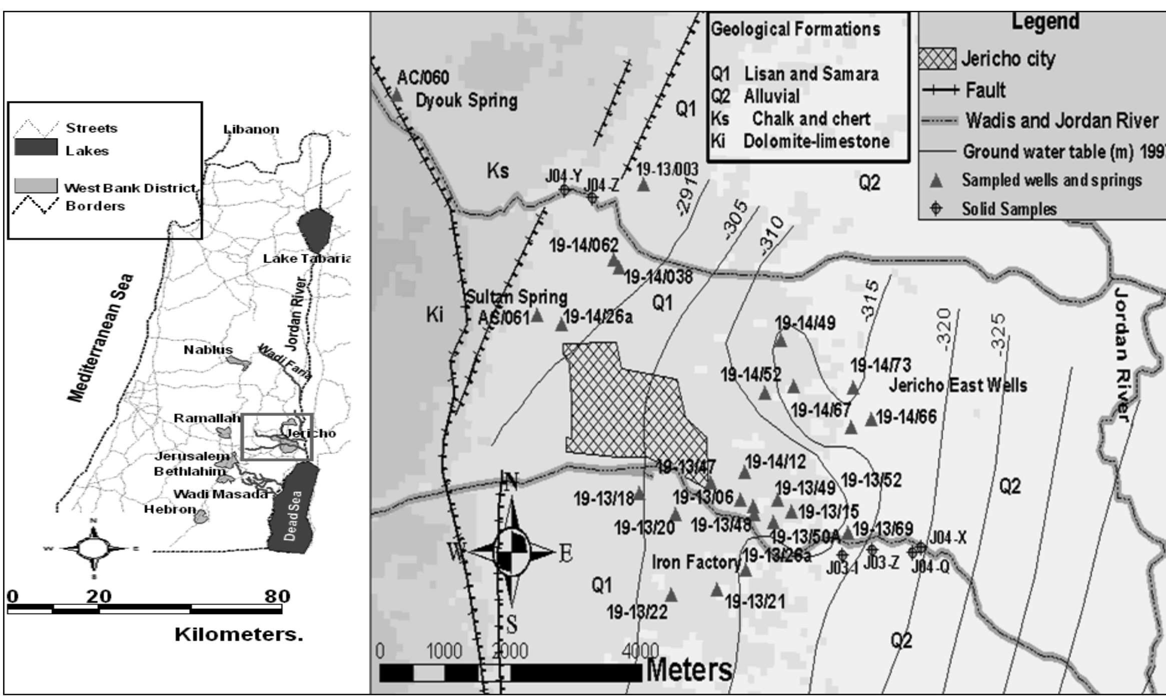

Figure 1. Study area, geological formations and sampling locations.

Pesticide samples were analysed by two different analytical methods for a total of 76 pesticides and 7 degradation products. The target compounds were extracted from water samples using C-18 solid-phase extraction (SPE) columns and then identified and quantified using capillary-column gas chromatography/mass spectrometry (GC/MS). Details of the analytical methods are described by Zaugg and others (1995) for GC/MS (Zaugg, et al., 1995). In general, method detection limits (MDL) for the GC/MS method are 10 to 50 times lower than detection limits for the HPLC method. However, MDL values are not absolute lower limits for detection, as the term implies, and any compounds that met defined detection criteria in a sample (see Zaugg and others, 1995, and Werner and others, 1996) were reported (Zaugg, et al., 1995; Werner et al., 1996). Values show less than the MDL are reported as estimated concentrations. All measurements were carried out on the UFZ-Environmental Research Centre, Halle/ Germany.

3. Result and Discussion

The data for common used pesticides in the groundwater wells as well as Li+ and Br- in mg/l are shown in Table 1. The wells, from which the groundwater samples were taken, can be divided into two major groups, one with high extensive agriculture practices as well as high pumping rate and the other with low or no surrounded agricultural activities. Figure 2 shows no clear behaviours for lithium and bromide in most of the groundwater samples. Except the springs of Sultan and Dyouk in addition to adjacent Samed well 19-14/26a in the West area, all the samples shows fluctuated amount of Li and Br. This amounts varied depending on well conditions, abstraction rate and the location toward the eastern high salinity area from the Lisan remnant (Khayat et al., 2006), where a surplus amount of lithium in these wells is related the influences of salinity sources described by (Marei andVengosh, 2001; Khayat et al., 2006).

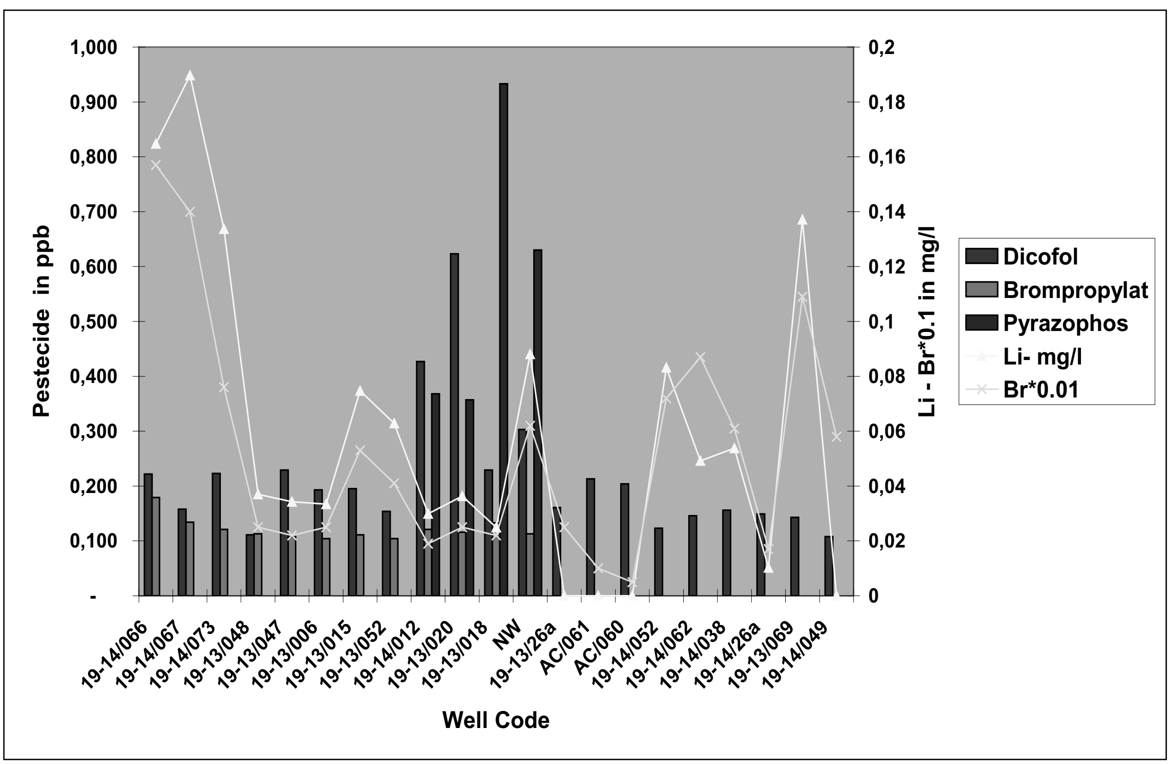

Figure 2. Li, Br - behaviors with the pesticides value in the groundwater samples.

The high values of pesticides were found in a trace amount in the highly extensive agricultural area within the Arab Project Area to the east of Jericho and in some samples from wells inside the areas of greenhouses and extensive agriculture. However, Decofol was found in all sampled wells and springs disrespect to surrounded activities. Dicofol is an organochlorine miticide used on a wide variety of fruit, vegetable, ornamental and field crops in Jericho area (Personal survey). Dicofol is manufactured from DDT. In 1986, use of dicofol was temporarily canceled by the EPA because of concerns raised by high levels of DDT contamination. However, it was reinstated when it was shown that modern manufacturing processes can produce technical grade dicofol which contains less than 0.1% DDT. Dicofol is moderately persistent in soil, with a half-life of 60 days (Wauchope et al., 1992; Tillman and Residues, 1992). Dicofol is susceptible to chemical breakdown in moist soils (Howard, 1991). It is also subject to degradation by UV light. In a silty loam soil, its photodegradation half-life was 30 days. Under anaerobic soil conditions, the half-life for dicofol was 15.9 days (Tillman and Residues, 1992). The aquifer in Jericho area is shallow and good aeriation conditions are present which promot aerobic conditions. More over, the soil type is lisan and clay Samra, all of these factors allow more persistance for the Dicofol which spread all over the area through irrigation backflow.

The second common pesticide found in some samples is Brompropylat. Fig. 2 shows relatively high concentration of Bromide in parallel with high Brompropylat concentrations. These pesticides also commonly used as Pre-harvest treatments for mites in the area. The health consequences for these pesticides are cumulative (Wauchope et al., 1992). Cypermethrin was found to have relatively high values in only 5 wells which is reach up to 295 µg/l. Cypermethrin is a synthetic pyrethroid insecticide used to control many pests, including moth pests of cotton, fruit, and vegetable crops. Cypermethrin has a moderate persistence in soils. This pesticide degrades more rapidly on sandy clay and sandy loam soils than on clay soils (which is predominant in the area), and more rapidly in soils low in organic material, thus a high amount of this chemical can reach rapidly to the groundwater. Moreover, the half life of Cypermethrin varied depending on the temperature, pH and the presence of oxygen, where it shows a half-life period of more than 50 days under laboratories conditions (Environmental Protection Agency, 1986). Thus, 5 wells which are coincident under clay layer of Samra soil contain a good residue of Cypermethrin. The last founded pesticide was Pyrazophos. Pyrazophos is an organophosphorus systemic fungicide used on a wide range of crops and cereals in the control of powdery mildew. Pyrazophos was found in the same wells contain Cypermethrin but in trace amounts. The four wells containing the residues of Pyrazophos are present in greenhouses area that covered mostly by clay layer of Samra. The half-life for Pyrazophos is about 25 days (Environmental Protection Agency, 1986), thus the evidence of residues presence in groundwater is low.

The time of sampling was in agriculture season, were these chemicals was pumped with irrigation water as surface application except in Arab Project wells where sprinklers are used. Thus, except dicofol, the other types of pesticides residues were absent. In general, the results reflect that the necessary time for these chemicals to reach the groundwater is relatively fast. It was noticed that each well has different kind of pesticides that follow the specific agricultural practice in the area and kind of adopted pesticide.

The well depth, soil type and abstraction rate also play role in the concentration of Pesticides in groundwater. The clay soil of Samra formation and the shallow nature of the wells are the main factors that control the presence of agrochemical residues in the groundwater.

Table1. Li, Br- and pesticides values in the groundwater samples.

Site	Well Code	Li-	Br-	Dicofol	Brompropylat	Pyrazophos	Cypermethrin
		mg/l	mg/l	µg/l	µg/l	µg/l	µg/l
Arab Project66	19-14/066	0,165	15,7	0,222	0,179	-	-
Arab Project67	19-14/067	0,19	14	0,158	0,134	-	-
Arab Project73	19-14/073	0,134	7,6	0,223	0,121	-	-
Fahmi Nahas48	19-13/048	0,037	2,5	0,111	0,113	-	-
Fahmi Nahas47	19-13/047	0,034	2,2	0,229	0,108	-	-
Sabiru Rantizi	19-13/006	0,033	2,5	0,193	0,104	-	-
Fahed Hishmi	19-13/015	0,075	5,3	0,195	0,111	-	-
Zuhdi Hashwa	19-13/052	0,063	4,1	0,154	0,104	-	-
Salah Arouri	19-14/012	0,03	1,9	0,427	0,121	0,368	81,31
Basil Husaini20	19-13/020	0,036	2,5	0,623	0,116	0,357	188,56
Basil Husaini18	19-13/018	0,025	2,2	0,229	0,133	0,933	294,99
Ibrahim Daek	NW	0,088	6,2	0,303	0,113	0,630	61,61
Iron Factory	19-13/26a	0	2,5	0,161	-	-	45,47
Ein Sultan	AC/061	0	1	0,213	-	-	-
Ein Dyouk	AC/060	0	0,5	0,204	-	-	-
Awni Hijazi	19-14/052	0,083	7,2	0,123	-	-	-
Saeed Aladeen	19-14/062	0,049	8,7	0,146	-	-	-
Mohammed Masri	19-14/038	0,054	6,1	0,156	-	-	-
Samed	19-14/26a	0,01	1,7	0,149	-	-	-
Arab Project69	19-13/069	0,137	10,9	0,143	-	-	-
Abdallah Araikat	19-14/049	0	5,8	0,108	-	-	-

4. Recommendation

- The method of pesticide adoption to the field should be taken into account to prevent the rapid contamination for the groundwater.
- The quality and the quantity of applied pesticide should also take into consideration, i.e. farmers should commit to the instructions of use on the bottle and up to date brochure must distributes for continuous awareness.
- Governmental monitoring program should be established, by which the banned chemicals must dropped from markets and the method of usage well monitored.

5. Acknowledgment

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Using of Phytoremediation to Clean up Contaminated Soil in Wad Asamin Valley – Hebron District

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Abstract

Municipal and industrial wastewater (WW) from Hebron city and the surrounding Israeli settlements has been flowing in an open stream into Wad Asamin valley for 50 years. The stream passes through 18 Palestinian residential communities contaminating around 8000 dunums of agricultural lands by insuring chemicals, toxic elements, and stone-cutting disposal into the soil. In addition, it compromises human health through providing convenient environment for the spread of insects and development of diseases. More dangerously, its negative impact extends to the ground water in the eastern water basin in addition to springs and artesian wells.

Hebron Municipality installed WW transmission 5.3 km long pipelines in “Khalit Adar” Area in 2004. This area is severely defiled by the WW stream pollutants which desecrate the soil and renders the land unproductive. Coherently, an open field experiment was conducted in 2010 to assess the effectiveness of two local plant cultivars (Corn and Tobacco) in remediating the contaminated soil. Representative Soil samples from the study area were chemically analyzed before and after planting; also, plant samples (stem and leaves) were analyzed at the end of the growing period.

The result indicated that the main pollutants, heavy metals, (Cr; Mn; Ni; Pb; Zn) were absorbed in a significant manner, yet in different order, by the two local cultivars used in the experiment. On the one hand, corn plants were capable to extract the heavy metals Cr > Zn> Mn> Ni> Pb respectively while tobacco expressed its ability to extract the same heavy metals in the following order: Cr>Ni>Mn>Pb>Zn.

Keywords: Heavy Metal, Maize, Tobacco, Phytoremediation, Phytoextraction, Bioaccumulation Factor (BF).

1. Introduction

Phytoremediation “green technology” is an cost-effective, ecologically safe and environmentally sound. It could be prescribed as ‘environmental medicine’ (Singh, and Jain, 2003). The major concept of it lies on the use of plants to remove pollutants from the environment (Raskin, et al., 1997). Phytoremediation includes phytovolatisation, phytostabilisation, phytofiltration, and phytoextraction processes (Umeoguaju, 2009). Phytoextraction involves uptake of pollutants from soil rhizofiltration, whereas the water remediation technique involves the uptake of contaminants by plant roots from aqueous medium, Phytotransformation which is applicable to both soil and water, involves the degradation of contaminants through plant metabolism. Phytostimulation or plant-assisted bioremediation, also used for both soil and water, involves the stimulation of microbial biodegradation through the activities of plants in the root zone, whereas phytostabilization, involves the use plants to reduce the mobility and migration potential of contaminants in soil (Miller, 1996).

Corn (Zea mays) has a fast growth rate and it's tolerant to the targeted heavy metals. It was able to absorb up to 0.1 mg/kg of copper, cadmium, chromium, lead, nickel, and zinc. These characteristics qualify corn as a hyper accumulator (Akhionbare, 2010). Moreover, maize is capable of continuous phytoextraction of metals from contaminated soils by translocation from roots to shoots in which it produces an extensive fibrous root system with large shoot biomass. As the corn crop has a high metal accumulating ability in the foliar parts with a moderate bioaccumulation factor, corn is considered a heavy-metal tolerant plant (Wuana1, and Okieimen, 2010). In this respect, crop plants such as corn, sorghum, and alfalfa are considered as metal accumulator plants and they may be more effective than hyperaccumulators due to their ability to remove a greater mass of metals relative to their faster growth rate and larger biomass (EPA, 2000).

As previously reported (Mojiri, 2011), the corn plant is considered an effective accumulator plant (Mojiri, 2011). Furthermore, the tobacco plant is considered as a hyperaccumulator for cadmium (Chitra, et al., 2011) and for remediation of percholate, Tobacco plants are considered as a potential candidate for phytoremediation (Sundberg, 2003; Kim, and Kim, 2010; Boonyapookana, et al., 2005). Moreover, tobacco accumulates Zn, Cu, Mn, Pb and Cd. In addition to another study conducted the results of the ability of tobacco (Nicotiana tabacum L.) to accumulate zinc and toxic heavy metals, lead and cadmium (Kaličanin, and Velimirović, 2012). In this sense, tobacco is considered as a hyperacculator plant (Angelova, et al., 2005).

2. Materials and Methods

2.1. Site Description

The study site is located in the southern part of the Hebron district of Palestine, which is known as Wadi Alsamin. The climate of the site is semi-arid with cold winters. Average annual rainfall and average annual temperature are 595 mm and 18 C$^{o.}$ Wadi Alsamin represents an open channel for municipal untreated wastewater. The stream starts to flow from the industrial area of Hebron city 797 m above sea level, and passes through 18 Palestinian residential communities that are located on the stream bank and 4 Israel settlements on the high surrounding lands, and reaches to the Aldahryya area at the Border with Israel at 396 m, where the stream is collecting and treating in the Israel wastewater treatment plant called shouket in the Beersheva area and reused it for agricultural purposes by the Israelis, only.

The polluted soil in the study area where the flow of wastewater has been stopped since 2004 is classified into two main types of soil according to land use. First; completely polluted soil by wastewater (the study area). This soil has been abandoned by farmers and is still uncultivated. Second: mixed polluted soil; during the construction of a transfer pipe line the deep soil was mixed with the upper and surrounding soil. The experiment for this study was conducted in the open field in an area of 1.15 dunum that is protected completely by fencing to prevent any damage or interference.

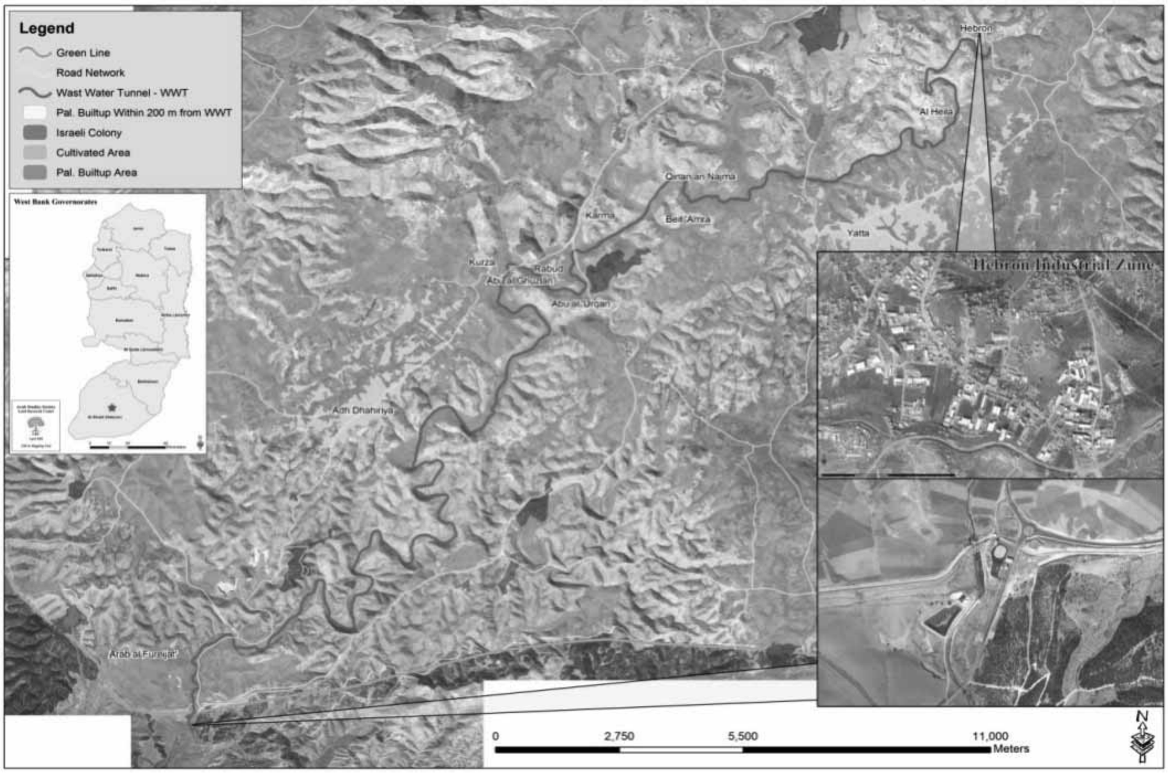


Figure 1. Wastewater Stream Line from Industrial Area in Hebron and Israel Wastewater treatment plant.

Source: Land Research Center-LR. GIS Department

2.2. Experimental design

The field trial was arranged in a split plot design, with two factors (Pollution levels and Varieties), and three replicates with total of 24 plots (Fig. 2). The allocated area was divided into 4 levels, each level included three blocks and each block included two main plots; one for tobacco and the other for corn plant. The area of each plot was 9 $m^{2,}$ with a buffer distance of 0.5 m between each plot and 0.7 between blocks.

Seeds of corn were sowed with 5 seeds per point in the field. After germination seedlings were individualize to one seedling per point with final density of 11 plant/m2. The tobacco plants were transplanted in the designed field plot at a density of 11 plants/m2. During the experiment period, field plots were watered and weeds removed manually.

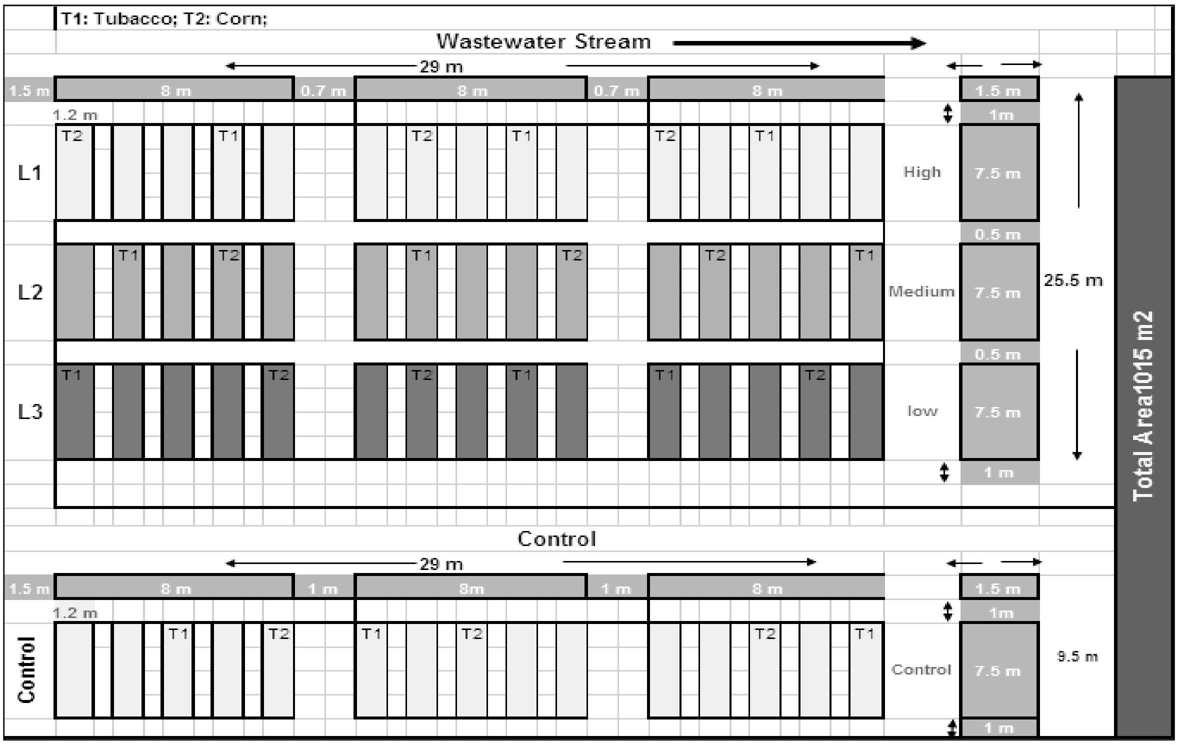


Figure 2. Experiment Layout

3. Results and Discussion

3.1. Physico-chemical Properties of Soil

Table 1 shows soil the pH and EC that was determined in the study area. Soil pH showed variations between levels depending on the distance of wastewater stream to control. The soil decrease from 7.8 to 7.2. Analysis of variance (ANOVA) ($P>0.05$) of all individual samples showed that significant differences were observed in level one compared to all levels, and control. The higher pH value of the soil in level one represents the high polluted soil where the wastewater stream flowed directly and is attributed to the alkalization effect of basic cations (especially Ca) (Madyiwa, et al., 2012) and due to chromate salts used in tanning procedure that leading to high pH and conductivity (salts, et al., 2004).

Table 1. Soil pH and EC (ms/cm) of analyzed samples.

Levels	PH	EC
HP	7.8a	364.7a
MP	7.5a	297.7a
SP	7.3a	287.3a
Control	7.2b	349.0a`

HP: High polluted, MP; Medium polluted; SP: Slightly polluted.

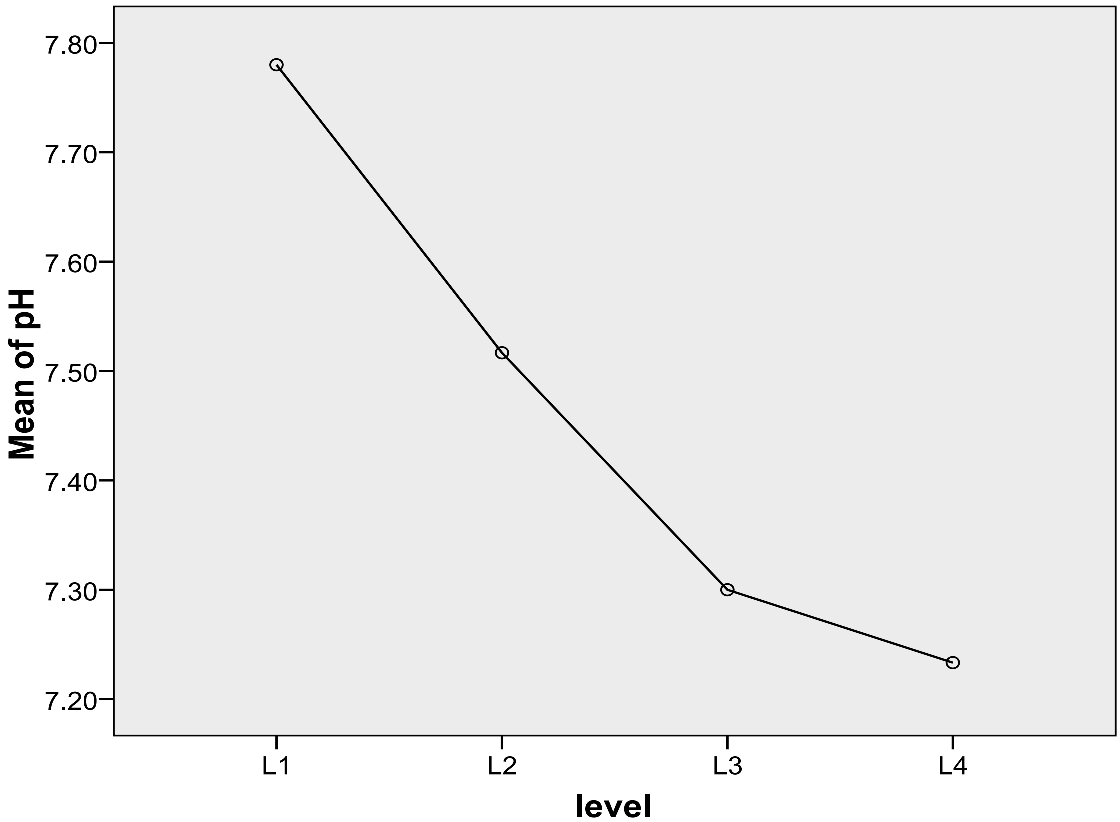


Figure 3. Variation of pH according to the levels

3.2. Heavy Metals Content in Soil before Planting

The mean concentrations of the heavy metals in the investigated soil are presented in the table (Raskin, et al., 1997), in which eight heavy metals were analyzed, Cd, Co, B, Cr, Mn, Zn, Ni and Pb, where Cd, Co and B were not detected. As there is no Palestinian Standard for the allowed concentration of heavy metals, it is possible to assess the degree of contamination compared to the levels at different distance from the stream, and as the ability of plant for metal extraction. The sequence of metal concentration in the study area was Mn>Cr>Zn>Ni>Pb. The mean concentration of Cr, Mn and Ni at $p < 0.05$ showed significant variance in polluted soil compared to the control. The relatively high values for the polluted soil samples might be a result of runoff of the stream in the polluted soil. For Cr metal the concentration in the control samples was significantly different from the polluted soil and the concentration in level three was significantly different from level one and two. This might be due to accumulation of chromium from the tannery effluent in the industrial area that contains chromate salts which are used in tanning procedures (salts, et al., 2010). Additionally the heavy metal concentration in the soil decreased where the movement of water and topography are the main controlling factor (Antanaitis, and Antanaitis, 2004). Pb was detected only in level three in the soil subjected to untreated wastewater with a distance of 30 m from the wastewater stream. Mn concentration was significantly higher in the control than in soil subjected to untreated wastewater. This might due to high soil pH in which, as the soil pH increases the Mn solubility decrease. In addition, the soluble manganese compounds can be leached from the soil (WHO, 2004).

Table 2. Variation of Heavy Metals (mg/kg) in the soil before planting.

	Elements				
levels	Cr	Mn	Zn	Ni	Pb
HP	173.7a	53.3a	68.0a	21.5a	0.0a
MP	147.0ab	48.7a	ND	7.5a	0.0a
SP	121.3b	44.3a	ND	5.0a	47.0a
Control	101.3c	531.7b	86.2a	47.0b	0.0a

HP: High polluted, MP; Medium polluted; SP: Slightly polluted.

3.3. Heavy Metals Content in Plant Parts

Results in Table 3 showed that the five detected heavy metals in soil Cr, Mn, Zn, Ni and Pb were found in leaf and stem which were only investigated in the selected plant parts (stem, leaf). The profile of metal content in corn plants were found to be in the order Zn > Mn > Ni > Cr > Pb. The accumulation of metals in leaves is more than in stem for all metals except for Zn which is higher in the stem than in leaves. In leaves the concentration of Cr, Zn and Ni in polluted soil is higher than in control soil. This may be because Zn and Ni are an essential micronutrient for plant (Hänsch, and Mendel, 2009) and the Cr was available in high concentration. Although the Mn metal was found in high concentration, its availability is limited due to relative high pH (WHO, 2004). Pb was detected only in leaf in the level three which is the furthest point from the wastewater stream probably because the Pb is immobile in soil (Camobreco, et al., 1996). Regarding the stem part; the concentration of Cr and Zn in polluted soil is higher than the control, while for Mn and Ni the control is more than the polluted soil and Pb is not detected in stem for Pb.

Table 3 . Heavy metals content and distribution in different plant parts of corn(mg/kg)

Levels	Cr		Mn		Zn		Ni		Pb	
	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf
HP	3a	3a	5a	10a	75a	32a	4a	1a	0	0a
MP	5a	13a	3a	13a	0a	0a	5a	18a	0	0a
SP	8a	16a	3a	12a	0a	0a	1a	3a	0	0.2a
Control	7a	11a	14a	43a	60a	22a	10a	11a	0	0a

HP: High polluted, MP; Medium polluted; SP: Slightly polluted.

For Tobacco plant, Table 4 shows that the profile of metal content were found to be in the order Zn > Mn > Cr > Ni > Pb. the concentration of metals in leaf is higher than stem part as corn palnt. The concentration in leaf and stem for Cr, Mn and Ni for control treatment is higher than in polluted soil while Zn in polluted is higher. Pb was detected only in stem.

Table 4. Heavy metals content and distribution in different plant parts of Tobacco (mg/kg).

Levels	Cr		Mn		Zn		Ni		Pb	
	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf
HP	2a	4a	9a	15a	41a	66a	0.5a	1	0a	0
MP	3a	3a	7a	12a	0a	0a	1a	2	0a	0
SP	2a	3a	9a	13a	0a	0a	0.2a	0.4	0.2a	0
Control	4a	8a	25b	66b	23a	55a	3a	6	0a	0

HP: High polluted, MP; Medium polluted; SP: Slightly polluted.

The bioaccumulation factor of heavy metals from soil to plant is an important factor to assess the efficiency of plant as an accumulator. Table 5 compare the BF of Corn and Tobacco in which the BF of corn plant for Ni, Cr, Zn is higher than Tobacco while for BF for Tobacco of Mn is higher than corn. There is significant difference of bioaccumulation Mn in corn plant between control and level tow and three. Whereas, bioaccumulation of Mn in tobacco the difference is significant between control and level one and three (Fig. 5, 9).

Table 5. Bioaccumulation Factor "BF" of Corn and Tobacco Plant.

Levels	Cr		Mn		Zn		Ni		Pb	
	Corn	Tobacco	Corn	Tobacco	Corn	Tobacco	Corn	Tobacco	Corn	Tobacco
HP	0.04a	0.03a	0.28ab	0.44a	1.57a	1.57a	0.24a	0.07a	0.00	0.00
MP	0.12a	0.04a	0.33a	0.40ab	0.00	0.00	2.96a	0.34a	0.00	0.00
SP	0.20a	0.04a	0.35a	0.49a	0.00	0.00	0.8a	0.12a	0.00	0.00
Control	0.18a	0.13a	0.11b	0.17b	0.95a	0.91a	0.45a	0.19a	0.00	0.00

HP: High polluted, MP; Medium polluted; SP: Slightly polluted.

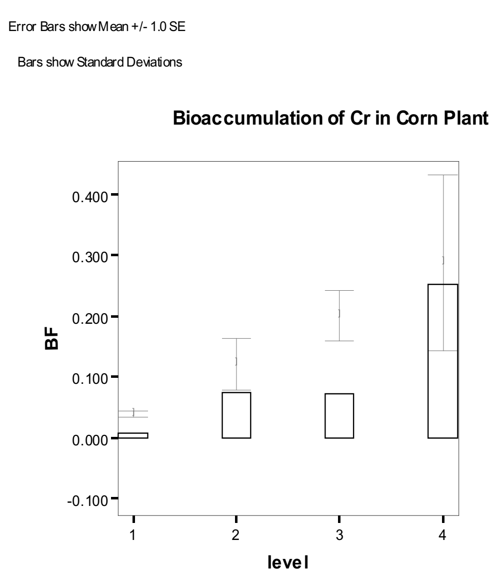


Figure 4. Bioaccumulation of Cr in Corn

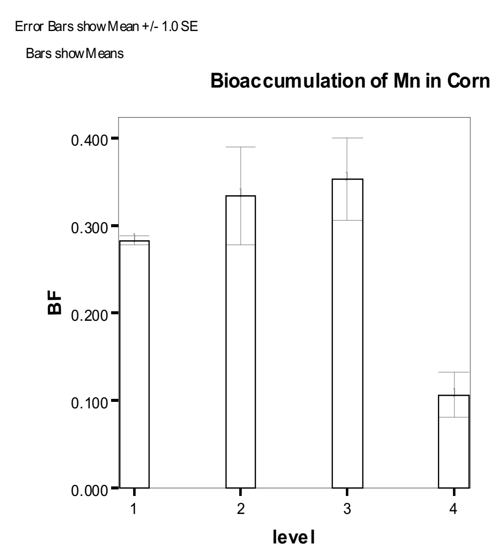


Figure 5. Bioaccumulation of Mn in Corn

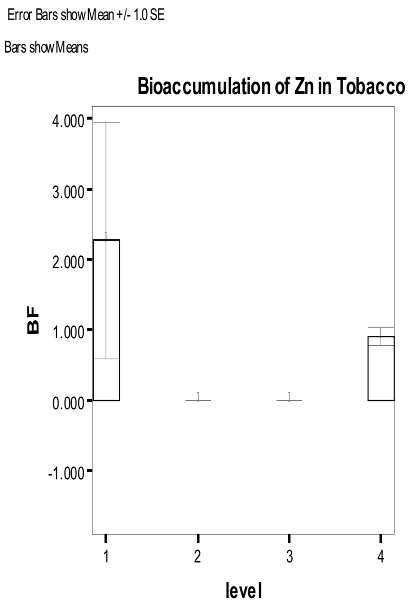


Figure 6. Bioaccumulation of Zn in Corn

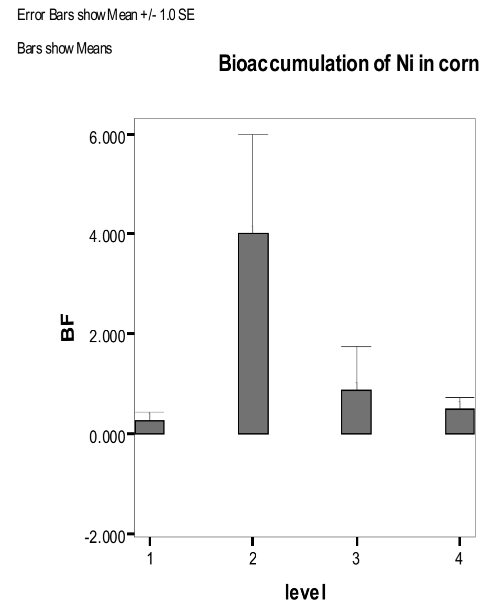


Figure 7. Bioaccumulation of Ni in Corn

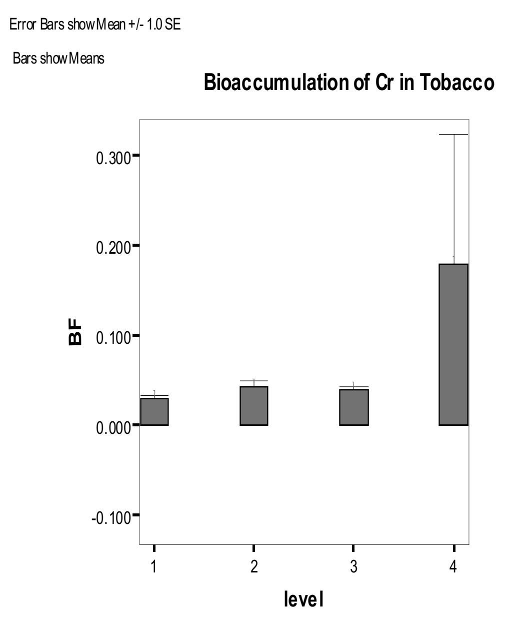


Figure 8. Bioaccumulation of Cr in Tobacco

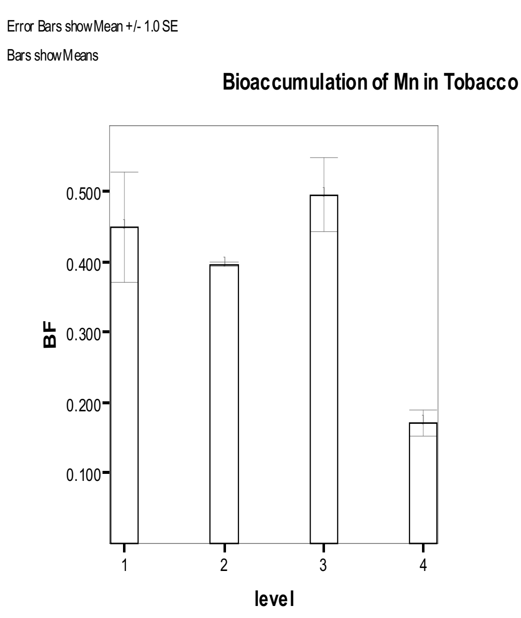
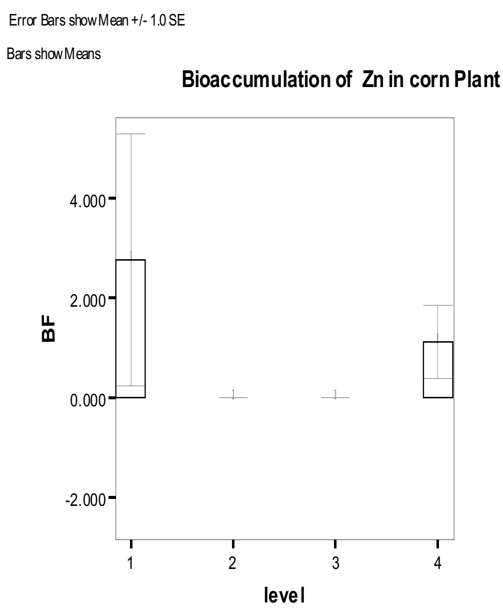


Figure 9. Bioaccumulation of Mn in Tobacco



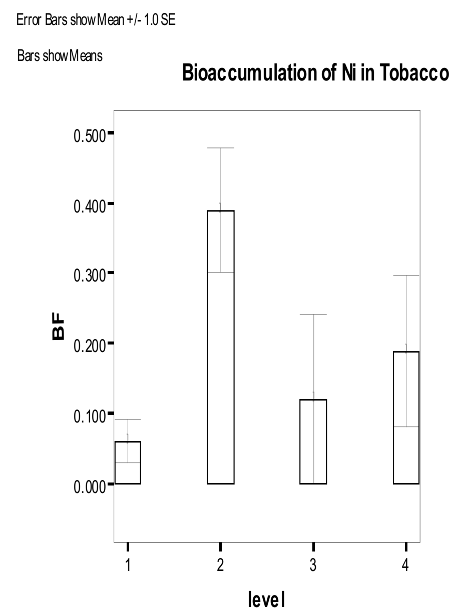


Figure10. Bioaccumulation of Zn in Tobacco **Figure 11. Bioaccumulation of Ni in Tobacco**

4. Conclusion

From this study it was concluded that the corn plant is more efficient for extraction of Cr, Zn, and Ni metals, whereas the tobacco plant is better for Mn metals. The plant that cultivated in soil subjected for untreated wastewater is more efficient for heavy metals uptake than in control soil. Concentrations of heavy metals were found in plant leaf part are higher than in stem part.

In Palestine further, explorations and research are necessary for improving phytoremediation of polluted soil as well as setting of standard limits for heavy metals in both soil and plants.

5. Acknowledgements

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Agriculture Practices and its Effect on Fruits, Soil and Water Quality
(Case Study: North Jordan Valley)

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Abstract

Crops quality is highly dependent on the quality of resources and inputs used for production in addition to agriculture practices implanted during the production chain. Producing high quality agriculture products is the key element in marketing in strong competition environment, in addition to its importance for consumer health and environment. The Palestinian agriculture contains many agricultural practices, especially in the Jordan valley where intensive agriculture and agribusiness oriented products are produced. Some of these practices can cause problems to environment, crops, and plants and even to human. Some of these practices have negative impact on the Palestinian agriculture in general and especially in Jordan valley where a random usage of pesticides, the use of unregistered pesticides for the specific crop (s), lack of commitment to safety period of pesticides exists. Also, irrigation with polluted water either from sources or though using open irrigation system (canals and pools) and the use of unfermented manure or polluted compost.

1. Introduction

Palestinian farmers used to add organic fertilizers in order to maintain soil fertility to achieve best production in terms of quantity and quality. Unfortunately, and in many cases the farmers add unfermented manure or contaminated manure, leading to fruits contamination which contact the contaminated soil and make it unsuitable for human consumption. Also the polluted irrigation water can contaminate fruits of plants irrigated with such water. Water contamination might occur through contacts with wastes or wastewater, flow through contaminated canals, or exposed to contaminants.

The study was conducted in two phases over two consecutive seasons (November, 2008 and November, 2009), in 4 localities in Jordan Valley (Bardala, Khardala, Ein Albida and froosh Biet dajan) and two localities in the mountainous areas of tubas Governorate (Wadi Alfar'a and Tamoon) where intensive cultivation of irrigated vegetables take place. Each season 153 samples of different vegetable fruits (tomato, cucumber, beans and bell pepper) irrigation water and natural manure) were collected and analyzed for chemical and microbial contents. The results of the first round of analysis showed that, the highest percentage of contamination was found on vegetable fruits, where 50% of sample were found contaminated with pesticides residues. Most of them were contaminated by unregistered pesticides. For the analyzed irrigation water samples, 50% of samples were contaminated with coli forms more than MRL of one or more of the following microbes: Fecal coli forms, Salmonella, and Coli forms. Organic fertilizers analysis showed that 8 samples out of 24 (33.3%) were contaminated with E. coli.

The main objective of this study is to investigate the factors, resources and practices that affect the quality of fresh agriculture products in the Jordan Valley Area of the West Bank with main focus on studying pesticide residues and measuring biological contamination.

2. Methodology and tools

302 samples were collected randomly from different fields in the study area of five localities in North West Jordan Valley for two different seasons (152 samples for each season). The collected samples included water and organic manure to test the microbial contamination, and samples of fruits to test both microbial and chemical contamination including the control samples. Then the samples packed in clean plastic bags for fruits and manure and in small clean plastic bottles for water, labelled then shipped to Israeli accredited laboratories for analysis.

The analysis of first season samples took place in Backtochem laboratory, while for the second season samples; the analysis was conducted by amino laboratory. Using GAZ chromatography analysis for pesticides and microbial cloning tests. The received results were analysed and compared between them based on crop level and on locality as well for the conducted two rounds of analysis. Then the results displayed to the farmers with technical recommendations to mitigated the impact of bad practices and improve the positive ones.

3. Results:

3.1. Irrigation Water Tests

18 samples of water were taken from 3 localities, where samples taken from 10 sources of water for irrigation (springs water, ground water wells, and water pools) in each round, while the other 3 localities are using pipe water from Mekorote Company.

During the first round of the study, out of 18 samples taken, nine (50%) of them were failed due to biological contamination with fecal coli forms. (failed samples, those samples which found containing coli forms more than accepted according to international standards and or European standards)

In locality #2 where the farmers used water from Spring, out of 6 samples tested, five (83.3%) were failed due to fecal coli forms contamination, followed by samples from locality #1 were farmers used spring water, 3 samples out of 8 (37.5%) found contaminated and locality 3 were 1 sample out of 4 (25%) was contaminated. The results are presented in table 1.

Table 1. Irrigation water analysis results

Locality	# of samples taken	First round		Second round		Source of water
		# of samples failed	%	# of samples failed	%	
#1	8	3	37.5	0	0	Spring and water pool
#2	6	5	83.3	0	0	spring and water pool
#3	4	1	25	0	0	water pool

3.2. Organic Fertilizers Tests

24 samples of organic manure were taken from the fields in 5 localities and were tested for presence of *E. coli.* The Results of the first round analysis showed that 8 samples out of 24 (33.3%) contaminated by *E. coli*.

100% of contamination was found in samples taken from locality #2, and out of 3 samples taken from locality #1, two of them (66.6%) found contaminated with E. Coli, while 28.5% of samples taken from locality #3 were found contaminated with E. Coli., also 25% and 12.5% were found contaminated from samples taken from localities #4 and #5 respectively. On the other hand, the results of collected second round samples reviled more negative results than first round, especially for the samples taken from localities 5 and 3 as shown in table 2.

Table 2: Organic manure analysis results

Locality	# of samples taken	First round		Second round	
		# of samples found contaminated with E.Coli	% of contaminated samples	# of samples found contaminated with E.Coli	%
#1	3	2	66.6	0	0
#2	2	2	100	1	50
#3	7	2	28.5	3	42.8
#4	4	1	25	1	25
#5	8	1	12.5	7	87.5

3.3. Microbial Contamination of Vegetable Fruits

49 samples of fruits were taken in each round (9 pepper samples, 4 green beans, 9 cucumber and 27 from tomato fruits). In the first round of analysis, 5 samples (10.2%) were found contaminated with E.Coli and other coli forms and exceeded the acceptable number. 2 samples of cucumber out of 9 samples taken were found contaminated with coli forms and *E.Coli* (the samples were taken from localities #2 and 4 respectively). Three samples of tomato fruits out of 27 samples (11.1%) was found contaminated with coli forms (2 from Locality #2 and #1 from locality #3) as shown in Table 3.

Table 3. Microbial analysis of vegetable fruits in the first round

Locality	Pepper			Beans			Cucumber			Tomato		
	# of samples taken	# of samples contami-nated	%	# of samples taken	# samples contamina-ted	%	# of samples taken	# of samples contaminat-ed	%	# of samples taken	# contami-nated	%
#1										5		
#2	6	0	0				2	E))1	50	2	2©	
#3	1	0	0				1	0	0	14		
#4	2	0	0	1	0	0	2	1©	50	3	1	
#5				3	0	0	4	0	0	3		

While the results of 49 samples taken in the second round showed high improvement of the results where only one sample of tomato fruits (2.04%) from locality # 1 found contaminated with *E. Coli.*

3.4. Pesticides Residue Analysis

61 samples of fruits were analyzed for pesticides residues, 31 samples (50%) were found containing chemicals either exceeds the MRL or even contains traces of forbidden pesticides.

3.5. Cucumber Fruits Analysis

Out of 19 samples of the analyzed cucumber fruits 5 samples were detected containing chemical residues of banned pesticides and one of the samples which has banned pesticides it found containing one ingredient more than MRL.

The highest ratio of samples contaminated with pesticide residues were found in samples taken from locality #3 were the cucumber sample tested from found contaminated with residues of forbidden pesticide followed by locality #4, were 2 samples out of 5 (40%) were found contaminated, one of them has residues of allowed pesticide more than MRL, while the other found contaminated with residues of forbidden pesticide, and samples from locality #5 in the third position were 20% of the analyzed samples (2out of 10) found containing residues of forbidden pesticides. The analysis results are presented in table 4.

Table 4. The results of chemical residue analysis of the sampled cucumber fruits

Locality	# of samples taken	# of samples failed	%	Active ingredient
#1	0	0		
#2	3	0	0	
#3	1	1	100	Keroxim-methyl (Forbidden)in EU
#4	5	2	40	Penconazole >0.1(MRL), Methoxyfenozide (Not registered for cucumber)
#5	10	2	20	Bromopropylate (Not registered for cucumber)

3.6. Pepper Fruits Analysis

12 samples of pepper fruits were collected from farms of 4 localities, all Samples were taken from fields in locality #3 where containing residues of pesticides not registered to be use for pepper, followed by locality #5 were 75% of samples containing residues of pesticides not registered, while only one sample from locality #2 out of 5 samples (20%) taken found containing residues of a permitted pesticide exceeding MRL. The analysis results of the sampled pepper fruits are presented in table 5.

Table 5. Results of chemical residue analysis of pepper fruits

Locality	# of samples taken	# of samples containing unaccepted pesticides residues	%	Active ingredient
#1	0	0	0	
#2	5	1	20	Tridemenole exceed MRL in Israel
#3	2	2	100	- Difenoconazole - Metominostrobin (Not registered for pepper)
#4	1	0	0	
#5	4	3	75	- Metominostrobin - Bromopropylate - Chlorpyrifos-Ethyl (Not registered for pepper)

3.7. Bean Fruits Analysis

3 samples of beans fruits were analyzed from localities #4 and #5, only one sample out of 2 samples taken from locality #5 was found containing residues of Carbofuran insecticide which is forbidden pesticide.

3.8. Tomato Fruits Analysis

28 samples of tomato fruits were analyzed for pesticides residues from the 5 targeted cooperatives. The results showed that 19 samples (67.85%) were containing residues of forbidden pesticides. The highest level of residues was found in locality #3 (92.3%) followed by samples taken from locality #4 (75%), locality #5 (66.6%) and finally localities #1 and #2 with 25% each. Table 6 presents the analysis results for chemical residues in the tested tomato fruit by locality.

Table 6. Results of chemical residue analysis of tomato fruits

Locality	# of samples taken	# of samples containing unaccepted pesticides residues	%	Active ingredient
#1	4	1	25	Bromopropylate
#2	4	1	25	Bromopropylate
#3	13	12	92.3	Bromopropylate, Fenazaquin, Propargite Dicofol, Kresoxim-methyl Metominostrobin, Cypermethrin (Forbidden)
#4	4	3	75	Propargite Bromopropylate Fenazaquin (Forbidden)
#5	3	2	66.6	Fenazaquin Bromopropylate Forbidden) (

3.9. Pesticides Detected in Fruits

The main pesticides detected in the analyzed vegetable fruit including active ingredients, trade names and classes and notes provided by the Laboratory are presented in table 7.

Table 7. Chemical pesticide residues analysis which are detected in the sampled fruits

Crop	Active Ingredient	Class	Notes (According to BactoChem Laboratory)
Cucumber	Methoxyfenozide	Insecticide (molting hormone agonist)	MRL
	Bromopropylate (P)	Acaricide	Not registered for use on cucumber in Europe and Israel
	Kresoxim-methy	Fungicide	MRL
Pepper	Bromopropylate	Acaricide	Not registered for use on pepper in Europe and Israel
	Difenoconazole (P)	Fungicide, Bactericide	Not registered for use on pepper in Europe and Israel
	Metominostrobin	Fungicide	MRL
	Chlorpyrifos-Ethyl	Insicticide	MRL
Bean	Carbofuran	Insecticide	MRL
Tomato	Bromopropylate (P)	Acaricide	Not registered for use on tomato in Europe and Israel
	Fenazaquin (P)	Insecticide	Not registered for use on tomato in Europe
	Kresoxim-methyl	Fungicide	MRL
	Propargite	Insicticide , Acaricide	MRL
	Dicofol	Insicticide , Acaricide	MRL
	Cypermethrin	Insecticide	MRL
	Fenarimol(P)	Fungicide	Not registered for use on tomato in Europe and Israel
	Triadimenol	Fungicide	MRL

(P): These pesticides are permitted in PA. (Listed in MOA list of pesticides allowed for use in PA, January, 2007) but crops are not specified

4. Summary of the analysis results for different conducted tests

Table 8 and figure 1 present the summary of different conducted types of analysis to measure the level of biological contamination and chemical residues whether in the irrigation water, organic manure, and/or vegetable fruits**.**

Table 8. Summary of results of all analysis

Type of test	First round analysis				Second round analysis			
	Passed	%	failed	%	Passed	%	failed	%
Vegetable Microbiology Examination	44	89.5	5*	10.5	48	98	1	2
Vegetable Pesticide Residue Examination	27	47.3	30*	52.7	26	45.6	31	54.4
Organic Fertilizer Examination	18	69.2	8*	30.8	14	53.8	12	46.2
Water Microbiology Examination	9	50	9*	50	16	100	0	0

*Standards used to determine whether the samples failed or passed

A- Vegetable microbiology examination

- MRL in 1 gram:

- coliform: 10000

- Fecal coliform less than 10

- *E.Coli* less than 10

B- Organic fertilizers MRL in 1 gram): *E. Coli*: less than 10

C- Water Microbiology examination: (MRL in 100ml.)

- Fecal coli form: 0

- Salmonella: 0

- Coli forms: 3

D- Pesticide residues: according pesticide registration for the crop and MRL standards.

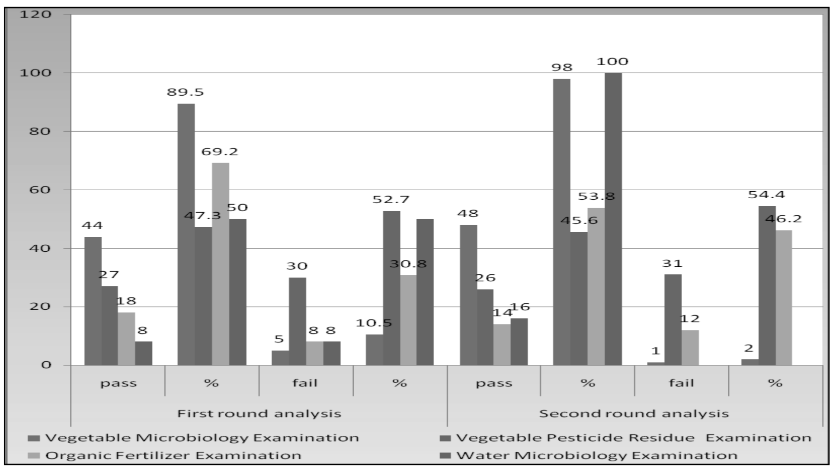

Figure 1. Comparison between the 1st round analysis and 2nd round analysis of different groups

5. Conclusions

The highest percentage of Biological contamination detected in water from samples collected in the first round, of locality #2 samples, this is may be due to two main reasons:

The source of irrigation water is spring, and the water may come in contact with nearby city sewage water which passes through the valley near the spring. Some of water samples were collected from pools which founded also contaminated, but no samples of ground water wells were found contaminated.

The farmers are storing the irrigation water in open pools before using for irrigation and biological contaminants might come in contact with water there. Then contaminated water will contaminate compost and fruits.

Due to awareness campaign held for the farmers after first season analysis results and the flooding did not happen in the second season, the water quality improved in the second round.

The highest percentage of samples with chemical residues detected in fruits of locality #3.

The most pesticide found in the fruits is Bromopropylate (P) and other acaricides. This is due to drought weather conditions prevailed during the period prior to sampling; where mites are dominant at this weather conditions and farmers use intensive chemicals t control the pests.

Most of the farmers asked after the analysis, said that they don't know weather the chemicals they apply are permitted or not.

6. Recommendations

a) Intensify extension and awareness services conducted for farmers and Provide extension agents and farmers with the lists of permitted chemicals for agro-use in PA, Israel and Europe.

b) Protect water sources (especially water springs) from pollution and pollutants.

c) Coordinate with MOA to solve the issue of registered pesticides in the Palestine which aren't registered either in Israel or Europe or both.

d) It is very important to register pesticides according to crops.

e) This study raised the issue of up grading a Palestinian laboratory and to acquire accreditation of their results by Israeli markets as they are the major importer of Palestinian products, and by other international markets, to facilitate acquiring quality certificates for Palestinian products.

7. References

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Phytotoxicity and Bioconcentration of Boron in Typha Latifolia and Schoenoplectuscalifornicus

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Abstract

Boron enters aquatic environments from both natural and anthropogenic sources such as municipal sewage containing sodium perborates from detergents and in runoff from areas using boron-containing herbicides or fertilizers. Accurate characterization of phytotoxicity of boron to sentinel aquatic plant species, *TyphaLatifolia* and *Schoenoplectuscalifornicus,* used in constructed wetland treatment system (CWTS), is important in order to predict risks in either wastewater treatments in CWTS or in receiving aquatic systems. The results of this study demonstrated that boron toxicity is manifested over time (13 months) in both plants with signs of toxicity increasing with the duration of exposure. In this experiment, aqueous concentrations of boron greater than 25 mg L^{-1} adversely affected both *T. latifolia*and *S. californicus*with browning and yellowing of shoots and decreased shoot density and height for *S. californicus.* The shoot density of *T. latifolia* decreased by 50% at 300 mg B L^{-1}. In both the shoots and the roots of these species, concentrations of boron increased proportionally with aqueous exposure concentrations as did the concentrations of boron in the hydrosoil. Thus adverse effects of boron were related not only to the aqueous boron exposures, but also to boron concentrations in the hydrosoil, roots and shoots. *S. californicus* was more sensitive than *T. latifolia*to aqueous boron exposures in simulated FGD water with 100% mortality of *S. californicus* at 300 mg L^{-1}, and shoot density and shoot height at 100 mg B L^{-1} were 43% and 40% less than untreated FGD water controls, respectively.

Keywords: Boron, FGD water, *T. latifolia, S. californicus, phytotoxicity.*

1. Introduction

Boron is an essential micronutrient for both plants and animals, with interspecies differences in concentrations required for optimum growth (Goldberg, 1997; Nielsen, 1997). However, boron is toxic at low concentrations and the difference between required and toxic concentrations is small (Butterwick, et al., 1989; Nable, et al., 1997). Reviews of current literature indicate that boron toxicity to agricultural plant species is well documented while data regarding boron toxicity to aquatic plant and animal species are limited (Nable, et al., 1997; Nielsen, et al., 1997; Reid, et al., 2004). Aquatic plants are essential components of healthy aquatic ecosystems (Wang, 1991). *Typhalatifolia*Linnaeus and *Schoenoplectuscalifornicus* (C. A. Meyer) Palla are useful sentinel aquatic plant species that have been used in previous toxicity tests (Moore et al., 1999; Muller, et al., 2001). Evaluation of *T. latifolia* and *S. californicus* responses to boron is important because of the ecological and economic importance of these plants. They play a major role in structural and functional aspects of wetland ecosystems including biogeochemical cycles, food webs, and physiological processes (Adriano, et al., 1984; Lombardi, et al., 1997). *T. latifolia*and *S. californicus*are an important biotic component of constructed wetlands and have been used to stabilize hydrosoil components and contribute organic matter (Murray-Gulde, et al., 2005). They are also used in constructed wetlands to aid in the removal of different contaminants (Sinicrope, et al., 1992; Powell, et al., 1996; Hawkins, et al., 1997; Gillespie, et al., 2000; Murray-Gulde, et al., 2005; Ye, et al., 2003).

Flue gas desulfurization (FGD) waters are produced at coal– fired power plants to decrease sulfur dioxide emissions. This process produces relatively large volumes of water that may contain significantly elevated concentrations of boron (33- 460 mg B L^{-1}) (Mierzejewski, 1991). These concentrations may prevent the establishment of vegetation especially in the first growing season. Retarded establishment may occur in wetland and aquatic systems as a result of discharging of these waters without sufficient treatment. The United States Environmental Protection Agency (U.S. EPA) through the National Pollutant Discharge and Elimination System (NPDES) requires treatment of FGD waters prior to discharge. Water quality criteria have not been established for boron, therefore, boron is not listed as a contaminant requiring monitoring or treatment.

Constructed wetlands planted with *T. latifolia* and *S. californicus* may be a viable option for treating contaminated waters, but performance may be dependent on responses of wetland plants to aqueous boron concentrations. Selection of plants used in constructed wetland treatment systems for renovation of contaminated waters is a critical step in the designing process in order to achieve the targeted performance (Huddleston, et al., 2000; Murray-Gulde, et al., 2005). *T. latifolia* and *S. californicus* have been used in numerous constructed wetland treatment systems (CWTS) designed to treat inorganics (arsenic, cadmium, copper, cyanide, lead, mercury, nitrogen, phosphorous, selenium, and zinc) (Ansola, et al., 2003; Hawkins, et al., 1997; Huett, et al., 2005; Murray-Gulde, et al., 2005; Sinicrope, et al., 1992; Sobolewski, et al., 1996) and organic compounds (biochemical oxygen demand, chemical oxygen demand, and chlorinated organics) (Moore, et al., 2000; Sherrard, et al., 2004). In order to understand the functional role of these constructed wetland plants used in phytoremediation of contaminated waters, additional data are needed regarding their environmental requirements and tolerances for constituents contained in complex waste streams or contaminated waters.

Often constructed wetland treatment systems are designed with emphasis on sequestering toxic constituents of concern in the hydrosoil (Murray-Gulde, et al., 2005) or designed based on phytoconcentration of these constituents within plant tissues (Ye, et al., 2003). Data regarding the relative partitioning of potentially toxic elements or compounds in plant tissues and to hydrosoil within CWTS can aid in design of these systems as well as understanding the potential toxicity that certain constituents may pose risks to wetland plants used in these treatment systems.

Renovation of waters associated with thermoelectric power generation is needed in order to reuse these waters (e.g. cooling waters) or discharge them into aquatic receiving systems (Mierzejewski, 1991) due to problematic constituents contained in these waters. With the advent of more stringent air quality standards, flue gas desulfurization technology is being implemented to decrease sulfur dioxide emissions (Lamminen, et al., 2001). During coal combustion, flue gases containing sulfur dioxide (SO_2) and other gaseous elements are produced. Some of these gaseous elements and compounds are transferred and transformed into soluble species by wet scrubbing of flue gases (Solan, et al., 1999). The resulting water produced by the wet scrubbing of flue gases is referred to as FGD water. The number of these scrubbing systems is increasing within the U.S. and consequently the annual production of FGD waters is increasing.

Constructed wetlands have been suggested for treatment of constituents of concern in FGD waters (Eggert, et al., 2008). Boron in FGD waters may be phytotoxic to wetland plant species in constructed wetland treatment systems, but potential boron toxicity is dependent on factors such as its concentration, form, frequency of occurrence, and duration of exposure in these waters. FGD waters can also contain elevated concentrations of other potentially phytotoxic constituents including arsenic, cadmium, chemical oxygen demand, chlorides, chromium, copper, lead, mercury, selenium, sulfate, zinc and hardness (e.g. calcium, iron, and magnesium), and are typically semi-neutral in pH (Mierzejewski, 1991). FGD waters vary in their composition and characteristics which are influenced by many factors such as coal type used, source water used in the scrubber, and type of flue gas scrubber employed (Eggert, et al., 2008). Since these waters vary widely in composition (e.g. boron concentrations), their phytotoxicity may also vary. In order to effectively use *T. latifolia* and *S. californicus* to remediate FGD waters, the responses of these plants to exposures of boron in FGD waters is needed to be understood. Since full-scale constructed wetland treatment systems are costly and inefficient for experimental purposes, a smaller scale experimental system is advantageous for assessing the effects of boron in FGD waters on these wetland plants (Eggert, et al., 2008). Studies in small containers can provide crucial information and important benefits such as rigorous testing of hypotheses through replication, control of environmental conditions, and cost effective results. Since FGD waters vary based on site specific operations, simulated FGD waters can be used to control composition of the experimental water, and to provide flexibility to alter constituents of interest such as boron concentrations in these experiments.

The objectives of this research were: 1) to determine responses of *T. latifolia*and *S. californicus* in terms of shoot height, shoot density, number of leaves per shoot (*T. latifolia*), length of brown shoot (necrotic tissues), and number of inflorescences produced following 13 months of exposure to a series of concentrations of boron(as boric acid) in simulated FGD water and then compare the responses of *T. latifolia*and *S. californicus*, 2) to measure concentrations of boron in the hydrosoil and bioconcentration of boron in plant tissue (i.e. shoots and roots) of *T. latifolia*and *S. californicus*, and 3) to determine relationships between responses of *T. latifolia*and *S. californicus* to boron exposures and concentrations of boron measured in the roots and shoots of these plants.

2. Materials and Methods

2.1. Exposure waters

Simulated FGD water was formulated by amending city water (Clemson, South Carolina, SC) with high-purity salts (Fisher Scientific, Inc) containing constituents of concern (Hg, Se, and As), technical grade salts of magnesium and calcium chloride, calcium sulfate, fly ash, and dibasic acid (Table 1). Simulated FGD water was formulated based on data from chemical analyses of actual FGD waters (Eggert, et al., 2008). For *T. latifolia* and *S. californicus* experiments, treatments were prepared by amending simulated FGD water with boric acid salts to achieve nominal boron exposure concentrations of 15, 50, 100, and 300 mg L^{-1} and 25, 50, 100, 300, 600 mg L^{-1}, respectively. Infield observations of *T. latifolia*, symptoms appeared in response to aqueous and sediment exposures of boron (>6 mg B L^{-1}) (data is not shown).Boron concentrations in thisstudy were chosen depending on previous studies which were done to determine the No Observed Effect Concentration and the Lowest Observed Effect concentration (NOEC and LOEC) of boron to *T. latifolia* seed germination and shoot and root growthof early seedlings of *T. latyfolia* andimmature *S. californicus* (data is not shown). In both *T. latifolia* and*S. californicus* tests, two controls were used: an unamended simulated FGD water [no boron added (CFGD)], and a low ionic strength control consisting of city water (C).

Table 1. High Purity salts used to prepare simulated FGD water (from Fisher Scientific, Inc)

Chemicals	Concentration
Cl	4000 mg L-1 1:1CaCl2 :MgCl2
SO4	1500 mg L-1 CaSO4 (gypsum)
Hg	0.030 mg L-1 Hg(NO3)2.H2O
Se	2 mg L -1 Na2 SeO4
As	0.250 mg L-1 Na2AsO3
DBA	0.1 ml L-1
Fly ash	100 mg L-1
Well water is the diluted water	

2.2. Experimental design

Bucket-scale experiments were conducted in controlled green house with a 16/8 light-dark photoperiod and temperature of 27 ± 3 ºC using *T. latifolia* (mature plants) and *S. californicus* plants (>1.5 years old and <126 cm). The hydrosoil used in these experiments was collected from a full-scale constructed wetland treatment system designed to treat FGD waters. Hydrosoil composition was dominated by clay (>70%) with sand, silt, and organic matter accounting for 23%, 5%, and 2%, respectively (Black, 1986). Five-gallon plastic (HDPE) buckets were filled to approximately 24 cm with hydrosoil and planted with five plants of *T. latifolia*or *S. californicus* per bucket. Three replicates were used per treatment. The plants were collected from a wetland site in Catawba County, NC. Both plant species were allowed to acclimate in the buckets and were supplied with city water (8L per bucket) for a period of one and a half months before initiation of boron treatments. Osmocote® time-release fertilizer (2.5 grams, 14-14-14) and 8-liters of simulated FGD water amended with boron were added to each bucket in the initiation of the experiment. To correct for effects of evapotranspiration and altered ionic strength of the exposure waters, city water was added to each bucket as needed. Exposure waters containing boron were renewed when the ionic strength decreased to less than 7 mS/cm. Boron concentrations in the overlying water were measured monthly and maintained at nominal treatment concentrations by addition of boric acid salts as needed. Water chemistry parameters (pH, Temperature, Dissolved Oxygen (DO), Electrical Conductivity (EC), hardness, and alkalinity) were analyzed according to Standard Methods (APHA, 1998). Powell (1997) found no correlation between boron concentrations and *T. latifolia*visual appearance during 6 months exposures but boron concentrations were not sufficient to cause adverse effect. In this study the concentrations were of sufficient duration (>1 year) to allow responses to boron to be manifested.

2.3. Responses measurements

Shoot density, shoot or leaf height and shoot or leaf appearance, live (green or senescent shoot or leaf), or dead (totally brown shoot or leaf), and the length of the brown portion of the shoot (necrotic tissues), were measured 3 times during the 13 months of the experiment. For this experiment, a shoot was considered to be the emergent portion of the plant from the hydrosoil

2.4. Plant and soil analyses

Soil samples were collected for analysis at termination of the experiment (after 13 months). Each soil sample was divided into two segments [surface (~12 cm deep) and subsurface soil (~12-24 cm deep)], and analyzed for pH and boron concentrations using a hydrochloric acid extraction method (Method 6010), (U.S. EPA, 1986). For plant analysis, one ramet was chosen randomly from each bucket and was rinsed thoroughly with Milli- Q water. The rhizome with the associated roots was separated from the shoots, and both segments were analyzed for boron using a dry ash method (Method 6010) (U.S. EPA, 1986).Boron was measured in *S. californicus* shoots that were brown for comparison with concentrations in green shoots. The targeted aqueous boron concentrations in phytotoxicity tests with *T. latifolia* and *S. californicus* were confirmed through analyses using Inductively Coupled Plasma Atomic Emission Spectrometer (Spectro Flame Modula; ICP-AES) according to EPA Method 200.7 (U.S. EPA, 1983).

2.5. Statistical Analyses

Significant responses to boron exposures in terms of length or height of shoot and number of shoots were determined by statistically significant differences relative to untreated controls ($p \leq 0.05$) using Statistical Analysis System (SAS Institute Inc., Cary NC, USA). Analysis of variance (ANOVA) with Dunnett's multiple range tests for significant differences relative to controls was performed if assumptions for parametric analyses were met. One way ANOVA on ranks with Wilcoxon test was performed if assumptions for parametric tests were not met. Linear regression analysis (General Linear Model (GLM)) used to quantify differences in boron concentrations in the soil and plant tissues of both *T. latifolia*and *S. californicus* was performed using SAS.The 5% alpha level was used in all statistical tests.

3. Results and Discussion

3.1. Confirmation of boron exposures

Boron treatment concentrations for *T. latifolia*tests ranged from 0.2 to 300 mg/L and measured boron concentrations were 92-126% of nominal concentrations. Treatment concentrations for the *S. californicus* test ranged from 0.2 to 600 mg/L and measured boron concentrations were 95-134% of nominal concentrations (Tables 2 and 3). Physical and chemical properties of exposure boron waters for *T. latifolia* and *S. californicus* are presented in Tables 4 and 5.

Table 2. Mean ± Standard Deviation (SD) of boron concentrations in exposure water, hydrosoil, shoots, and roots of T. latifolia

BT	Mean B mg L-1 (±SD) Exposure water	Mean B mg kg-1 (±SD) Soil surface	Mean B mg kg-1 (±SD) Soil subsurface	Mean B mg kg-1 (±SD) Roots	Mean B mg kg-1 (±SD) Leaves
C*	0.2 (0.06)	7.3 (6.4)	2.0 1.8	15.3 (7.0)	80.3 (16.3)
CFGD**	2.9 (0.44)	5.9 (1.1)	5.2 (2.6)	38.0 (39.2)	73.7 (52.6)
15	14.6 (0.91)	19.3 (1.0)	15.1 (0.81)	75.0 (67.4)	117.7 (62.3)
50	47.9 (3.54)	49.4 (4.3)	48.4 (4.2)	82.0 (11.53)	299.0 (59.9)
100	97.4 (6.71)	100.1 (6.8)	94.5 (6.6)	168.0 (30.5)	630.3 (110.2)
300	290.9 (16.4)	247.5 (8.6)	251.4 (32.6)	832.0 (565.3)	1694.7 (730.9)

C: City water control
CFGD: water control
B: Boron
BT: Boron Treatments
C: Control
CFGD: Control an unamended simulated FGD water [no boron added]

Table 3. Mean ± Standard Deviation (SD) of boron concentrations in exposure water, hydrosoil, shoots, roots of S. californicus

BT	Mean B mg L-1 (±SD) water	Mean B mg kg-1 (±SD) Soil Surface	Mean B mg kg-1 (±SD) Soil Subsurface	Mean B mg kg-1 (±SD) Roots	Mean B mg kg-1 (±SD) Shoot (brown parts/ Tips)	Mean B mg kg-1 (±SD) Shoot (green parts)
C	0.1 (0.04)	1.8 (2.5)	2.3 (3.5)	8.7 (9.8)	96 (24.0)	14 (7.1)
CFGD	3.1 (0.64)	5.2 (1.1)	4.7 (0.8)	8 (2.6)	338.5 (12.0)	39.5 (14.8)
25	24.9 (1.41)	26.1 (1.3)	26.3 (3.7)	45.3 (18.9)	934 (215.0)	124 (72.1)
50	48.7 (2.52)	48.3 (5.4)	49.8 (2.5)	60.7 (5.5)	925 (141.4)	264 (42.2)
100	99.2 (5.96)	100.4 (28.5)	88.8 (8.3)	142.3 (19.5)	5594 (0)	560 (0)
300	296.5 (14.15)	218.4 (9.6)	238.2 (18.4)	696.7 (77.5)	2000.5 (450.4)	*
600	592.5 (38.1)	246.5 (41.1)	330.3 (97)	951.7 (106.7)	1748 (280.01)	*

* No green parts
C: City water control
CFGD: CFGD: control an unamended simulated FGD water [no boron added]
B: Boron
BT: Boron Treatments
C: control
CFGD: control an unamended simulated FGD water [no boron added]

Table 4. Physical and chemical properties T. latifolia boron treatments in simulated FGD water

Water characteristics	Boron Treatments					
	C	C FGD	15	50	100	300
pH (SU)	7.2-8.64	6.84-7.83	7.78-7.88	6.94-7.75	6.71-7.83	7.33-7.8
EC µs	499-686	6,65-9,190	9280-9880	6520-8990	6180-9190	6710-9360
DO %	45.7-120.4	77.2-80.9	93.7-95.2	73.70-83.80	47.2-77.2	59.2-73.4
Hardness *mg/L	82	5300	5700	5700	6000	6000
Alkalinity *mg/L	60	40	42	150	134	148

C: City water control
CFGD: control an unamended simulated FGD water [no boron added]
*as $CaCO_3$

Table 5. Physical and chemical properties of S. californicus boron treatments in simulated FGD water

Water characteristics	Boron Treatments						
	C	C FGD	25	50	100	300	600
pH (SU)	6.54-6.94	6.64-7.04	6.72-7.2	6.92-7.36	7.15-7.81	7.39-7.54	7.35-7.56
EC µs	250.6-549	6690-8990	6470-8950	6720-9200	6950-9380	6840-9710	6590-9610
DO %	57.60-84.30	60.5-81.6	68.2-81.6	68.8-84.8	71.1-78.1	65.8-73.9	44.7-67.1
Hardness *mg L-1	76	6400	5600	5900	5300	6000	5700
Alkalinity *mg L-1	56	38	44	94	108	122	140

C: City water control
CFGD: control an unamended simulated FGD water [no boron added]
*as $CaCO_3$

3.2. Plant responses

Symptoms of boron toxicity to *T. latifolia* and *S. californicus* developed progressively during the duration of the experiment (13 months) and were proportional to boron exposures. These symptomsappeared first on the tips of the oldest leaves with yellowing and browning of the tips and margins of the leaves. Although heights of *T. latifolia*leaves, and number of leaves were not adversely affected at boron exposure concentrations ≤ 300 mg L^{-1}, shoot density was significantly adversely affected at 300 mg B L^{-1} (*p value* ≤0.05) (Figures 1 and 2). For *T. latifolia*, necrotic tissue appeared in the tips of older leaves as spotting and yellowing during the first two weeks of exposure and progressed during the first two months in boron treatments ≥300 mg L^{-1}. However, necrotic tissue developed in all boron treatments following 4-months of exposure, but necrotic tissue increased significantly (100-200%, relative to the control) at boron concentrations of ≥50 mg L^{-1} (*p value* ≤0.05)(Table 6).

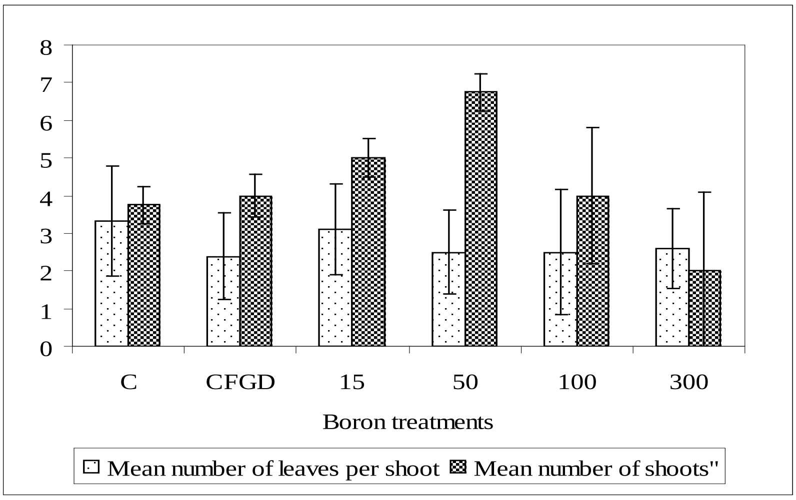
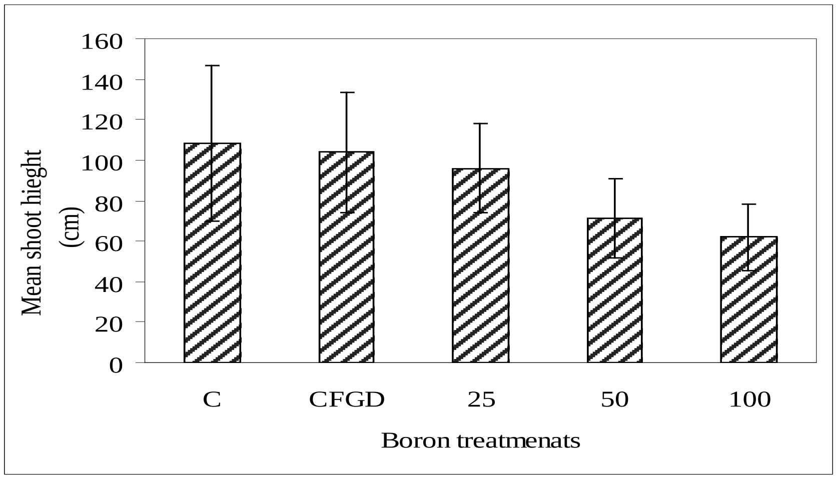


Figure 1. T. latifolia shoot height responses to boron exposures in simulated FGD water.

C: City water control. CFGD: control an unamended simulated FGD water [no boron added]



Fiugure. 2. T. latifolia shoot density and number of leaves per shoot responses to boron exposures in simulated FGD water.

C: control CFGD: control an unamended simulated FGD water [no boron added]

These are typical boron phytotoxicity symptoms (Blevins and Lukaszewski, 1998; Marschner, 1995; Roessner, et al., 2006). Following 13 months of exposure, the remaining green leaves (living tissue) were young leaves (totally green leaves <20 cm) which were not exposed to boron for sufficient duration to manifest apparent adverse effects, mostly in boron treatments ≤100 mg L^{-1}. Totally brown leaves were the older leaves (≤180 cm). *T. latifolia* did not produce any inflorescences even in the controls during the 13 months of this experiment.

Table 6. Response measurements of T. latifolia to boron exposures in simulated FGD water

T	Mean leaf height (cm) (± SD)	Brown shoot length Following 1.5 months exposure (cm) (Range)	Brown shoot length following 13 months exposure (cm) (Range)	Mean number of plants (± SD)	Mean number of leaves (± SD)
C	96 (31.7)	1 (0-9)	17 (0-23)	3.75 (0.50)	3.3 (1.45)
CFGD	81 (40.9)	3 (0-17)	28 (0-43)	4.00 (0.58)	2.3 (1.15)
15	94 (27.3)	2 (0-9)	34 (0-67)	5.00 (0.51)	3.1 (1.2)
50	98 (21.2)	1 (0-6)	45 (17-67)	6.75 (0.5)	2.5 (1.1)
100	102 (30.8)	2 (0-10)	47 (23-72)	4 (1.83)	2.5 (1.66)
300	102 (29.0)	4 (0-30)	67 (45-84)	2.00 (2.08)	2.6 (1.06)

C: City water control
CFGD: control an unamended simulated FGD water [no boron added]
SD: Standard Deviation
T: Treatments

It has been demonstrated that plant height decreased with increasing rate of B applications (Aydin, and Çakir, 2009). In this study, *S. californicus*shoot height, shoot density, and inflorescence production significantly decreased with increasing boron exposure concentrations ≥100 mg L^{-1} (*p value* ≤0.05) (Figure 3 and 4).For *S. californicus*, necrotic tissue appeared in the tips of older leaves, and spotting and yellowing progressed into the shoot. Symptoms of boron phytotoxicity developed progressively during the 13 months of the experiment and the intensity of the symptoms increased with increasing boron concentrations. The brown portion of the shoot (necrotic tissues) increased significantly (200-300%) at boron concentrations of ≥50 mg L^{-1}(*p value* ≤0.05) (Table 7). Shoots without necrosis (totally green leaves <17cm) most probably were young shoots which were not exposed to boron for sufficient duration to manifest symptoms of phytotoxicity.

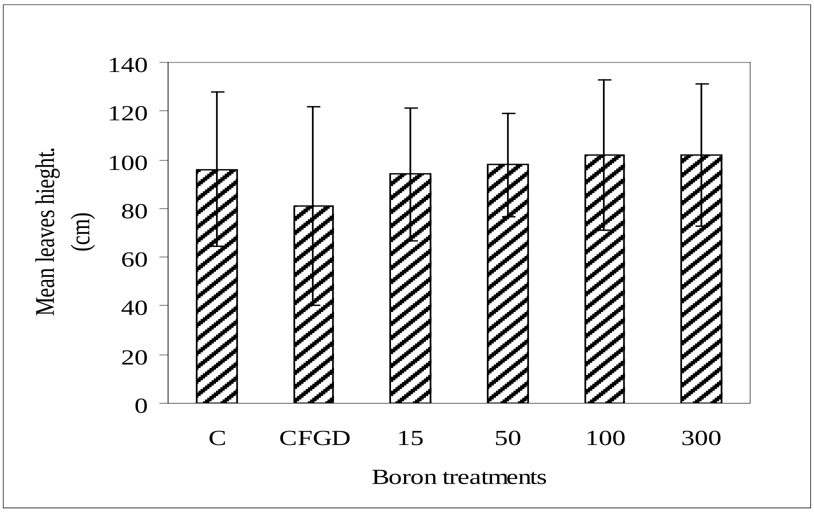


Figure 3. S. californicus shoot height responses to boron exposures in simulated FGD water.

C: City water control, CFGD: control an unamended simulated FGD water [no boron added]

At boron concentrations ≥300 mg L^{-1}, only totally brown shoots (necrotic tissue) were observed. The number of inflorescences was negatively affected by increasing boron concentrations and production of inflorescences completely ceased at boron concentrations ≥300 mg L^{-1} during the13-month exposures to boron (Figure 4).

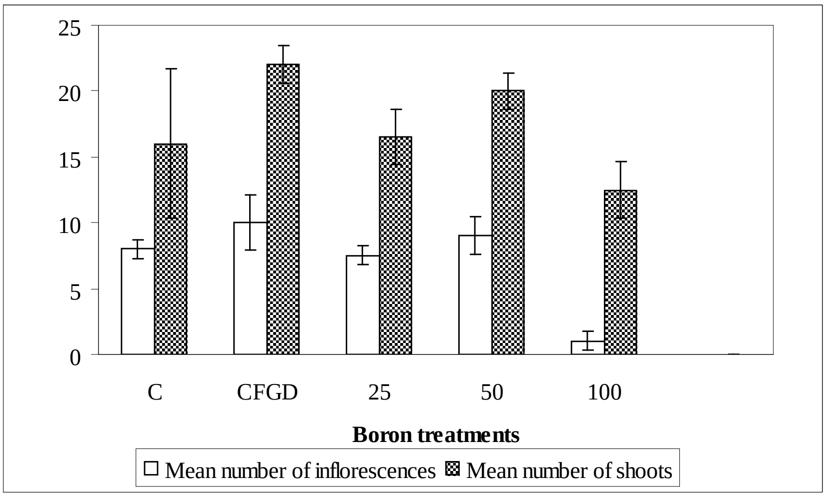


Figure 4. S. californicus shoot density and inflorescence production responses to B simulated FGDwater.

C:control, CFGD: control an unamended simulated FGD water [no boron added]

Table 7. Response measurements of S. californicus to boron exposures in simulated FGD water.

T	Mean shoot heights (cm) (± SD)	Mean brown shoot length following 1.5 months exposure (cm) (Range)	Mean brown shoot length following 13 months exposure (cm) (Range)	Mean number of shoots (± SD)	Mean number of inflorescence (± SD)
C	108 (38.4)	3 (0-11)	26 (0-72)	16 (5.7)	8 (0.7)
CFGD	104 (29.7)	8 (0-28)	26 (0-67)	22 (1.4)	10 (2.1)
25	96 (22.2)	1 (0-8)	42 (0-96)	16.5 (2.1)	7.5 (0.7)
50	71 (19.6)	2 (0-14)	65 (0-117)	20 (1.4)	9 (1.4)
100	62 (16.6)	9 (0-23)	102 (36-154)	12.5 (2.1)	1 (0.7)
300	24 (1.7)	11 (4-46)	Totally brown shoot	0	0
600	0	18 (2-84)	Totally brown shoots	0	0

C: City water control
CFGD: control an unamended simulated FGD water [no boron added]

3.3. Boron concentrations in the hydrosoil and plant tissues

3.3.1. Boron concentrations in the hydrosoil

The results of this study indicated that boron concentrations in the surface soil (~12 cm) were not significantly different from boron concentrations in the subsurface soil (~12-24 cm) (Tables 2 and 3). Boron concentrations in the hydrosoil were proportional (99-105 %) to boron concentrations in exposure waters for all *T. latifolia* and *S. californicus* treatments ≤ 100 mg L^{-1}. Hydrosoil boron concentrations in the *T. latifolia* and *S. californicus* treatments of 300 and 600 mg L^{-1} were not proportional to aqueous boron concentrations (74 and 42 %, respectively) indicating that the hydrosoil adsorption capacity was exceeded at boron treatments ≥300 mg L^{-1}. A p-value ≤ 0.05 is regarded as statistically significant.

3.3.2. Boron concentrations in plant tissues

Boron accumulates normally in plant leaf tissue at concentrations of 10 - 50 mg kg^{-1} (Hakki, et al., 2007) andmay exceed 700 to 1000 mg kg^{-1}dry wt in extreme conditions of B toxicity (Nable, et al., 1997). Moreover, it had been found that boron is concentrated in shoots more than roots and these concentrations were correlated with increasing boron exposure (Asad, et al., 1997). Similar to previous studies, in this study, boron concentrations in *T. latifolia*and *S. californicus* roots and shoots increased with increasing aqueous boron exposure concentrations (Figures 4 and 5) and the shoots had higher boron bioconcentrations than the roots.

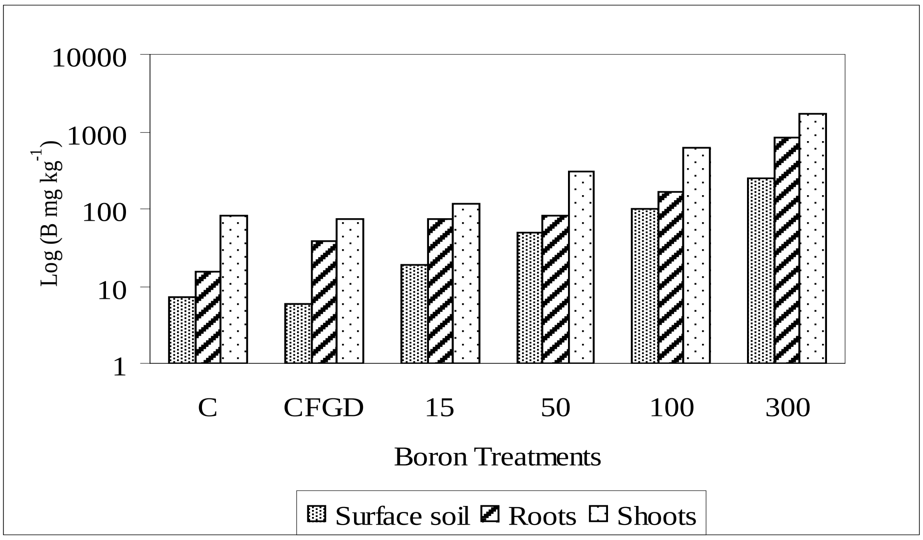


Figure 5. Difference in boron concentrations in the soil, roots, and shoots of T. latifolia

C: City water control, CFGD: control an unamended simulated FGD water [no boron added]

For instance, *T. latifolia* shoots had boron concentrations 2-4 times greater than the roots (Table 2). In *S. californicus* treatments of ≤100 mg B L^{-1}, boron concentrations in the brown shoots (necrotic tissue) were 15-39 times more than boron concentrations in the roots (Table 3), while in treatments of ≥300 mg B L^{-1}, boron concentrations were 1-3 times higher in the brown shoots than the roots (Figure 6).

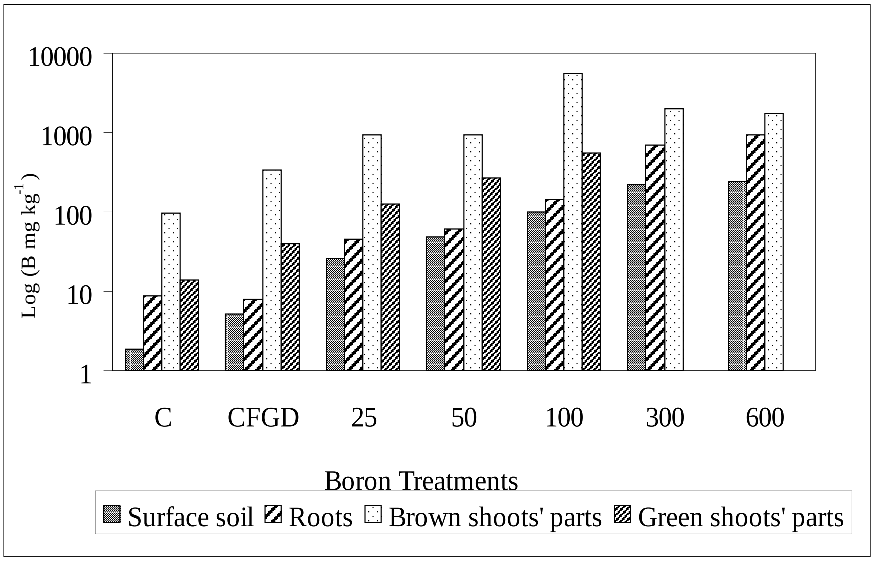


Figure 6. Differences in boron concentrations in soil, roots, and shoots of S. californicus.

C: City water control, CFGD: control an unamended simulated FGD water [no boron added]

3.3.3. Correlation between plant responses to boron exposures and boron concentrations in the hydrosoil and plant tissues.

The results of this study agreed with previous studies where boron accumulation in roots and shoots was positively correlated with the boron application to the soil (Aydin, and Çakir, 2009). Moreover, many species are quite sensitive to elevated B levels in their tissues, showing severe toxicity symptoms at tissue levels of about 50 mg kg^{-1} and such levels can be found in tissues when the available soil B exceeds 3 mg kg^{-1} (Hakki, et al., 2007). Reduced growth of shoots and roots is typical of plants exposed to high B levels (Nable, et al. 1990). In this study, length of shoot browning (necrotic tissues) observed in *T. latifolia*and *S. californicus* shoots significantly increased with increasing boron exposures and consequently, with increasing boron concentrations in the shoots and the roots indicating that these symptoms were developed due to boron exposures. In comparison with controls, *T. latifolia* had the greatest production of necrotic tissue and brown shoot length (3.7 times), and plant density was significantly affected (50%) at a boron concentration of 300 mg L^{-1}. For *S. californicus* treatments ≤100 mg L^{-1}, significant decreases in shoot density (≤43%), shoot height (≤40%), and inflorescence production (≤90%) were observed, however, significant boron bioconcentration was also observed in the roots and the shoots at these relatively low concentrations. For boron concentrations of ≥300 mg L^{-1}, totally brown shoots (necrotic shoots) and no production of inflorescences were observed. At these higher concentrations of boron, significant decreases (28-58%) in boron concentrations in the hydrosoil in proportional to exposure boron concentrations were also observed indicating that the hydrosoil adsorption capacity may be exceeded. A p-value ≤ 0.05 is regarded as statistically significant.

3.3.4. Differences between T. latifolia and S. californicus responses

*Typhalatifolia*and *Schoenoplectuscalifornicus* differ in their responses and tolerance of boron exposures, as well as bioconcentration potential for boron in simulated FGD water. Boron concentrations in *T. latifolia*hydrosoil and roots did not differ significantly from boron concentrations in *S. californicus*hydrosoil and roots (Figure 7 and 8). However, *S. californicus* had significantly more boron in its shoots than *T. latifolia* (Figure 9). Therefore, differences in the responses of *T. latifolia*and *S. californicus*to boron exposures could be related to significant differences in boron bioconcentration in shoots. Necrotic tissue increased significantly with increasing boron concentrations in shoots.

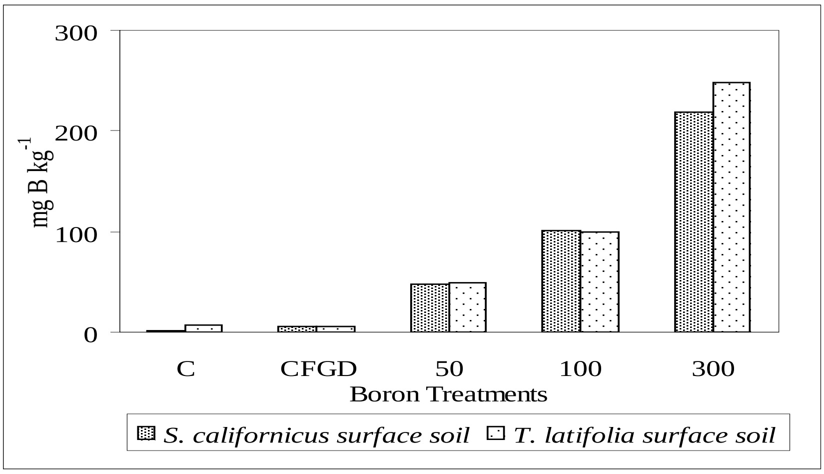


Figure 7. Comparison between boron concentrations in T. latifolia and S. californicushydrosoil.

C: City water control, CFGD: control an unamended simulated FGD water [no boron added]

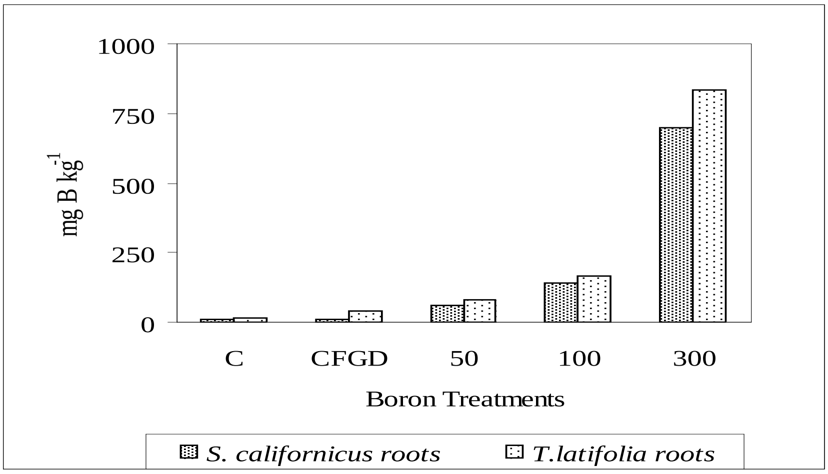


Figure 8. Comparison between boron concentrations in T. latifoliaand S. californicus roots.

C: City water control, CFGD: control an unamended simulated FGD water [no boron added]

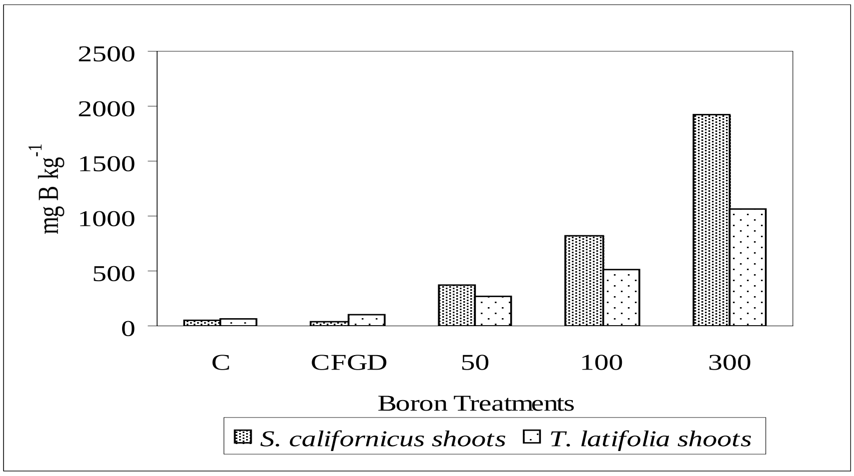


Figure 9. Comparison between boron concentrations in T. latifoliaand S. californicus.

C: control, CFGD: control an unamended simulated FGD water [no boron added]

For the duration of this experiment, *T. latifolia* withstood (green and senesced shoots were present) boron concentrations of 300 mg B L^{-1} with significant adverse effects on shoot density, while *S. californicus* did not withstand (totally brown shoots) boron concentrations ≥300 mg L^{-1}. *T. latifolia* shoot density, leaf height, and number of leaves per shoot were not adversely affected at boron concentrations ≤100 mg B L^{-1}. In contrast, *S. californicus*shoot density and height were adversely affected at boron concentrations of ≥100 mg L^{-1}(Table 8).

Table 8. Comparison between T. latifoliaand S. californicus

Treatments	Mean number of shoots (±SD)		Mean Shoot height (cm) (±SD)	
	T. latifolia	S. californicus	T. latifolia	S. californicus
C	3.75 (0.5)	16 (5.7)	96 (32)	108 (38)
CFGD	4 (0.6)	22 (1.4)	81 (41)	104 (30)
50	6.75 (0.5)	20 (1.4)	98 (21)	71 (22)
100	4 (1.8)	12.5 (2.1)	102 (31)	62 (13)
300	2 (2.1)	0.0 (0.0)	102 (29)	0

C: City water control
CFGD: control an unamended simulated FGD water [no boron added]

The wide variance in responses of plants species to aqueous exposures of boron was reviewed by Blevins and Lakaszewski (1998). The effects of boron on a range of plants from jack pine (*Pinusbanksiana*) to duckweed (*Spirodellapolyrrhiza*) have been evaluated in careful laboratory studies (Apostol, and Zwiazek, 2004; Davis, et al., 2002). After 6 weeks of exposure, chlorosis and necrosis related to boron exposure was observed in jack pine (Apostol, and Zwiazek, 2004). Duckweed was relatively sensitive with a 10-d EC_{50} of about 18-22 mg B L^{-1} (Davis, et al., 2002). In the present study, mature plants of *T. latifolia* and *S. californicus* responded to concentrations of boron at ≥50 mg L^{-1}. Powell et al. (1996) reported that *T. latifolia* accumulated relatively little boron but developed chlorosis in four weeks of exposure in laboratory bioassays. In a field investigation, Powell, et al. (1997) found no correlation between tissue concentrations of boron in *T. latifolia* and plant health; however boron concentrations in this study were not sufficient to cause severe adverse effects. In the present study, plant tissue concentrations of boron were strongly related to observed adverse effects for *S. californicus* but less strongly related for *T. latifolia*. In a treatment wetland microcosm study of coal gasification wastewater containing boron, Ye, et al. (2003) found that most (57%) of the boron accumulated in the sediment with relatively little in the plants and growth of *T. latifolia* was not affected by this complex mixture (coal gasification wastewater) over the 54-d study. The data in the present study also indicate the need for careful selection of wetland plants for remediation of contaminated waters containing multiple constituents of concern. Prior evaluations are useful for selection of compatible plants for treatment systems for complex matrices such as FGD waters that may contain phytotoxic concentrations of boron, especially if other constituents have the capacity to interact synergistically.

4. Conclusions

The results of this study demonstrated that boron toxicity is manifested over time in *T. latifolia*and*S. californicus* with signs of toxicity increasing with the duration of exposure. These results indicated that boron in FGD waters can adversely affect *T. latifolia* and *S. californicus* (necrosis) at boron concentrations >25 mg L^{-1}. In this study, *S. californicus*shoot height and density were negatively affected at boron concentrations of ≥100 mg L^{-1} while *T. latifolia* shoot density alone was adversely affected at boron concentrations of ≥300 mg L^{-1}. For both plants, boron concentrations in hydrosoil were proportional to aqueous boron exposures and were significantly less than boron concentrations in the roots. Boron was bioconcentrated in the shoots, specifically the tips.

Boron concentrations in the shoots are correlated with plant appearance, necrosis and shoot density for both *T. latifolia*and *S. californicus* and shoot height and inflorescence production for *S. californicus*. In FGD water, boron toxicity symptoms to *T. latifolia* include necrosis and decreased shoot density and for *S. californicus*, include necrosis, decreased shoot density, shoot height, and inflorescence production. The results of this study indicated that *S. californicus* was more sensitive to boron exposures in FGD water than *T. latifolia.* In constructed wetland treatment systems used to treat FGD waters, *T. latifolia* and *S. californicus* can be used when boron concentrations in these waters are maintained at ≤25 mg L^{-1}.

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Salinity and Ambient Ozone Effects on Olive Leaf Gas Exchange

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Abstract

Saline water is often available for irrigation and ambient ozone pollution is significant in the Mediterranean region. These two factors may negatively affect cultivated plant productivity. We studied the effects of a combination of these stress factors on leaf gas exchange of young olive trees, a major crop in the above region. Two–year–old 'Konservolea' and 'Kalamata' olive plants grafted on seedling rootstock were grown in sand:perlite mixture irrigated with half strength Hoagland's solution containing or not 100 mM NaCl. In open top chambers, the plants received outside air with ambient ozone or charcoal–filtered air from April to September. Leaf gas exchange parameters and chlorophyll fluorescence were measured periodically. High ozone concentrations from May to September able to damage plants (daylight mean ozone concentration >60 nL L^{-1}) did not affect the olive leaf functions studied, showing that young olive trees are relatively resistant to ozone levels found around the Mediterranean region. Irrigation with 100 mM NaCl solution decreased stomatal conductance by around 45%, photosynthetic rate by more than 35% and Fv/Fm values below 0.75. Both studied olive cultivars showed similar behavior to salinity stress possibly due to the seedling rootstock on which both cultivars were grafted. The combination of salinity and ambient ozone stress did not result in any further effects to leaf gas exchange besides the ones from the salinity stress alone.

Key Words: *Olea europaea*, Photosynthesis, Stomatal conductance, Chlorophyll fluorescence.

1. Introduction

Olive tree is considered as a moderately salt tolerant plant species (Bernstein 1965; Maas & Hoffman, 1977). Nevertheless, salinity decreased olive leaf net photosynthetic rate (Ps) and dry matter productivity via CO_2 availability to chloroplasts as stomatal and mesophyll conductance decreased at numerous publications (Loreto *et al*., 2003). The extent of this Ps and stomatal conductance (g_s) reduction depend on cultivar, rootstock and salinity severity (NaCl concentration and duration under salinity) (Al–Yassin, 2004; Chartzoulakis, 2005). Rootstock may be important for salinity resistance in glycophytes, due to the ability of the roots to exclude or retain the Na^+ and Cl^- ions (Chartzoulakis *et al*., 2002; Levy and Syvertsen, 2004). All published work about salinity effects on olive has been conducted with own–rooted plants. Recently, own–rooted 'Kalamata' olive trees were considered more resistant to salinity than 'Konservolea' (synonymous to 'Amfissis') trees (Chartzoulakis *et al*., 2002). But these two main table olive cultivars in Greece are commercially available as grafted plants on olive seedling rootstock. Thus, their behaviour to salinity could be different from the own–rooted plants.

High tropospheric ozone (O_3) concentrations have been found around the Mediterranean region (Riga– Karandinos & Saitanis, 2005). These O_3 levels are often higher than the safe limits for plants (40 nL L^{-1} during the growing season) (WHO, 2000). High ambient O_3, a highly oxidizing molecule, can enter the leaves through the stomata and generate reactive oxygen species, which may negatively affect most of the cellular processes, cause cell damage and death and, thus, reduce leaf and plant productivity. Olive is a sclerophyllus evergreen species expected to have reduced O_3 sensitivity due to reduced mesophyll gas conductivity and increased antioxidant capacity (Bussotti & Gerosa, 2002). Actually, only one scientific team has worked with O_3 effects on two Italian olive cultivars. 'Frantoio' olive plants were severely affected by exposure to close–to–ambient concentrations of O_3 (100 nL L^{-1} for 5 h day^{-1} and 120 days) with reduced Ps and g_s, but 'Moraiolo' plants were more resistant to O_3 as Ps was not significantly affected due to reduced g_s (Minnocci *et al*., 1999; Vitagliano *et al*., 1999). A Spanish research group has published a comparative study on ozone effects to various Mediterranean forest species including wild olive seedlings. They found no effects from relatively high ozone exposure (ambient + 40 nL L^{-1} for 12 h day^{-1} five days per week and 24 months) to Ps and biomass accumulation (Ribas *et al*., 2005), but the same group had previously reported for the same wild olive seedlings and shorter exposure to ozone (ambient + 40 nL L^{-1} for 9 h day^{-1} and 10 months) close to 20% reductions in plant height and stem growth (Inclan *et al*., 1999).

As O_3 and salinity cause alterations in g_s (Hassan, 2004), the combination of these two stresses can result in: no interaction (in alfalfa, Olszyk *et al*., 1988), synergistic, additive (in rice, Welfare *et al*., 1996) or antagonistic effects (in wheat, Hassan, 2004) on leaf gas exchange. There is no work published on the effects of a combination of O_3 and salinity stresses in cultivated woody plant species.

As salinity and O_3 are common problems in the Mediterranean area and both pollutants act on leaf gas exchange through stomatal opening, we hypothesized that the presence of these two pollutants could have antagonistic effects on leaf productivity in olive. Thus, we studied the effects of O_3 and salinity separately and in combination on olive leaf gas exchange and water relations for two main table olive cultivars.

2. Material and Methods

2.1. Plant material and treatments

Two–year–old uniform (similar height, canopy and trunk diameter) olive plants (*Olea europaea L*.) of two Greek table olive cultivars 'Konservolea' and 'Kalamata' grafted on seedling rootstock (seeds were collected from wild olive plants growing freely in forests) were planted individually in 12–L pots containing sand–perlite mixture 1:1 v/v. Plants of each cultivar were lightly pruned and transferred to open–top chambers (OTCs) constructed as described by Heagle *et al*. (1983). Each OTC was constructed of an iron frame covered with a HDPE sheet (180 μm thickness, >80% light penetration) and was continuously ventilated with an air ventilation unit bringing ambient outside air into the chamber at 1600 m^3 h^{-1}. Air was distributed via perforated tubes 15 cm in diameter positioned at 70 cm above ground along the chamber walls (the lower level of tree canopy). Mean air temperatures for two years (2006, 2008) were 21.8 °C for May, 28.2 °C for June, 28.5 °C for July, 28.1 °C for August, 23.2 °C for September and 22 °C for the first half of October. For the above period, maximum and minimum air temperatures were 37 °C and 13 °C, respectively.

Six OTCs were used in this experiment, three chambers ventilated with charcoal– filtered air and the other three with outside air containing ambient ozone levels. Two to three times per week half of the pots of each cultivar (randomly chosen) inside each chamber received two L per pot of half strength Hoagland's solution containing 100 mM NaCl, while the rest of the pots received half strength Hoagland's solution. There were four pots per treatment in each chamber and from each cultivar. Ambient or charcoal–filtered air fumigation and salinity treatment were applied from April until October for two experimental years, 2006 and 2008.

To avoid salt shock, the NaCl–treated plants were initially given 25 mM NaCl and the concentration increased by 25 mM in weekly intervals reaching 100 mM NaCl at the end of April. The conductivity of drainage water (leachate) from pots was measured weekly. In order to avoid any salt accumulation in the pots, all pots were flushed with half strength Hoagland's solution twice per month keeping the leachate conductivity of the pots receiving NaCl close to 13 mS cm^{-1}.

2.2. Ozone Monitoring

Ozone was monitored with two Eco Sensors ozone monitors (Model C– 30ZX, Eco Sensors, Santa Fe, NM, USA), one placed in a chamber with charcoal–filtered air and another one in a chamber with non–filtered (ambient) air. The data from each ozone analyzer were logged in a data logger and collected weekly from May 1st to October 15th.

2.3. Leaf parameters measured

A portable photosynthesis unit (LCi Photosynthesis System**,** ADC BioScientific Ltd, Hoddesdon, Herts, UK) was used to monitor leaf net photosynthetic rate, transpiration rate, stomatal conductance, photosynthetically active radiation, leaf temperature and calculate leaf water use efficiency. The measurements were taken at monthly intervals from June to September during morning hours between 09:00 and 11:00 am on mature leaves fully exposed to light. Throughout the measurement periods, relative humidity was below 50%, photosynthetically active radiation was above 1200 μmol m^{-2} s^{-1} and ambient CO_2 concentration was above 360 μL L^{-1}. During the same days, leaf chlorophyll fluorescence was also measured with the OS–30p fluorometer (ADC BioScientific Ltd, Hoddesdon, Herts, UK) after 30 min dark adaptation and application of saturating excitation light provided by a 660 nm solid state source. The ratio between variable and maximal fluorescence (Fv/Fm) was calculated.

2.4. Statistical analysis

Data from 2008 are shown (data from 2006 showed similar trend). Analysis of variance was conducted over three factors (cultivar, time and treatment) using the SPSS 16.0 statistical package (SPSS Inc., Chicago, IL). Means were separated by Duncan's test. Overall least significant differences at 5% were calculated and are shown.

3. Results

3.1. Ambient ozone concentrations

Ozone concentration in Velestino area (Central Greece) was high during the entire period of measurements. Daylight mean ozone concentration from May 1st to October 15th exceeded 60 nL L^{-1} and maximum values were 72–93 nL L^{-1} inside the chamber with non–filtered air. AOT40 (cumulative exposure to ozone above 40 nL L^{-1}) values reached 54176 nL L^{-1} h for the mentioned period. In the chamber with filtered air, daylight mean ozone concentration was below 24 nL L^{-1} and maximum values reached 27 nL L^{-1}.

3.2. Salinity and ozone effects

Salinity significantly decreased olive leaf g_s (around 45%), transpiration rate (>30%), and Ps (>35%), but only slightly decreased WUE in both cultivars studied throughout the measurement period (Table 1 and 2). These reductions were similar in the two cultivars. At all times, air filtering to remove the high ambient ozone did not have any positive effect on leaf functioning.

Supporting the above, leaves from the no-NaCl with low or ambient ozone treated plants had Fv/Fm values above 0.8, showing no stress, while leaves from the high salinity treatments had Fv/Fm values lower than 0.75 after June showing stress due to NaCl (Table 2).

Table 1. Changes in leaf photosynthetic rate (Ps, μmol m^{-2} s^{-1}), transpiration rate (Trans., mmol m^{-2} s^{-1}) and water use efficiency (WUE, mmol CO_2 / mol H_2O) during the summer period for 'Konservolea' and 'Kalamata' olive trees grafted onto seedling rootstock. Overall least significant differences (LSD) at 5% level are included.

		'Konservolea'			'Kalamata'		
Treatment	**Month**	**Ps**	**Trans.**	**WUE**	**Ps**	**Trans.**	**WUE**
-NaCl LowO3	June	13.0 a	3.67 ab	3.72 c	14.8 a	4.15 a	3.59 b
	July	12.6 ab	3.79 a	3.32 cd	12.4 bc	3.78 ab	3.29 bc
	August	11.4 c	3.75 a	3.06 d	11.8 c	3.14 cd	4.13 a
	September	11.6 bc	2.64 cd	4.47 b	11.4 c	3.23 c	3.67 b
-NaCl AmbO3	June	12.3 b	3.51 ab	3.54 cd	13.0 b	3.99 ab	3.29 bc
	July	12.2 b	3.61 ab	3.38 cd	11.9 c	3.47 bc	3.47 bc
	August	11.2 c	3.35 b	3.45 cd	11.5 c	3.72 b	3.14 cd
	September	11.7 bc	2.84 c	4.14 bc	11.7 c	2.82 d	4.20 a
+NaCl LowO3	June	7.7 d	2.45 cd	3.15 d	8.2 d	2.81 d	2.96 cd
	July	7.5 d	2.27 d	3.34 cd	7.8 de	2.39 e	3.29 bc
	August	6.5 f	1.62 e	4.04 bc	7.0 e	2.28 e	3.21 bc
	September	6.8 ef	1.59 e	5.04 a	6.8 e	2.36 e	2.90 cd
+NaCl AmbO3	June	7.8 d	2.46 cd	3.17 d	8.3 d	3.01 cd	2.76 d
	July	7.3 de	2.30 d	3.24 d	7.2 e	2.31 e	3.16 c
	August	6.3 f	1.68 e	3.78 c	6.9 e	2.31 e	3.16 c
	September	6.8 ef	1.65 e	4.13 bc	6.7 e	2.29 e	2.96 cd
	LSD0.05	0.7	0.4	0.5	0.7	0.4	0.4

Values with similar letter(s) within a column are not significantly different at P=5% by Duncan's Multiple Range Test

Table 2. Changes in leaf stomatal conductance (g_s, mol m^{-2} s^{-1}) and leaf chlorophyll fluorescence ratio Fv/Fm over the summer period for 'Konservolea' and 'Kalamata' olive trees grafted onto seedling rootstock. Overall least significant differences (LSD) at 5% level are included.

		'Konservolea'		'Kalamata'	
Treatment	**Month**	**gs**	**Fv/Fm**	**gs**	**Fv/Fm**
-NaCl LowO3	June	0.18 a	0.82 a	0.21 a	0.83 a
	July	0.17 ab	0.83 a	0.18 b	0.83 a
	August	0.16 b	0.82 a	0.14 d	0.82 ab
	September	0.13 cd	0.83 a	0.15 cd	0.83 a
-NaCl AmbO3	June	0.15 b	0.83 a	0.20 a	0.83 a
	July	0.16 b	0.83 a	0.16 c	0.81 bc
	August	0.14 c	0.82 a	0.15 cd	0.82 ab
	September	0.12 d	0.82 a	0.13 d	0.82 ab
+NaCl LowO3	June	0.09 e	0.80 b	0.11 e	0.80 c
	July	0.08 ef	0.73 d	0.09 f	0.74 d
	August	0.08 ef	0.75 c	0.09 f	0.75 d
	September	0.06 f	0.75 c	0.08 f	0.75 d
+NaCl AmbO3	June	0.09 e	0.80 b	0.12 de	0.80 c
	July	0.09 e	0.73 d	0.08 f	0.74 d
	August	0.08 ef	0.75 c	0.12 de	0.74 d
	September	0.07 f	0.76 c	0.08 f	0.75 d
	LSD0.05	0.019	0.02	0.019	0.02

Values with similar letter(s) within a column are not significantly different at P=5% by Duncan's Multiple Range Test

4. Discussion

The high ambient ozone concentrations measured in the rural area of Velestino have been found before for Volos, a nearby urban area (Riga–Karandinos, & Saitanis, 2005). Actually, the ambient ozone concentrations found today in various rural or not Mediterranean areas are high enough (like in Velestino) to damage many plant species (WHO, 2000). Ozone was found to reduce gas exchange rates in various tree species with concentrations and AOT40 values significantly lower than in our study (Pye, 1988). Only the ozone that diffuses into a plant through the stomata to the photosynthesizing cells within a leaf impairs plant processes or performance. Thus, stomatal conductance is considered the regulatory point of plant sensitivity to ambient ozone (Reich, 1987). This stomatal conductance is relatively low in sclerophyllous evergreen broadleaf drought–resistant species such as olive (Larcher, 1995). Based on the above, olive is expected to be relatively tolerant to high ozone levels due to low stomatal and mesophyll conductance and the position and size of stomata (Ribas, *et al*., 2005). Nevertheless, Minnocci *et al*. (1999) found that g_s was substantially reduced in both olive cultivars studied (own–rooted) and Ps was reduced in only one of them after exposure to 100 nL L^{-1} for 5 h day^{-1} for 120 days reaching AOT40 around 36000 nL L^{-1} h. No conclusive results were found on wild olive seedling dry matter productivity from exposure to higher than our study's AOT40 values in Spain (Inclan, *et al*., 1999; Ribas, *et al*., 2005). Based on the data presented herein and other previously published (Abusafieh, *et al.*, 2011), it is clear that the two cultivars used in our study (grafted on wild olive seedling rootstock) were not stressed or negatively affected in any significant way from the ozone levels found today in the Mediterranean region with AOT40 exceeding 54000 nL L^{-1} h over one growing period. This could be due, as described above, to low stomatal conductance, which would diminish ozone access to intercellular spaces and photosynthesizing cells, but also due to the high antioxidant capacity of olive leaves, which would protect the cells from oxidative damage. Thus, damage from ozone in olive seems to be genotype–dependent and may be affected from the rootstock, ozone concentration and duration of exposure to ozone, an estimation of which is AOT40 and, possibly, biochemical factors associated with the leaf antioxidant capacity of each cultivar. In addition, although in all experimental work the olive plants have been properly irrigated and fertilized, the farm cultivated olive plants are normally grown in dry climates where, during the summer months and even if irrigated promptly, transpirational demand during the hot daylight hours is high and stomatal conductance is very low. This coincides with the hours when ozone concentration is also highest. Thus, ozone can not significantly enter and accumulate in the olive leaves in levels high enough to cause damage, as it can happen to other woody species (Bussotti, & Gerosa, 2002).

Salinity in the absence or presence of ambient ozone reduced leaf productivity via reductions in g_s and mesophyll CO_2 conductance, which negatively affected each other, and, finally, leaf Ps and dry matter productivity, as described by Loreto *et al*. (2003). Under salt stress, besides the reduced g_s, olive leaves become thicker and more succulent (Bongi, and Loreto, 1989). Increasing leaf thickness may further reduce the mesophyll conductance by extending and making more tortuous the CO_2 pathway toward the chloroplast (Evans, et al., 1994). Low CO_2 availability to chloroplasts will reduce Ps and Fv/Fm as found in our study. The reduction in Fv/Fm can be ascribed as down regulation of PSII that reflects the protective or regulatory mechanism to avoid photodamage of photosynthetic apparatus (Demming-Adams, 1992).

In the extensive literature about salinity tolerance of olive, the 100 mM NaCl in the irrigation solution is the critical concentration of NaCl to damage olives (Chartzoulakis, 2005). Tolerant to salinity cultivars maintained their leaf Ps, when irrigated with 100 mM NaCl solution for a short period of time, but Ps and g_s significantly decreased at 200 mM NaCl (Tattini, *et al.*, 1995). In our study, the duration of salinity stress resembled field conditions, when saline water is available for irrigation over an entire season, and the studied table olive cultivars grafted on wild olive rootstock showed significant reductions in leaf functioning. Thus, the certain combination of seedling rootstock and table olive cultivars used in our study can be considered quite sensitive to salinity as far as leaf productivity is concerned. But our olive plants showed no macroscopic damage (leaf scorching, leaf drop) due to salinity in any of the experiments.

In a previous study with young own–rooted olive trees (Chartzoulakis, *et al*., 2002); 'Kalamata' plants were found more tolerant to NaCl than 'Konservolea' plants, due to lower g_s and Ps of 'Kalamata' leaves. In our study, with the same as above cultivars but grafted on the same seedling rootstock, there were no differences in the gas exchange properties and thus NaCl tolerance between the two cultivars. This was probably due to the seedling rootstock, which seemed to increase the leaf productivity of 'Kalamata' trees and improve the NaCl tolerance of 'Konservolea' trees. It is expected and is well documented that roots play a substantial regulating role in Na^+ and Cl^- ion uptake and transport to leaves (Tattini, *et al*., 1994; Chartzoulakis, *et al*., 2002; Levy, & Syvertsen, 2004). Actually, we found similar Na^+ ion concentrations in the leaves of the two cultivars, when salinity was applied (1.16 and 1.15 g kg^{-1} dry matter for 'Konservolea' and 'Kalamata' leaves, respectively). Even though the rootstock may have the most significant effect on salt tolerance of olives, no previous work has been published on the salinity sensitivity of grafted olive plants. Grafting economically important olive cultivars on resistant easy-to-root cultivars or selections should be further studied, as a way to reduce the negative consequences on plant productivity from saline irrigation water.

Our results showed no interaction between salinity and ozone in any of the physiological parameters studied. Similar results were obtained in alfalfa (Olszyk, et al., 1988). Our hypothesis was that salinity and ozone will act antagonistically as salinity reduces stomatal conductance and this would cause reduced intercellular ozone levels and, thus, reduced oxidative damage. On the contrary, it was possible that these two stress factors, as both cause oxidative damage to cells, could act synergistically and result in even more damage than each factor separately. This has actually been found in rice (Welfare, *et al*., 1996). Nevertheless, the ambient ozone levels today were not found to negatively affect olive leaf gas exchange even in the presence of high NaCl concentration, another significant stress factor.

5. Conclusion

In conclusion, similar significant reductions in the leaf gas exchange parameters were found in 'Konservolea' and Kalamata' olive trees irrigated with 100 mM NaCl solution possibly due to the seedling rootstock on which the two cultivars were grafted. The presence of relatively high ambient ozone concentrations over the summer period (more than 5 months) did not affect olive leaf gas exchange. The combination of salinity and ambient ozone stress did not modify the olive leaf physiological parameters any further than the salinity stress alone.

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8. المقترحات

- وضع سياسة وطنية وإقليمية لمواجهة نقص المياه الهائلة .
- تكييف برنامج توفير المياه للتخفيف من حدة الجفاف .
- الاستفادة من المياه الزائدة (من خلال التخزين) خلال السنوات الرطبة .
- إرشاد المزارعين ودعمهم، لتغيير الأنماط الزراعية، والتحول من الزراعة المروية المكشوفة، إلى المحمية، واستخدام تكنولوجيا وأساليب الري الحديثة، وزراعة محاصيل ذات احتياجات مائية اقل ومحاصيل أكثر تحملا للجفاف لما في ذلك من توفير للمياه .
- توعية المواطنين ودعمهم لضمان ترشيدهم لاستخدام المياه في القطاع الزراعي .
- العمل على اتخاذ كافة الإجراءات التي تكفل تقليل كميات المياه الفاقدة سواء كانت نتيجة تسرب المياه من القنوات المفتوحة، أو شبكات المياه، أو من خلال التبخر .
- إعادة تأهيل وصيانة الآبار في المنطقة .
- العمل على محاربة كافة أشكال الاستغلال غير القانوني للمياه .
- استغلال مياه الجريان السطحي في الوديان وخصوصا مياه الينابيع المنسابة في الوادي في فترة الشتاء، من خلال عمل السدود الصغيرة، برك التجميع، وأشباهها من وسائل الحصاد المائي، لتجميع المياه واستغلالها لاحقا في مواسم الجفاف .
- العمل بالتعاون مع المؤسسات الحقوقية الرسمية والأهلية والدولية على تعديل الاتفاقيات الموقعة مع الإسرائيليين والخاصة بالمياه بما يكفل حصول الفلسطينيين على حقوقهم واحتياجاتهم من كميات ونوعية المياه .
- عمل المزيد من البحوث المتعلقة بالجفاف، لتخفيف حدة تأثيرها السلبي على الإنسان
- كل ما سبق من مقترحات هدفها النهائي تحقيق إدارة سليمة للعرض والطلب على المياه، يقود إلى إنتاج زراعي أفضل، وبالتالي تحسين الدخل الزراعي، والتقليل من التأثيرات السلبية للازمة المائية اقتصاديا واجتماعيا على السكان عموما والمزارعين خصوصا في منطقة الأغوار .

9. المراجع

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يتضح بحسب الجدول (7) إن تأثير الأزمة المائية على الإنتاج الزراعي في منطقة العوجا جاء عموما سلبيا وبدرجة متوسطة، واشد هذه التأثيرات تمثلت في تقلص المساحات المزروعة بالخضار (2.65) وتقلص عدد الدورات الزراعية (2.65) بما يعكس انخفاض الإنتاجية الزراعية لوحدة المساحة.

6. حلول لمواجهة الأزمة المائية في القطاع الزراعي

أهم وسائل مواجهة الأزمة المائية من وجهة نظر المزارعين تتمثل في الإدارة الجيدة للعرض عبر استعادة الحقوق المائية من الإسرائيليين، ثم الاستفادة بالحصاد المائي بإقامة السدود على الأودية لتجميع مياه الجريان السطحي التي ينتهي بها المطاف بالجريان في هذه الوديان، وحفر آبار جديدة لأغراض الشرب والزراعة. يلي ذلك مواجهة الأزمة بإدارة الطلب على المياه بأساليب مختلفة أهمها: ترشيد استهلاك المياه الزراعية، وزراعة محاصيل أكثر تحملا للجفاف وأخرى اقل استهلاكا للمياه واستخدام أساليب ري عصرية. علما بأنه لم ترتقي الجهود الرسمية والأهلية في مساعدة المزارعين وسكان المنطقة على تجاوز الأزمة المائية.

7. الاستنتاجات والمقترحات

- يتضح أن الجفاف يحدث في منطقتنا (تقريبا كل 7 سنوات) في حين أن الطلب على المياه في تزايد مستمر.
- إن للجفاف آثار على جميع أنواع المياه المستخدمة، حيث يلاحظ انخفاض حاد في توافر المياه، ولا سيما مياه الينابيع التي انخفضت بحدة حوالي 40%.
- يتضح أن هناك انخفاض في مستويات المياه الجوفية وأصبح عدد كبير من الآبار الضحلة خارج نطاق الضخ.
- اعتماد منطقة الأغوار على الزراعة المروية المكشوفة عمق من اثر الأزمة المائية على المزارعين في المنطقة.
- شبكة المياه العامة هي المصدر الرئيس للمياه الزراعية ومياهها تتعرض لاستغلال غير قانوني مكثف.
- الآبار في المنطقة بحاجة إلى تأهيل وصيانة.
- أهم التحديات التي تواجه قطاع المياه في المنطقة تتمثل في محدودية المصادر المائية الطبيعية، والاستغلال الإسرائيلي الجائر لمصادر المياه المتوفرة في المنطقة.
- تأثيرات الأزمة المائية على المنطقة انعكست سلبيا وبشدة اجتماعيا واقتصاديا على حياة السكان عموما والمزارعين خصوصا.
- أهم التأثيرات السلبية للازمة المائية انعكست بضعف مقومات الإنتاج الزراعية، المادية والبشرية مما اضعف الوضع الاقتصادي العام للمزارعين.
- التأثيرات الاجتماعية للازمة المائية هي انعكاسات غير مباشرة وناتجة عن تأثيرات اقتصادية، مردها ضعف الإنتاج الزراعي.
- التكيفات والحلول المطلوبة لمواجهة الأزمة المائية تتمثل في تكيفات وحلول على مستويي العرض والطلب.
- هناك غياب شبه كامل للجهود الحكومية والأهلية لمساعدة المزارعين والسكان على مواجهة الأزمة المائية.

1.5 . تأثيرات اقتصادية

يمكن تلخيص أهم التأثيرات الاقتصادية الناتجة عن الأزمة المائية في منطقة العوجا كما يظهر في الجدول رقم (6) .

جدول (6) المتوسطات الحسابية والانحرافات المعيارية للتأثيرات الاقتصادية للازمة المائية في منطقة العوجا على حياة المزارعين .

الرقم	المجال	سلبا	لا تأثير	إيجابا	متوسط حسابي	انحراف معياري
1	الدخل العائلي من الزراعة	95	13	9	2.74	0.400
2	الدخل من وحدة المساحة الزراعية المستغلة	77	10	30	2.40	0.542
3	نسبة البطالة في التجمع السكاني (**)	74	33	10	2.55	0.492
4	الاستهلاك الذاتي من 58الانتاج 74مقابل التسويق (**)	82	14	21	2.52	0.494
5	حاجة الأسرة لشراء الطعام من الأسواق (**)	58	23	36	2.19	0.590
6	كلفة الإنتاج (**)	74	27	16	2.50	0.503
7	أسعار المياه(**)	99	7	11	2.75	0.374
8	أسعار تسويق السلع الزراعية	79	23	15	2.55	0.488
9	نسبة جفاف المحصول (**)	88	12	17	2.61	0.458
10	القيمة الكلية				2.53	0.489

(**) الأثر السلبي ينعكس بالزيادة في واقع المؤشرات .

يتضح بحسب الجدول (6) إن تأثير الأزمة المائية على الأوضاع الاقتصادية للمزارعين في منطقة العوجا، جاء عموما من وجهة نظرهم سلبيا وبدرجة متوسطة (2.53) . غير إن هذا التأثير جاء سلبيا وبدرجة كبيرة في مجال انخفاض الدخل العائلي من الزراعة وارتفاع أسعار المياه الزراعية (2.74) و(2.75) على التوالي .

2.5 . تأثيرات في مجال الإنتاج الزراعي

أهم التأثيرات للازمة المائية على الإنتاج الزراعي في منطقة العوجا يلخصها جدول (7)

جدول (7) المتوسطات الحسابية والانحرافات المعيارية لتأثيرات الأزمة المائية على الإنتاج الزراعي في منطقة العوجا

الرقم	المجال	سلبا	لا تأثير	ايجابا	متوسط حسابي	انحراف معياري
1	حجم الثروة الحوانية	60	17	40	2.17	0.608
2	الانتاج الحيواني من المواشي	75	23	19	2.48	0.509
3	الانتاج من الدواجن	43	33	41	2.02	0.599
4	كم الانتاج الزراعي	76	20	21	2.47	0.512
5	نوع المنتج الزراعي	72	10	35	2.32	0.574
6	مساحة الارض المستغلة	79	18	20	2.50	0.501
7	مساحة الارض المزروعة بالخضار	94	5	18	2.65	0.428
8	مساحة الأرض المزروعة بالاشجار المروية	82	15	20	2.53	0.491
9	مساحة الارض المزروعة بالمحاصيل	71	17	29	2.36	0.550
10	عدد الدورات الزراعية	95	3	19	2.65	0.425
11	الزراعة المكشوفة المروية	84	11	22	2.53	0.490
	القيمة الكلية				2.43	0.527

في تربة مالحة مثل المناطق الواقعة شرق أريحا، شمال شرق نويعمة وشرق العوجا، حيث ينصح في هذه المناطق زراعة المحاصيل العلفية والتي تتحمل الملوحة العالية . ويفضل تسوية الأرض في المناطق التي تروى بمياه مالحة حيث أن ذلك يسهل حركة المياه للأسفل ويمنع تراكم الأملاح في منطقة نمو الجذور. وينصح بمقاربة الفترة بين الريات في المناطق التي تروى بمياه مالحة وذلك لتجنب تركيز الأملاح نتيجة لفقد المياه بالتبخر والنتح. وفي حالة الري بمياه مالحة يفضل استخدام نظام الري بالتنقيط أو الري السطحي وعدم استخدام نظام الري بالرشاشات وذلك تجنبا لحرق أوراق النباتات بسبب الأملاح. وفي حال هطول الأمطار على الأراضي المالحة يفضل تشغيل نظام الري لمنع دخول الأملاح الجوانب إلى منطقة الجذور.

ومن اجل تحسين الخواص الفيزيائية للتربة يوصى بإضافة الأسمدة العضوية المختمرة للتربة خلال فصل الشتاء. ولتجنب تراكم الأملاح في التربة ينصح بغسل التربة بين فترة وأخرى مع التأكد من وجود نظام صرف جيد خاصة في الأراضي التي تروى بمياه مالحة.

ولضمان اكبر نسبة إنبات ونمو جيد للنبات يجب زراعة البذور أو الأشتال على جانب الخط بين أسفل الثلم وأعلى نقطة فيه بدلا من الزراعة في أسفله

جدول رقم (5) ملخص تحليل مياه الآبار الزراعية الواقعة في الضفة الغربية مقارنة مع المستويات المثلى لبعض الخصائص الفيزيائية والكيماوية لمياه الري.

الخصائص الكيماوية	الرمز	الوحدة	المدى الطبيعي	نتائج التحليل*
				الأغوار
التوصيل الكهربائي	E.C	ميكروموز/ سم3	0–3000	606–8090
ا التركيز الكلي للأملاح	TDS	ملغم/ لتر	0–2000	318–3643
كالسيوم	Ca	ملغم/ لتر	0–20	30–364
م مغنيسيوم	Mg	ملغم/ لتر	0–5	13–240
صوديوم	Na	ملغم/ لتر	0–40	6–699
بيكربونات	HCO3	ملغم/ لتر	0–10	153–514
كلوريد	Cl	ملغم/ لتر	0–30	4–1636
كبريتات	SO4	ملغم/ لتر	0–2	13–720
نترات	NO3	ملغم/ لتر	0–10	0–92
بوتاسيوم	K	ملغم/ لتر	0–2	2–93
د درجة الحموضة	pH		1–14	6–8.5
نسبة الادمصاص	SAR	ملليمكافيء/ لتر	0–15	0.1–7.7

المصدر: إدارة مياه الري، 1997 *سلطة المياه الفلسطينية، 1999

5. تأثيرات الأزمة المائية على القطاع الزراعي في منطقة الأغوار والعوجا

لقد انعكست الأزمة المائية في منطقة الأغوار عموما ومنطقة العوجا بشكل خاص على القطاع الزراعي اقتصاديا واجتماعيا بأشكال مختلفة حيث كان لها تأثيرات اقتصادية، وعلى الإنتاج الزراعي والحياة الزراعية، والعمالة وكانت هذه التأثيرات سلبية بشكل عام.

جدول رقم (3) الفترة الحرجة لنقص المياه لبعض المحاصيل .

نوع المحصول	الفترة الحساسة للجفاف	نوع المحصول	الفترة الحساسة للجفاف
مشمش	الأزهار وتطور البراعم	الذرة الصفراء	الأزهار وتكوين البذور
فاصولياء	الأزهار وملىء القرون	البطاطا	التبرعم وتكوين الدرنات
ملفوف	نمو الرأس والنضوج	الفجل	استطالة الجذور
خس	نمو الرأس إلى الحصاد	السبانخ	جميع المراحل
البازيلاء	الأزهار وتكوين البذور	الفلفل	جميع الأطوار
البصل	نمو الرأس	قمح	الأزهار وتكوين الثمار
الباذنجان	الأزهار وتكوين الثمار	البندورة	الأزهار وتكوين الثمار
الزيتون	قبل الأزهار ومرحلة استطالة الثمار	الخوخ	نمو الثمار
العنب	خلال فترة نمو أو ظهور النموات الجانبية السريعة	موز	جميع الأطوار
حمضيات	الأزهار وتكوين الثمار		

Crop water Requirement, Fao.vo24,1984

جدول رقم (4) يوضح حساسية المحاصيل المختلفة للجفاف

محاصيل عالية الحساسية	محاصيل متوسطة إلى عالية الحساسية	محاصيل قليلة إلى متوسطة الحساسية	محاصيل قليلة الحساسية
موز	فاصولياء، بندورة	حمضيات	ذرة بيضاء
خس	ملفوف	برسيم حجازي	قطن
بطاطا	بصل	بصل	
الخضار الورقية	ذرة صفراء	عباد الشمس	
	فلفل	قمح	

المصدر (مجلة المهندس الزراعي العدد 67، آذار، 2000)

4 . نوعية مياه الري

يمكن اعتبار مياه الري في الأغوار والتي مصدرها الينابيع بأنها جيدة مع بعض الاستثناءات وذلك لان مياه بعض الينابيع تتراوح ملوحتها ما بين 730 و 980 ميكروموز/ سم3. ولذلك لا ينصح باستعمال المياه ذات الملوحة المرتفعة في ري المحاصيل الحساسة للملوحة مثل الفاصولياء، الخس، الفول، البصل والجزر. وتبلغ الملوحة الان بين 1200-1500 PPm (شكارنه 2010) ولا ينصح باستعمال مياه بعض الآبار الواقعة في منطقة الأغوار والتي قد تصل ملوحتها إلى 8090 ميكروموز/ سم3 (سلطة المياه الفلسطينية، 1999) لأغراض الري إلا بعد خلطها بمياه عذبة للتخفيف من درجة ملوحتها. هناك مياه بعض الآبار تصل ملوحتها إلى أكثر من 2250 ميكروموز/ سم3. وهذه تفرض درجة من القيود على استعمالها للري كزراعة المحاصيل التي تتحمل الملوحة ومنها النخيل، القمح والشعير. هذه الآبار تقع في العوجا، الجفتلك. زبيدات مرج نعجة وفي أريحا. ورغم إن محاصيل القمح والشعير تستطيع تحمل الولحة إلا انه يجب الانتباه إلى أن هذه المحاصيل تعتبر حساسة للملوحة في مرحلة النمو الأولى أكثر من المراحل الأخرى لذلك يفضل ريها خلال المرحلة الأولى بمياه ذات ملوحة منخفضة.

تعتبر أشجار الفاكهة من المحاصيل الحساسة للملوحة، لذلك لا ينصح بزراعتها في المناطق التي تروى بمياه مالحة أو

1. أطوال أنابيب الري في الحقل = مساحة الأرض المراد ريها ÷ المسافة بين خطوط الزراعة .
2. عدد النقاطات (العيون) اللازمة = مجموع أطوال أنابيب الري في الحقل ÷ المسافة بين النقاطة والتي تليها .
3. كمية المياه المزودة للحقل في الساعة = عدد النقاطات في الحقل ÷ المسافة بين النقاطة والتي تليها .
4. عدد ساعات الري في اليوم = كمية المياه التي يحتاجها النبات في اليوم (م3) لوحدة المساحة ÷ كمية المياه التي يمكن تزويدها لوحدة المساحة في الساعة .

الظواهر الناجمة عن عدم انتظام الري في بعض الخضروات .

جدول رقم 2 يبين بعض الظواهر الناجمة عن عدم انتظام مواعيد الري أو زيادة أو نقصان كمية مياه الري في بعض الخضروات المروية .

جدول رقم (2) الظواهر الناجمة عن عدم انتظام مواعيد الري وكمية مياه الري المضافة لبعض الخضروات المروية

الظاهرة	السبب
صغر حجم جذور الجزر وتخشبها	قلة الري
تشقق وتشوه جذور الجزر	عدم انتظام الري
تشقق الرؤوس في الملفوف	زيادة الري
نموات إضافية في البطاطا	عدم انتظام الري
تكوين رؤوس بصل مبكرة	عدم انتظام الري
تشقق الثمار في البندورة	كثرة الري بعد فترة جفاف طويلة
تعفن الطرف الزهري في البندورة	قلة الري
الطعم الحار في اللفت	قلة الري
تفلق جذور الشمندر	كثرة الري بعد فترة جفاف طويلة
تأخر موعد النضج في البطيخ	زيادة الري
تشويه شكل الرؤوس في الثوم ونمو الفصوص قبل اكتمال نموها وتكوينها	عدم انتظام الري

المصدر (أريج، 1999)

4.3 . بعض النصائح الخاصة بجدولة مواعيد الري

ينصح بإتباع برنامج لمواعيد الري يعتمد على قياس المحتوى المائي للتربية باستخدام أجهزة التنشيوميتر . وكذلك ينصح زيادة المدة بين الريات في أشجار الفاكهة إذا وصلت الثمار إلى حجمها الطبيعي لان ذلك يساعد على نضج الثمار بالتساوي . وينصح مقاربة المدة بين الريات في المحاصيل الورقية (الملفوف، الخس، السبانخ، . . . . الخ) لان هذه المحاصيل ذات مجموع جذري سطحي وتحتاج إلى توفر المياه في التربة بشكل مستمر . علما بأنه ينصح ري المحاصيل في ساعات المساء أو الصباح الباكر وذلك لتقليل الفقد الناتج من التبخر والنتح . ويفضل عند الري باستخدام الرشاشات أن يكون وقت الري في الصباح الباكر عندما تكون الرياح ساكنة . وتزويد النباتات باحتياجاتها من المياه خاصة خلال الفترات التي تعتبر حساسة لنقص المياه (المرحلة الحرجة) (جدول رقم 3) بشكل عام يمكن اعتبار مرحلة الأزهار وتكوين البذور والثمار من أكثر فترات النمو حساسية للجفاف، وذلك بسبب كونها مراحل نمو النبات حاجة للماء . وفي حال عدم توفر مياه كافية لجميع المحاصيل المزروعة، يفضل إعطاء الأولوية في الري للمحاصيل الأكثر حساسية للجفاف وذات القيمة الاقتصادية العالية جدول رقم 4 يوضح حساسية المحاصيل المختلفة للجفاف .

جدول رقم (1) نسبة استخدام أنظمة الري المختلفة في الضفة الغربية

نوع المحصول	الأغوار (%)	المناطق المرتفعة (%)
الخضروات	100	100
الأنظمة الحديثة	99.4	98.5
الأنظمة التقليدية	0.6	1.5
الأشجار المثمرة (الحمضيات وغيرها)	100	100
الأنظمة الحديثة	70	35
الأنظمة التقليدية (الأحواض)	30	65
الموز	100	–
المحاصيل الحقلية والعلفية	100	100
الأنظمة الحديثة	98	100
الأنظمة التقليدية(الغمر)	2	–

المصدر: (أريج، 1998)

3.2 . نقاط عامة يجب أخذها بعين الاعتبار عند تصميم شبكة الري

عند اختيار نظام الري بناءاً على نصيحة المرشدين الزراعيين المختصين، اخذين بعين الاعتبار نوع المحصول ونوع التربة ونوعية مياه الري. وفي المزارع التي يستعمل فيها نظام الري بالرشاشات يجب الأخذ بعين الاعتبار زاوية واتجاه فتحة الرشاشات لتتلاءم مع سرعة واتجاه الرياح السائدة في المنطقة. وكذلك يجب أن يكون هناك تداخل بين مياه الرشاشات بمقدار 25–30% . ويجب التأكد من أن لا يزيد مقدار تصريف أول عين في أنبوب الري عن آخر عين عن 10% في نظام الري بالتنقيط. بالإضافة إلى انه يجب أن لا يزيد مقدار تصريف أول فتحة في خط التوزيع لأنابيب الري عن آخر فتحة لخط التوزيع لآخر أنبوب للري عن 7.5% .

3.3 . كمية مياه الري اللازمة للمحاصيل المروية

كمية مياه الري المثلى اللازمة لمحصول ما، هي تلك الكمية التي يجب إضافتها للمحصول للوصول بالتربة إلى السعة الحقلية في منطقة الجذور. لقد تم تقدير كمية مياه الري التي يجب إضافتها لكل محصول في محافظات الضفة الغربية من خلال استخدام البرنامج المحو سب (CROPWAT) يجب إدخال المعلومات التالية للبرنامج:

المعلومات المناخية وتشمل متوسط كل من درجة الحرارة والرطوبة النسبية وسرعة الرياح وعدد الساعات المشمسة ومعدل سقوط الأمطار في المنطقة (تم الحصول على جزء من المعلومات المناخية من محطات الأرصاد الجوية الموزعة في الضفة الغربية والجزء الآخر تم شراؤه من خدمات الأرصاد الجوية الإسرائيلية للفترة (1969–1993)). وعامل النبات ويشمل نوع النبات ومراحل النمو وفترة حياة النبات. وكذلك العمليات الزراعية وتشمل موعد الزراعة وطريقة الزراعة (النمط الزراعي) وكفاءة نظام الري المستخدم وتصنيف التربة علما بأن كميات المياه المقدرة غير ثابتة حيث أنها تتغير بتغير أي عامل من العوامل السابقة. وفي حالة التربة المالحة أو الري بمياه فيها نسبة من الملوحة يفضل إضافة كمية إضافية من مياه الري من اجل غسل الأملاح بعيدا عن منطقة الجذور. وفي حالة انه اعتبرت كفاءة نظام الري المستخدم 75% لجميع المحاصيل. وقدرت كمية مياه الري اللازمة لأشجار الفاكهة على أن الأشجار مثمرة، يستطيع المزارع تقدير كمية مياه الري اللازمة للحقل بطريقة سهلة من خلال تقدير المحتوى المائي للتربة بأخذ كمية صغيرة من تربة المزرعة في اليد وملاحظة درجة تماسك هذه الكتلة ويمكن أيضا الاستعانة بالمعادلات التالية في حساب كمية المياه اللازمة لري الحقل:

3.2 حدود البحث :

- الحدود الجغرافية : منطقة الأغوار (أريحا ، وقرية العوجا) .
- الحدود البشرية : المزارعين العاملين في القطاع الزراعي .

3 . الزراعة المروية في الضفة الغربية

تتركز الأراضي الزراعية المروية في الضفة الغربية في منطقتين رئيسيتين هما ، وادي الأردن (الأغوار) والمنطقة شبه الساحلية (محافظة جنين ، طولكرم قلقيلية) حيث تمثل مساحة هذه المناطق حوالي 89% من مجموع مساحة الأراضي المروية في الضفة الغربية . وتبلغ مساحة الأراضي المروية في الضفة الغربية 108852 دونماً (دائرة الإحصاء الفلسطينية ، 1999)، وهذه تشكل حوالي 6.5% من مجموع الأراضي المزروعة في الضفة الغربية ، ولا تتجاوز الان اكثر من 55.000 دونم (Paltrade، 2009)). تحتل الخضراوات الجزء الأكبر من المساحة المروية حيث تشكل حوالي 63%، تليها مساحة أشجار الفاكهة حيث تشكل 28% وتحتل المحاصيل والعلفية 9% من مجموع المساحة المروية (معهد الأبحاث التطبيقية ، 2001) .

تعتمد الزراعة المروية في الضفة الغربية على مياه الآبار الجوفية ومياه الينابيع . تقدر كمية المياه المستخدمة سنوياً لري المساحة المروية بحوالي 84.8 مليون م3 وهذه الكمية لا تكفي لسد احتياجات المساحة المروية الحالية . حيث تبلغ الاحتياجات المائية المثلى لهذه المساحة 116.2 مليون م3 (سلطة المياه الفلسطينية ، 2009) . من جهة أخرى ، فقد تبين أن بعض المزارعين يقومون بإضافة كمية من مياه الري أكبر مما يحتاجه المحصول ، الأمر الذي قد يؤثر سلبياً على نمو النبات علاوة على ما يسببه من رفع تكلفة المياه . وهذا يعود إلى اعتماد المزارع على خبراته الذاتية في تقدير كمية مياه الري . لذلك كان من الضروري القيام بعمل نشرة إرشادية تهدف إلى تعظيم الإنتاج الزراعي في قطاع الزراعة المروية من خلال الإدارة الجيدة لمياه الري . (وزارة الزراعة الفلسطينية ، ومعهد الأبحاث التطبيقية- القدس ، 2001) .

1.3 أنظمة الري المستخدمة في الضفة الغربية

يمكن تقسيم أنظمة الري السائدة في المناطق المروية في الضفة الغربية إلى الأنظمة القديمة وتشمل الري السطحي بواسطة الاثلام والأحواض والغمر ، والأنظمة الحديثة وتشمل الري بواسطة الرشاشات والتنقيط . إن الري بواسطة الأنظمة القديمة يؤدي إلى فقدان كميات كبيرة من مياه الري من خلال التبخر أو تسرب كمية من المياه إلى الأسفل بعيدا عن منطقة الجذور إن من الجريان السطحي . إن كفاءة الري بواسطة الأنظمة القديمة لا تتجاوز في أحسن الظروف 50% (أبو نزهة ، 2006)

أما كفاءة أنظمة الري الحديثة فإنها مرتفعة مقارنة بالأنظمة القديمة ، حيث تصل كفاءة الري بواسطة الرشاشات إلى حوالي 70% ، وبواسطة التنقيط تتجاوز 85% . من هنا نجد أن الري بواسطة الأنظمة الحديثة يوفر على الأقل 25-35% من مياه الري . وبذلك يمكننا زيادة الرقعة الزراعية المروية هذا علاوة على تخفيض تكاليف الإنتاج وما يتحقق من زيادة في إنتاجية المحصول وتحسين نوعية الإنتاج . جدول رقم (1) يبين نسبة استخدام أنظمة الري المختلفة في الضفة الغربية حسب النمط الزراعي . يعتمد اختيار نظام الري على عدة عوامل منها ، نوع المحصول وخواص التربة ودرجة انحدارها ودرجة ملوحتها ، والعوامل الجوية السائدة ونوعية مياه الري . لذلك يجب على المزارع استشارة المختصين عند اختيار نظام الري .

شأنه شان كافة القطاعات، يواجه تحديا مائيا حقيقيا وبما أن محافظة الأغوار ومن ضمنها منطقة (أريحا والعوجا) من أهم المناطق الزراعية الفلسطينية، حيث تعتبر سلة الغذاء الفلسطيني بما تزرع من الخضار المروية والأصناف التي لا تتوفر في غيرها من المناطق الفلسطينية الأخرى كالنخيل والموز، فإنها بالطبع تواجه تحديات كبيرة. وإذا أخذنا بعين الاعتبار الانخفاض الحاد في معدل تدفق عين العوجا، المصدر الرئيس للمياه الزراعية في المنطقة وان معدل تساقط الأمطار في المنطقة لا يتجاوز (150) مم، فانه يمكن وبيسر توقع حجم الأزمة التي تعيشها منطقة الأغوار (أريحا والعوجا) في مجال المياه على المستوى الزراعي. (PHG، 2007).

وتعتبر الأراضي الفلسطينية من المناطق القاحلة وشبه القاحلة وبخاصة الأجزاء الجنوبية والشرقية من الضفة الغربية وقطاع غزة. ويبلغ متوسط هطول الأمطار في شمال الضفة الغربية حوالي 550 – 600 ملم في حين أنها تصل في المناطق الجنوبية إلى 150 ملم. ويصل متوسط سقوط الأمطار في المناطق الجبلية الغربية حوالي 650 ملم. وتأخذ بالنقصان لتصل إلى حوالي 150 ملم في وادي الأردن. كما وان الإدارة السليمة للموارد المائية هي أساس التنمية المستدامة لقطاع الزراعة بشكل عام والزراعة المروية بشكل خاص. وذلك من خلال رفع كفاءة استخدام مياه الري، بهدف تعظيم العائد من استخدام وحدة الأرض والمياه. مع التأكيد على ضرورة اختيار المحاصيل الزراعية الملائمة لنوعية وكمية المياه. المتوفرة والمستخدمة في الري . والاهتمام في بعض الطرق المستخدمة في صيانة أنظمة وأجهزة الري. لتعود الفائدة على المزارعين العاملين في قطاع الزراعة المروية (معهد الأبحاث التطبيقية، 2001).

2. أهمية البحث

- يعتبر البحث توثيق علمي لإظهار تأثير الجفاف على القطاع الزراعي بشكل عام والزراعة المروية بشكل خاص.
- يمكن أن يمثل هذا البحث أساسا سليما للتخطيط نحو المساعدة على التعامل مع الأزمة المائية وأثاراها على القطاع الزراعي.

1.2 أهداف البحث

- الهدف الرئيسي هو التعرف على انعكاسات تأثيرات الأزمة المائية (الجفاف) في منطقة الأغوار على القطاع الزراعي بشكل عام والزراعة المروية بشكل خاص الأغوار.
- التعرف على الوسائل والطرق الممكنة لمواجهة خطر الجفاف وتأثيره على مختلف المجالات (الاقتصادية، الاجتماعية، الإنتاج الزراعي).
- بيان أهمية الدور الحكومي والأهلي والدولي في مواجهة الجفاف.

2.2 منهجية البحث

اعتمد البحث المنهج الوصفي، من خلال جمع البيانات المتوفرة لدى وزارة الزراعة والمؤسسات العاملة في القطاع الزراعي، بالإضافة إلى الأدبيات ذات العلاقة، وبالاستناد إلى نتائج البحث سيتم استخلاص الاستنتاجات التي بدورها ستبني عليها التوصيات والمقترحات.

تأثير الجفاف في منطقة الأغوار على الزراعة المروية

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ملخص

تتركز الأراضي الزراعية المروية في الضفة الغربية في منطقتين رئيسيتين هما وادي الأردن (الأغوار) والمنطقة شبه الساحلية (محافظات جنين، طولكرم، قلقيلية) حيث تمثل مساحة هذه المناطق حوالي 89% من مجموع مساحة الأراضي المروية في الضفة الغربية وهي تشكل حوالي 5،6% من مجموع الأراضي المزروعة في الضفة الغربية.

تعتمد الزراعة المروية في الضفة الغربية على مياه الآبار الجوفية ومياه الينابيع، وتقدر كمية المياه المستخدمة سنوية لري المساحة المروية بحوالي 8،84 مليون متر مكعب وهذه الكمية لا تكفي لسد احتياجات المساحة الزراعية المروية، حيث تبلغ الاحتياجات المائية المثلى لهذه المساحة حوالي 120 مليون متر مكعب. تعتبر الأراضي الفلسطينية من المناطق الجافة وشبه الجافة وبخاصة الأجزاء الجنوبية والشرقية من الضفة الغربية.

يبلغ هطول الأمطار في شمال الضفة الغربية حوالي 550 – 600 ملم في حين تصل في المناطق الجنوبية (الأغوار) إلى 150 ملم، وعليه يعتبر القطاع الزراعي الأكثر تضررا من الجفاف، ومن المعروف أن حوالي (37%) من السكان يعتمدون على الزراعة في دخلهم لذلك سيكون للجفاف تأثيرا سلبيا على القطاع الزراعي.

سيتم العمل في هذه الورقة العلمية البحثية على بيان مدى تأثير الجفاف في منطقة الأغوار على الزراعة المروية مع التزايد المستمر للطلب على المياه وزيادة حدة الجفاف والانخفاض الحاد في توفير كميات المياه اللازمة للزراعة المروية ولا سيما مياه الينابيع والمياه الجوفية ومياه الآبار بالإضافة إلى تسليط الأضواء على مشكلة العجز المائي في فلسطين وما يترتب عليها من آثار مدمرة تنعكس سلباً على التنمية الزراعية والاجتماعية والاقتصادية، على أمل الخروج بالتوصيات للتقليل من الآثار السلبية لظاهرة الجفاف في هذه المنطقة واتخاذ التدابير ووضع الخطط المبنية على أسس علمية للتعامل مع أزمة المياه والبحث عن حلول وأساليب لمواجهة هذه التأثيرات والحد منها مما سيؤدي إلى دعم وتنمية القطاع الزراعي في فلسطين.

1. مقدمة

يشكل الماء مع الهواء أهم العناصر التي تحتاجها الكائنات الحية لتعيش، والماء هو عصب الحياة والوجود، وتعتبر المشاكل والتحديات التي تواجه قطاع المياه من أهم المشاكل التي تواجه العالم عموما ومنطقة الشرق الأوسط ومنها فلسطين على وجه الخصوص. وتعاني فلسطين من نقص حاد في المياه، كنتيجة للمناخ الجاف وشبه الجاف وللسيطرة الإسرائيلية على معظم مصادر المياه في الضفة الغربية وغزة، في ظل زيادة مطردة في عدد السكان، مما يخلف آثار سلبية كبيرة على الاقتصاد الوطني عموما وعلى القطاع الزراعي، الذي تزداد احتياجاته المائية باستمرار. (اتحاد لجان العمل الزراعي، 2009) ونتيجة لهذه المحدودية للمياه ومصادرها على المستوى الفلسطيني، فان القطاع الزراعي، يمثل العصب الرئيس للاقتصاد الفلسطيني.

وقد كان توجه المزارعين المستهدفين لتطوير المعرفة والعلوم الزراعية لديهم حيث تم طرح عدة مواضيع للتدريب عليها من قبل المزارعين لمواكبة العلوم الزراعية المتطورة وتطبيق التكنولوجيا الحديثة والتي تعمل على التوسع الرأسي للزراعة الحديثة عوضا عن التوسع الأفقي المحدود في مناطقنا الزراعية و مواجهة بالعوائق والظروف السياسية المحيطة، وقد كانت الرغبة من المزارعين المستهدفين بالتدريب 32% من المزارعين المستهدفين يريدون التدريب على أمراض النبات ووقايته و 26% يريدون التدريب على أدارة المزرعة بشكل عام و 12% فقط يريدون التدرب على الري وأساليب الري ومعرفة تحديد كمية ووقت الري للمحاصيل وكانت 30% من المزارعين تؤيد دورات التدريب على إدارة المزرعة، ’مراض النبات والوقاية والري.

5. المراجع

غازي الصوراني، دراسة أولية «المسألة الزراعية والمياه والثروة الحيوانية والصيد في الضفة الغربية وقطاع غزة» يناير 2006. صفحة 3. http: //www. ahewar. org /debat /files /85784. pdf

الجهاز المركزي للإحصاء الفلسطيني تقرير إحصاءات المياه في الأراضي الفلسطينية-التقرير السنوي2007.

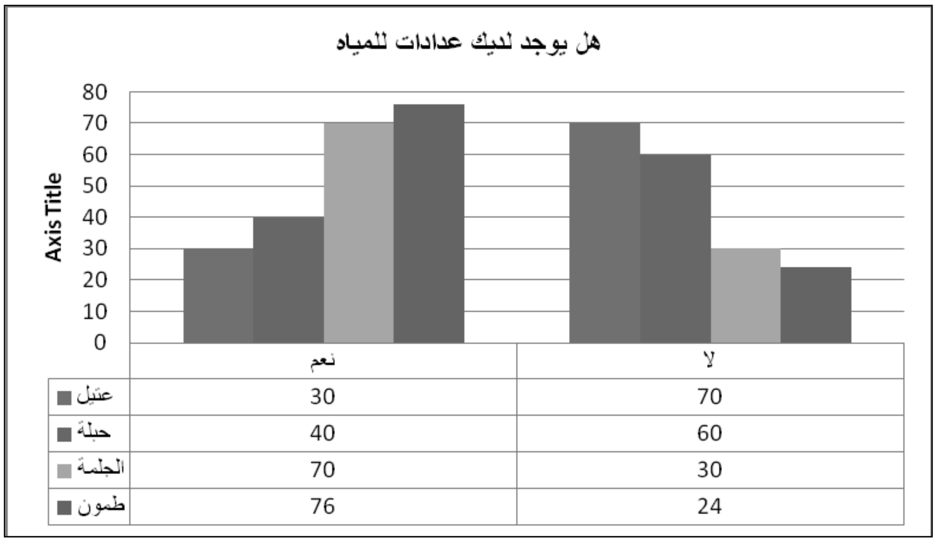
المصدر: تقرير حول واقع المياه في الأراضي الفلسطينية، مركز المعلومات الإسرائيلي لحقوق الإنسان في الأراضي الفلسطينية 2007.

Freijat, F., (2003). Impact of Israeli Settlements on Palestinian Water Resources, chapter five, found in Daibes, F. (Editor) Water in Palestine, Problems-Politics-Prospects, PASSIA-Jerusalem, October 2003.

http://www.palestinehistory.com/arabic/sights/images/maps_pal1.jpg

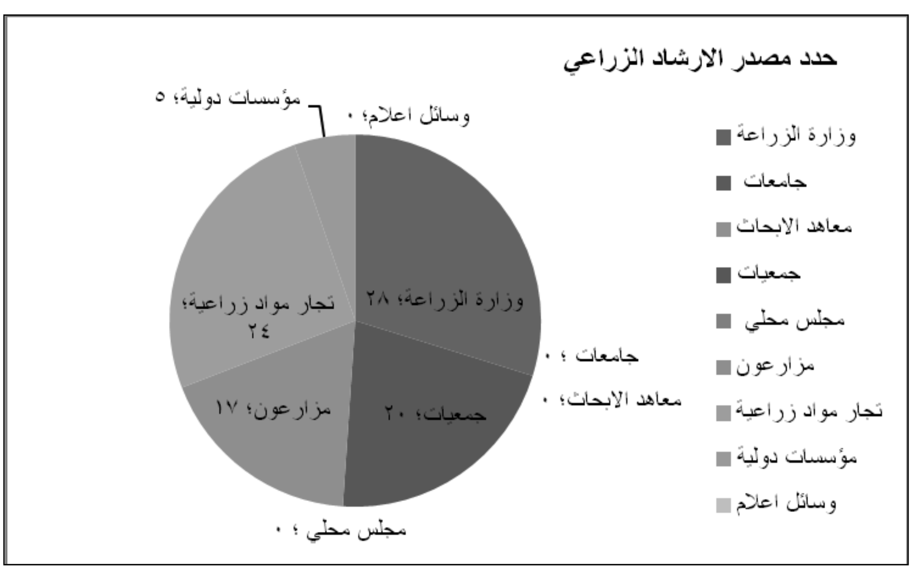
PHG: Water Monitoring Report in Palestine 2006. Ramallah – Palestine.

تعتبر النسب متقاربة و متشابهة في المناطق الأربعة المستهدفة من البحث . ، وكانت نسبة المزارعين الذين يستخدمون عدادات لحساب كمية الري المضافة تصل الى 60-70% في كل من منطقة طمون والجلمة و 30-40% في كل من منطقة حبلة وعتيل وهذا يظهر تدني الوعي لدى المزارعين في منطقتي حبلة وعتيل لحساب كميات المياه المستخدمة والمضافة للمحصول كما هو موضح في الشكل (16) .



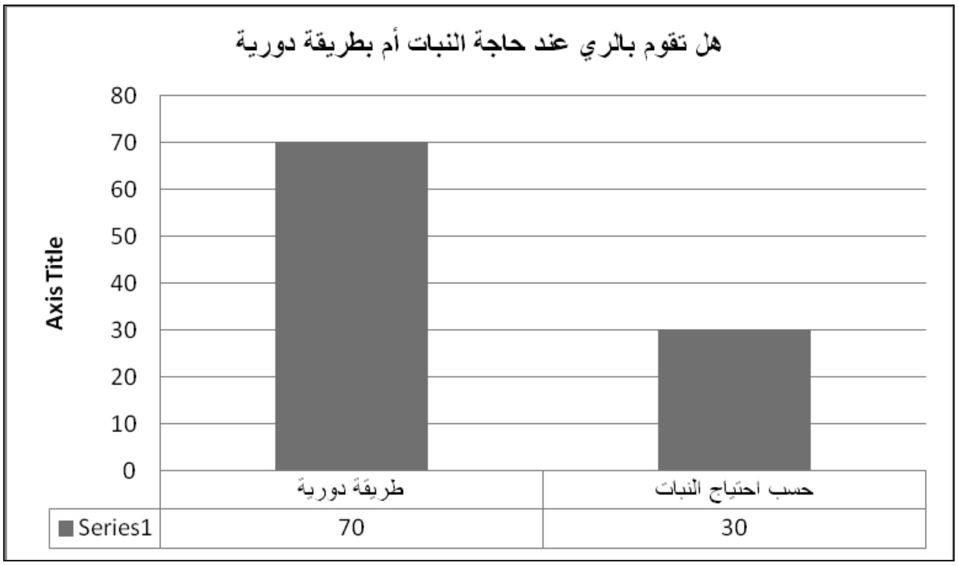
الشكل 16 . يوضح نسبة حيازة المزارعين المستهدفين من الدراسة لعدادات المياه

وبناء على ذلك فقد أشارت الإحصائيات الى تدني مصادر الإرشاد الزراعي كما هو في شكل (17) والمتخصصة في موضوع المياه والري للمحاصيل حيث كانت نسبة مصدر الإرشاد الزراعي من قبل وزارة الزراعة الفلسطينية للمزارعين في مناطق البحث 28% و كانت 24% شركات تجارة المواد الزراعية و 20% من خلال الجمعيات التعاونية الزراعية و 18% من خلال الزارعين المثقفين والمدربين في عمليات الري .



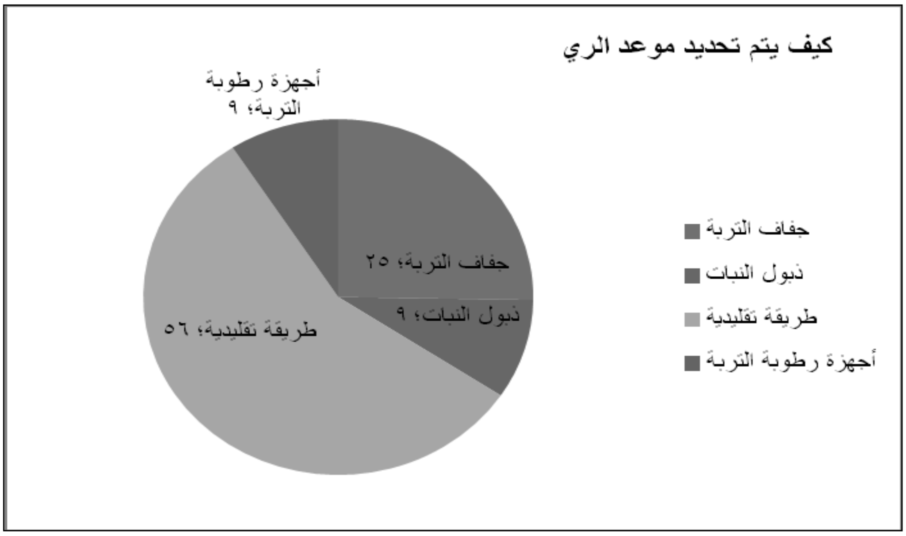
الشكل 17 . يوضح نسبة الإرشاد الزراعي من ذوي الاختصاص للمزارعين المستهدفين من الدراسة

من خلال مناقشة النتائج السابقة والخاصة بسعر المياه وتحديد موعد الري أشار المزارعين في مناطق الدراسة بنسبة 64% لا تتلقى معلومات لمواعيد وكميات الري في الزراعات المحمية من قبل الجهات العاملة في القطاع الزراعي بينما كانت نسبة 36% يتلقون معلومات بخصوص الري من ناحية الكمية ومعدل الري ، وعلى ذلك كانت نسبة70% من المزارعين المستهدفين من البحث تقوم بطرقة دورية في ري المحصول ولا يوجد هناك تفاوت أو فارق بين مناطق البحث في نسبة الري بطريقة دورية للمحصول بينما كانت نسبة 30% فقط من المزارعين تقوم بعملية ري المزروعات عند احتياج النبات .



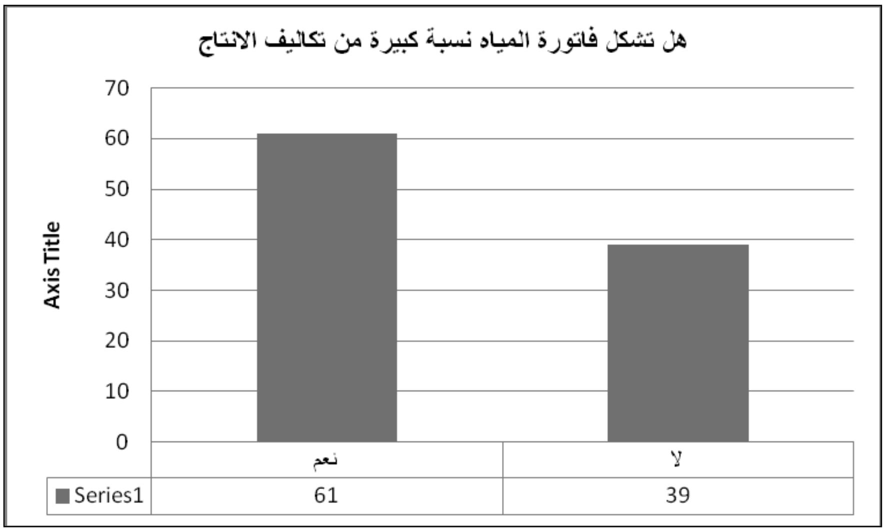
الشكل 14 . يوضح طريقة الري هل هي على أسس علمية أم تقليدية

وعن سؤال الزارعين حول كيفية تحديد موعد الري وجد أن النسبة الأعلى والتي تشكل 56% بطريقة تقليدية وكانت سائدة في مناطق البحث المختلفة كما هو موضح في الشكل (15) بينما كانت نسبة 25% تأخذ جفاف التربة مقياسا لتحديد موعد الري ونسبة 10% تأخذ النبات كمؤشر لعملية الري و نسبة 9% فقط تعتمد على أجهزة محددة لقياس الرطوبة في التربة وهي النسبة الأدنى بين المزارعين



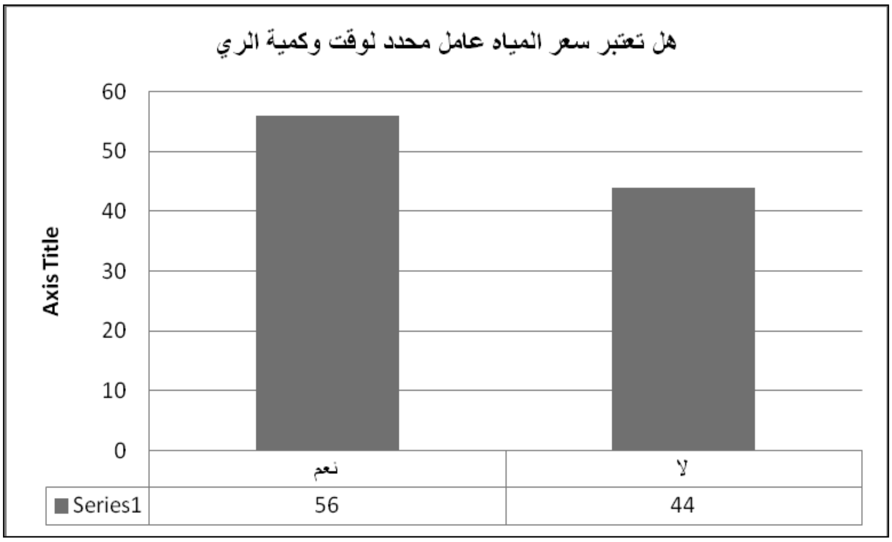
الشكل 15 . يوضح تحديد موعد الري عند المزارعين المستهدفين من الدراسة

وقد كانت نسبة حوالي 70% من المزارعين المستهدفين من البحث أن فاتورة المياه تشكل نسبة كبيرة من تكاليف الإنتاج بينما أشارت نسبة 30% أن فاتورة المياه لا تشكل نسبة عالية من تكاليف الإنتاج كما كان هذا واضحا بين المزارعين المستهدفين في منطقة عتيل ويوضح الشكل رقم (12) توزيع المناطق المستهدفة من البحث.



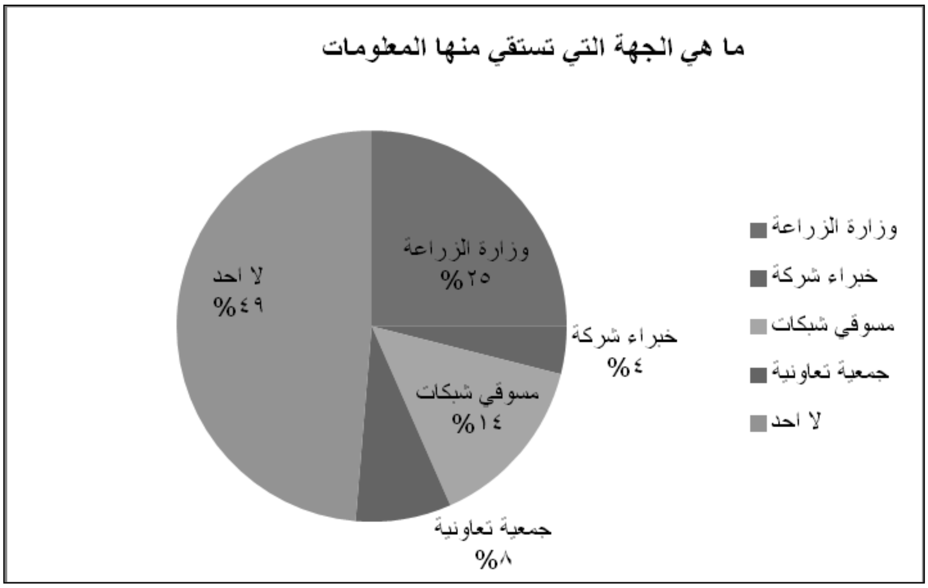
الشكل 12 . يوضح تشكيل فاتورة المياه نسبة كبيرة من تكاليف الإنتاج

وبناء على محدودية المياه لدى المزارعين المستهدفين من البحث فقد أجاب نسبة 56% من المزارعين بأنه يعتبر سعر المياه عامل مؤثر ومحدد لوقت وكمية المياه وقد كان هذا واضحا في منطقة حبلة والجلمة وطمون وعلى العكس من ذلك كانت نسبة 44% من المزارعين المستهدفين من البحث لا ترى أن سعر المياه عامل محدد لوقت وكمية الري كما كان واضحا في منطقة عتيل، ، وقد وجد أن نسبة 75% من المزارعين المستهدفين من البحث يعتبرون سعر المياه عامل محدد لوقت وكمية الري في كل من منطقة حبلة ومنطقة الجلمة ومنطقة طمون على العكس من منطقة عتيل حيث كانت نسبة 25% من المزارعين لا تعتبر أن سعر المياه عامل محدد لوقت وكمية الري كما كان في منطقة عتيل. ويوضح الشكل رقم (13).



الشكل 13 . سعر المياه هل هو عامل محدد لوقت وكمية الري

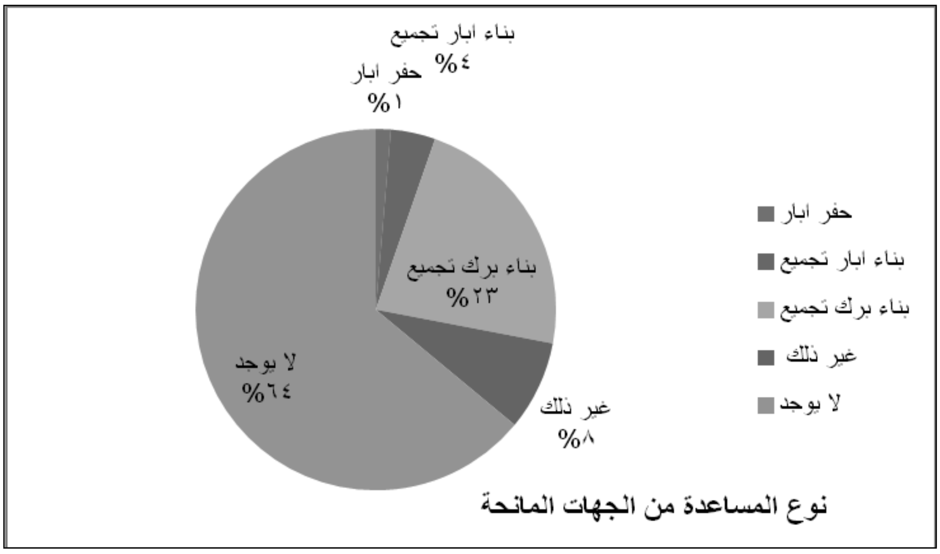
الأسس العلمية للزراعة المحمية للتعامل مع التربة والنبات و الماء وتمكين المزارع من مواكبة التطورات الزراعية التكنولوجية .



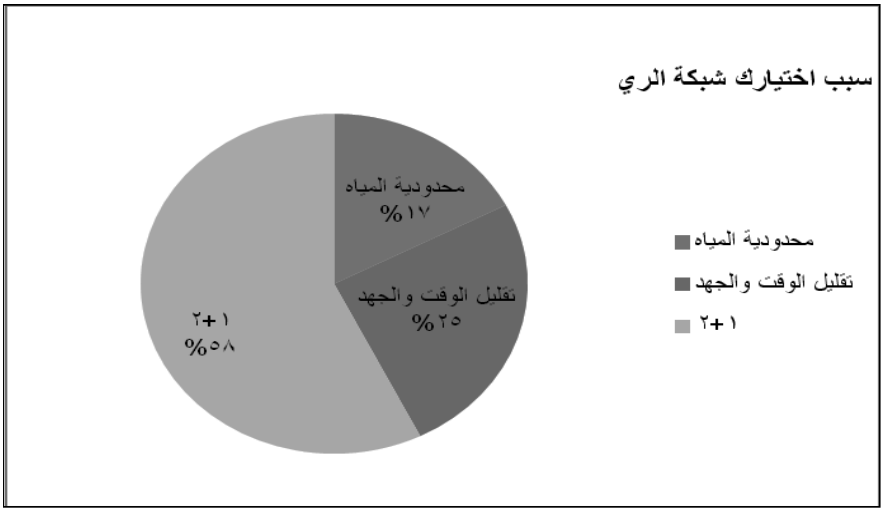
الشكل 10 . يوضح نسبة تلقي المزارع للمعلومات من خلال جهات الاختصاص

وعلى صعيد المساعدات لتطوير مصادر المياه المقدمة للمزارعين المستهدفين في مناطق البحث كانت النسبة الأكبر حوالي 65% لم تتلقى مساعدات لتطوير مصادر المياه و حوالي 35% تلقت مساعدات بسيطة من جهات متعددة ويوضح الشكل (11) نسبة تلقي المزارعين مساعدات خارجية من جهات مانحة في المناطق المستهدفة من البحث .

وعن السؤال عن نوع المساعدات الخارجية من الجهات المانحة والمتعددة لتطوير مصادر المياه فقد كانت نسبة نوع المساعدة 23% بناء برك تجميع ، 8% مساعدات عينية ، 4% بناء آبار تجميع و 1% حفر آبار وشكلت نسبة 64% عدم تلقي أي مساعدات من حيث بناء آبار ، برك تجميع أو هبات مساندة للمزارعين . نوع المساعدات المقدمة من الجهات المانحة .

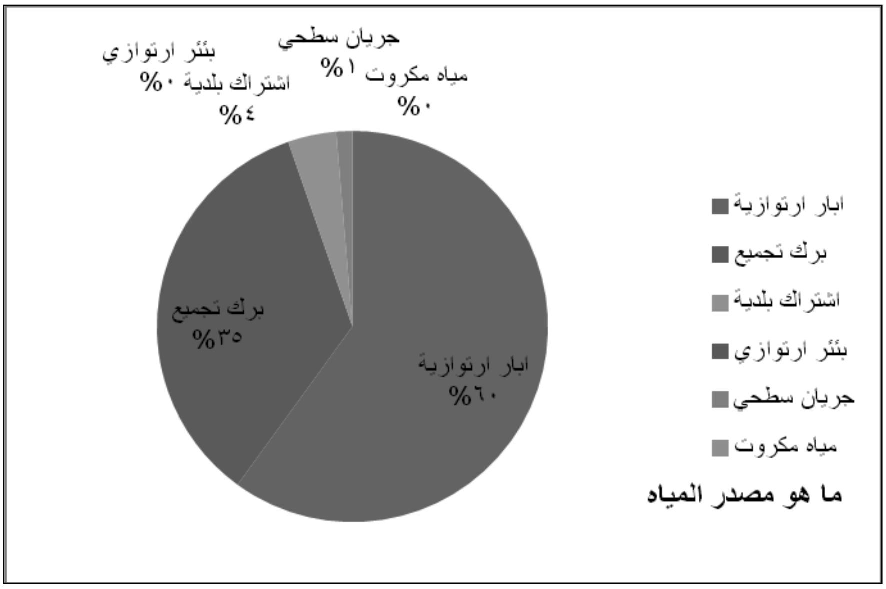


الشكل 11 . يوضح نسبة نوع المساعدات المقدمة للمزارعين المستهدفين من الدراسة



الشكل 8. يوضح سبب اختيار شبكة الري في مناطق الدراسة

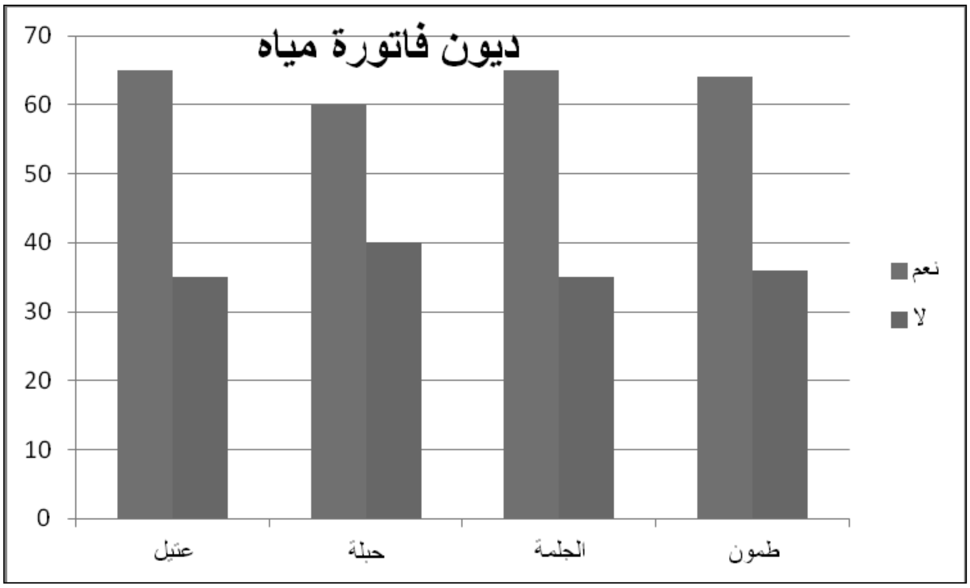
أما عن سؤال المزارعين عن مصادر المياه المتوفرة والتي يستعملها المزارع فقد كانت النسبة الأعلى 60% وهو مصدر آبار ارتوازية ، 35% برك تجميع ، 4% اشتراك بلدية و 1% جريان سطحي كما هو موضح بالشكل (9) ، إضافة إلى ذلك فقد تم التطرق إلى مصدر المعلومات عن الري والكميات المحددة للري ومواعيد الري للمحاصيل ، وجد أن الجهة 49% من المزارعين المستهدفين لا يأخذون أي معلومة من أحد ، 25% يأخذون المعلومات من وزارة الزراعة ، 14% يتلقون المعلومات من مسوقي الشبكات والمحللات التجارية ، 8 % يأخذون معلوماتهم من الجمعيات التعاونية و 4% من خبراء الشركات.



الشكل 9. يوضح مصادر المياه للمزارعين المستهدفين من الدراسة

وقد وجد أن نسبة 45% من المزارعين المستهدفين يعملون بخبرة مكتسبة من العمل دون أي مؤهل علمي ، 38% كانت بتوارث عن الآباء والنسبة الأقل وتشكل 17% التي تلقت تدريب عملي من قبل جهات معينة والتي تمكن المزارع الفلسطيني من معرفة

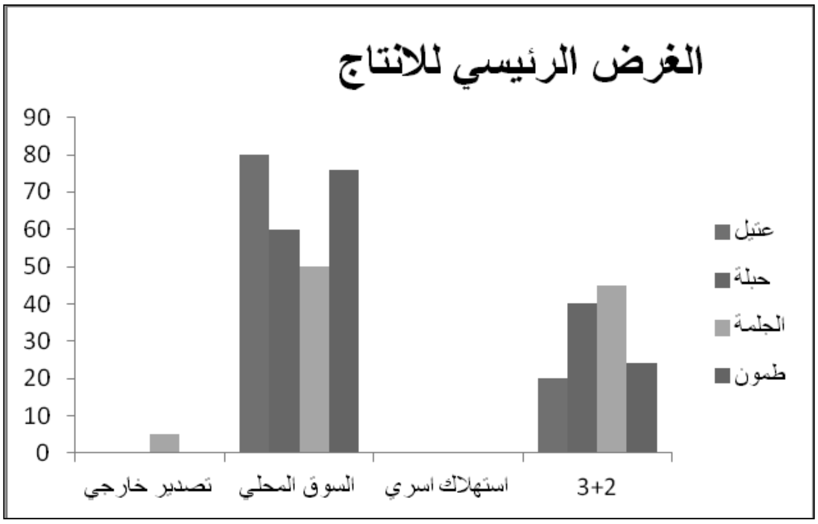
بعد الاطلاع على ما ذكر من نتائج حول التحصيل العلمي للمزارعين، ملكية المزارع، أنواع الزراعة ،الهدف من الإنتاج الزراعي وأكثر المحاصيل زراعة لدى المزارعين في المناطق الأربعة المستهدفة من البحث نتجه الى عرض مفصل لهدف وغرض من البحث حول المياه واستخدامات المياه في الزراعة المحمية، وبالسؤال حول ديون فاتورة المياه وجد أن النسبة الأعلى للمزارعين ذات مديونية للمياه حيث شكلت نسبة المديونية ما يقارب 65% من المزاعين مقارنة ، 35% من المزارعين لا يترتب عليهم ديون من فاتورة المياه، ويوضح شكل (7) التوزيع للمدن المستهدفة من البحث . وقد وجد أيضا أن معظم المزارعين المستهدفين من البحث يستخدمون طريقة الري بالتنقيط، حيث شكلت النسب الأعلى من الدراسة 87% من المزارعين يستخدمون طريقة الري بالتنقيط ، 10% يستخدمون الري بالرشاشات و 3% يستخدمون الري السطحي في بعض الزراعات لديهم.



الشكل 7 . يوضح ديون فاتورة المياه للمزارعين المستهدفين من الدراسة

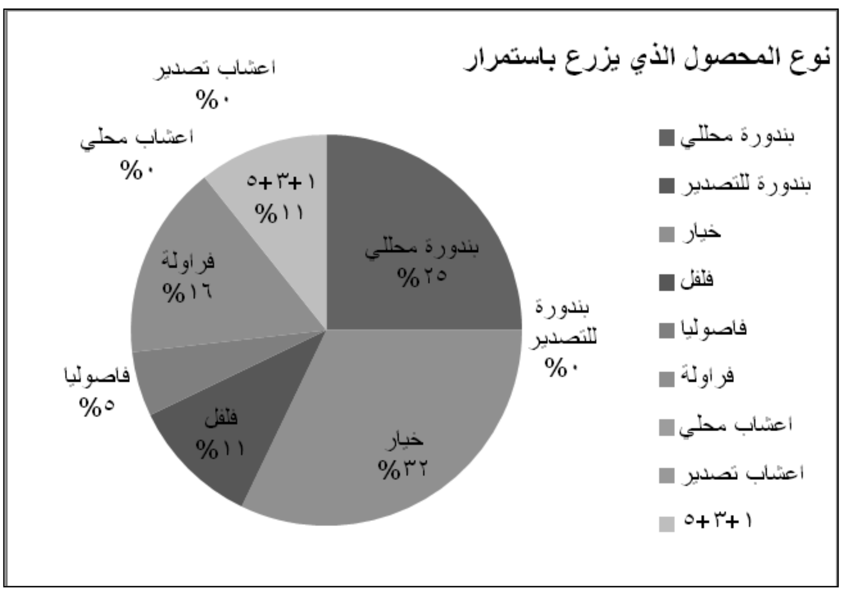
وعن سؤال المزارعين حول سبب اختيار شبكة الري وما هو الهدف من اختيارها وجد أن 25% من المزارعين المستهدفين لتقليل الجهد في عملية الزراعة و 17% لمحدودية المياه وأن النسبة الأكبر والتي شكلت 58% من المزارعين المستهدفين عزت الأمر الى تقليل الوقت والجهد و محدودية المياه بشكل عام ومن ذلك نجد أن نسبة محدودية المياه تصل بين المزارعين المستهدفين الى 75% مقارنة 25% من المزارعين الذين لا يعانون من محدودية المياه.

أظهرت النتائج أن الغرض الرئيسي من الإنتاج 68% للبيع في السوق المحلي و 31% للبيع في السوق المحلي بالإضافة للاستهلاك الأسري و وجد أن 1% فقط ممن شملتهم الاستبيان يزرع للتصدير الخارجي كما هو موضح في شكل رقم (5)، وهذا مؤشر يدل على قلة تصدير المنتجات الزراعية وذلك للممارسات الإسرائيلية من عراقيل وتنكيل وإغلاق طرق مما يؤدي الى التقليل من إمكانية تصدير هذه المنتجات الزراعية.

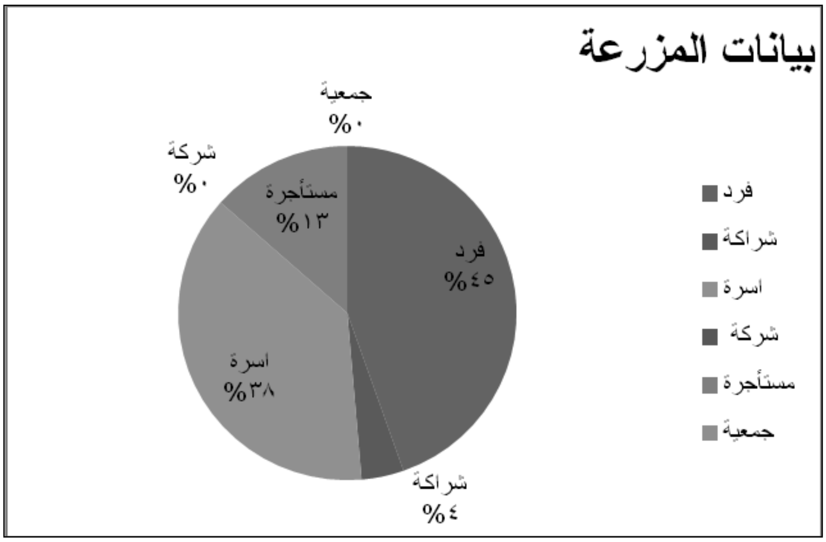


الشكل 5. يوضح نسبة الغرض الرئيسي للإنتاج من مناطق الدراسة

وعن سؤال المزارعين حول الزراعات المفضلة لهم والتي تزرع باستمرار في المناطق الأربعة المستهدفة من البحث كما هو في شكل رقم(6) وجد أن زراعات معظم المزارعين كانت تتركز حول محاصيل معينة حددت 25% محصول البندورة، 32% الخيار، 16% فراولة و 11% فلفل وكانت مجموعة من المزارعين تشكل نسبة 11% تقوم بزراعة الأعشاب والتي يتم استخدامها للسوق المحلي، و كانت 5% من المزارعين تعمل على زراعة الفاصوليا.



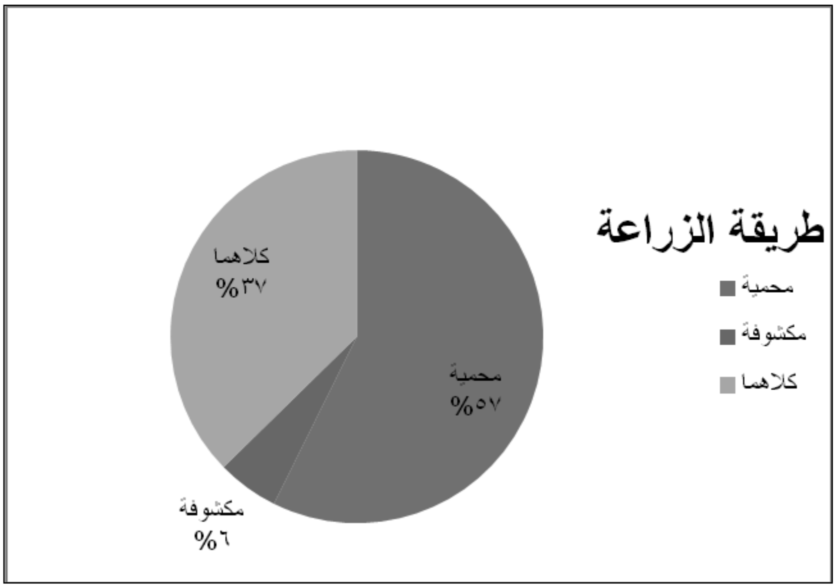
الشكل 6. يوضح نسبة نوع الحصول الذي يزرع باستمرار في مناطق الدراسة



الشكل 3 . يوضح نسبة حيازة الأراضي للمزارعين المستهدفين من الدراسة

وقد وجد أن نسبة المزارعين الذين يعملون بالزراعة بشكل أساسي وليست عملا جزئيا ما يزيد عن 85% بينما كانت نسبة المزارعين الذين يعملون في الزراعة كعمل ثانوي ما يقارب 15% وهذا يدل على توجه المزارعين للعناية بأرضهم واعتماد غالبية السكان على العمل بالزراعة نتيجة قلة فرص العمل المتاحة والمتوفرة.

وبالإشارة إلى طريقة الزراعة للمزارعين المستهدفين من الاستبيان فكانت 58% زراعة محمية و 37% من المزارعين يمارسون الزراعة المحمية والمكشوفة و 5% يعملون في الزراعة المكشوفة فقط كما هو موضح بالشكل رقم (4). وبذلك مؤشر يدل على توجه المزارعين للزراعة المحمية والتي تعتمد على التكنولوجيا الزراعية الحديثة والتي تعمل على زيادة الإنتاج بطريقة أكبر من الزراعة التقليدية.

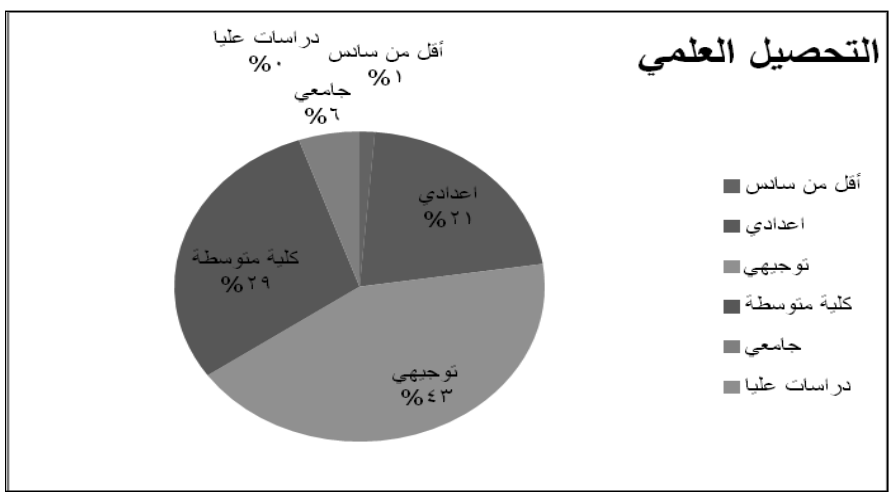


الشكل 4 . يوضح طرق الزراعة التي يتبعهما المزارعين المستهدفين من الدراسة

- سوف تنعكس نتائج هذه الدراسة على واقع المزارعين في المناطق المستهدفة من البحث من حيث تقنين كميات الري وتوفير أثمان المياه التي تهدر بدون جدوى الأمر الذي يعطي المزارعين.

4. النتائج

دراسة النتائج في المناطق المستهدفة من البحث يتضح أن المزارعين الذين استهدفهم البحث حاصلين على 1% ابتدائي ، 21 % التعليم الإعدادي ، 43% شهادة الثانوية العامة، 29% كلية متوسطة و 6% خريج جامعي، وهذا يمكنهم من فهم واستيعاب الأساليب والتقنيات الحديثة في أساليب الري المختلفة والاستجابة للمتغيرات الجديدة في طرق الري من ناحية الكمية واختيار وقت الري المناسب في الزراعة الحديثة وتقبل الإرشاد ونتائج البحوث الزراعية التطبيقية. وتوضح النتائج أيضًا أن المستوى التعليمي للمزارعين هو في حالة جيدة جيدة، حيث وصل نسبة عدد المزارعين المؤهلين فوق مستوى المرحلة الثانوية حوالي 78 % من إجمالي عدد مزارعي الدراسة، بينما تصل نسبة المؤهلين بالمستوى الإعدادي وما دون 22% . وتشير هذه النتائج إلى قلة الأمية وارتفاع فئة المتعلمين في وسط المزارعين. هذه الخصائص توفر القابلية والاستجابة إلى فهم المعلومات الفنية الجديدة بسهولة والقدرة على استيعاب وتعلم التقنيات الزراعية الحديثة والأساليب الجديدة في عملية الري في الوقت المحدد وكمية الري اللازم إعطاؤها للمحصول والتي تعود بالنفع علي المزارع وعلي مزرعته علي المدى الطويل، من حيث الحد من هدر المياه الزائد في ري المحاصيل وتكميم هذه الكمية للحد من هدر مصادر المياه وتقليل تكاليف الإنتاج من حيث تقليل كميات المياه المستخدمة في الري والذي ينعكس عنه تقليل كلفة فاتورة المياه كما هو موضح في شكل رقم (2).



الشكل 2. يوضح نسبة التحصيل العلمي للمزارعين المستهدفين من الدراسة

أظهرت النتائج أن أغلب المزارعين من الذين شملهم الاستبيان مالكين للمزارع حيث أن 45% يملكها فرد، 38% تملكها أسرة و 13% يعملون في مزارع مستأجرة و 4% يعملون كشركاء في المزرعة بينما لم يكن هناك أي شيء في مزارع تعاونية أو شركات كما هو موضح في شكل رقم (3).

زراعية مقترنة بالمحافظة على المصادر المائية المحيطة، وسيتم تسليط الضوء في هذه الدراسة، على طرق الري وآلية اتخاذ قرار الري عند المزارع الفلسطيني التي يمارسها في ري المحصول، وكيف يمكن خلق تنمية زراعية في ضمن محدودية المياه في فلسطين مقترنة بالمحافظة على المصادر المائية المتاحة.

- يهدف البحث إلى إجراء تحليل متوازن وزيادة الوعي والإرشاد في تحديد الخطوات التي يتبعها المزارع الفلسطيني عند اتخاذ القرار بري المحصول.
- زيادة البيانات والمعلومات عن الزراعة المحمية في المنطقة المستهدفة من البحث وتحديد الطرق الأفضل في أرشاد المزارعين في ري محاصيلهم حفاظا على المصادر المائية واستدامتها والحد من هدر المياه.

3. الأدوات والطرق

منهج ميداني: من خلال زيارة المناطق المستهدفة من البحث، كذلك زيارة المزارعين وإجراء المقابلات معهم، و زيارة المؤسسات والجهات المعنية.

منهج وصفي إيضاحي: من خلال وصف للوضع الموجود على أرض الواقع. تم تحليل البيانات باستخدام برنامج excel stat وذلك للحصول على نتائج ملموسة تترجم الوضع الحالي للمزارعين المستهدفين من البحث.

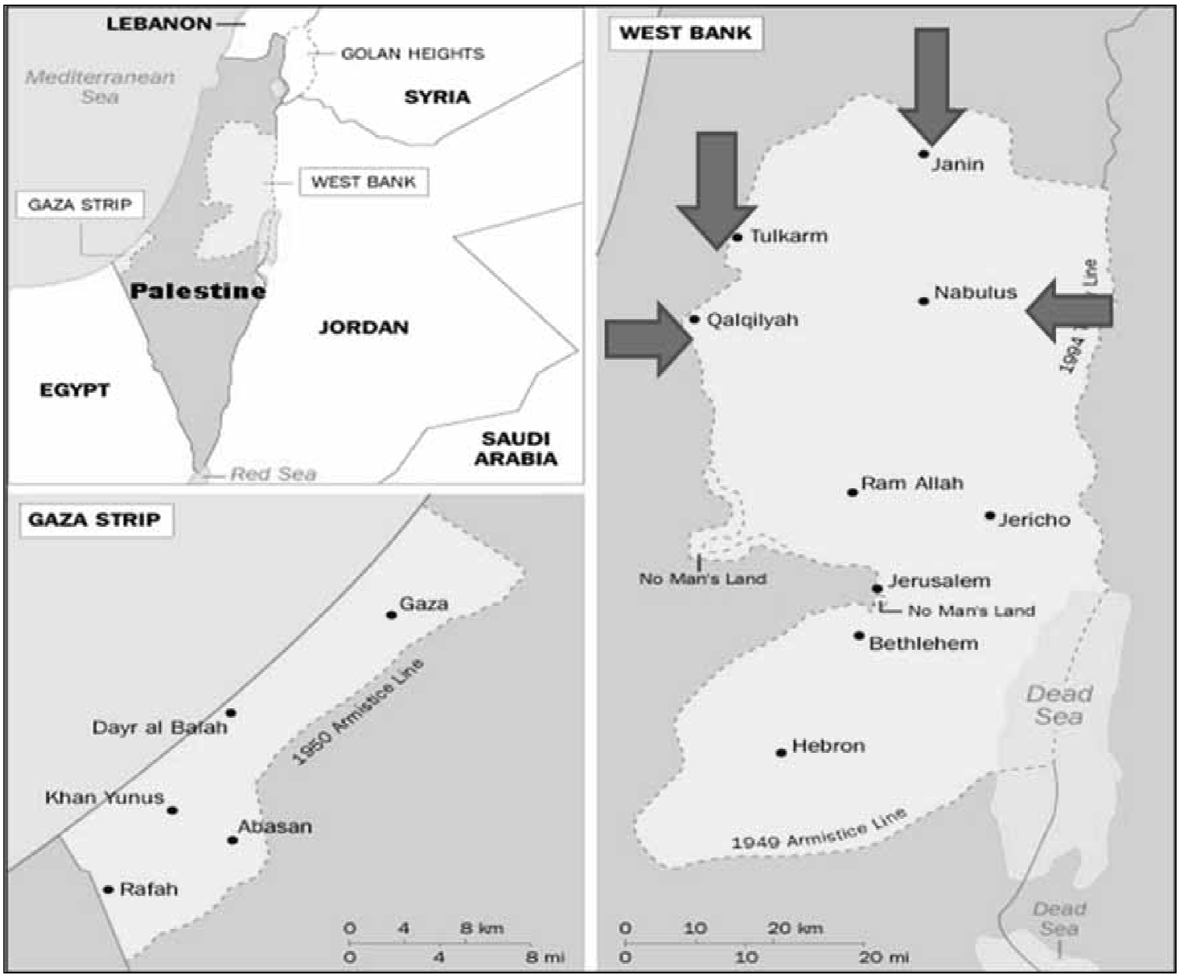
1.3. أدوات البحث المستخدمة في الدراسة

تم عمل إستبانة تتكون من ستة أجزاء أساسية تضم: بيانات عن المزارع، بيانات عن المزرعة، بيانات عن المحصول، بيانات عن التربة والري، بيانات عن العمالة وأخيرا بيانات عن إتخاذ قرار الري.

تم توزيع هذه الإستبانة على المزارعين في المناطق المستهدفة من البحث من خلال زيارة المزارعين من قبل الباحثين لتعبئة الإستبانة على أرض الواقع بطريقة سليمة والوصول إلى بيانات واضحة وصحيحة.

2.3. أهمية الدراسة

- تشكل هذه الدراسة مصدرا للباحثين في قطاع الزراعة وخاصة البيوت المحمية وكميات المياه مستقبلا كونها الأولى في المحافظات المستهدفة من البحث حسب علم الباحثين.
- تساعد هذه الورقة المسئولين للوقوف على حقيقة الأمر الواقعي ومعرفة التحديات والمشاكل لإدراجها في الخطة الإستراتيجية لوزارة الزراعة.
- زيادة الوعي والإرشاد للمزارعين من حيث كمية وكيفية ري المحاصيل المحمية والتوعية في تقنين كميات مياه الري للحفاظ على مصادر المياه المتاحة في ظل أزمة المياه التي تعاني منها فلسطين.
- كثير من المزارعين يعتمدون على القطاع الزراعي بشكل كلي، وهذه الدراسة ستعمل على تقليل وتحديد المشاكل والتي تشكل خسائر كبيره لهم، وبالتالي تقديم الحلول لهم سوف يساعدهم على التقليل من هذه المشاكل الأمر الذي ينعكس ايجابيا على مستوى دخلهم وبالتالي يتحسن مستواهم المعيشي.
- سوف تخرج هذه الدراسة بمجوعة من البيانات ذات العلاقة بكمية وكيفية ري المحاصيل الزراعية، مما يشكل فائدة لمجموعة أخرى من مزارعي المجتمع الفلسطيني وهذا يحد من مشكلة أزمة المياه.



الشكل رقم 1 . يوضح حدود ومنطقة الدراسة

المصدر : http : / /www . palestinehistory . com /arabic /sights /images /maps__pal1 . jpg

2.2 . مشكلة الدراسة

تكمن مشكلة الدراسة في تحديد الخطوات التي يتبعها المزارع الفلسطيني عند اتخاذ القرار بري المحصول، هل هي على أسس حسابية و علمية؟ أم بطرق تقليدية؟ حيث يتم الاعتماد على سلوك المزارعين وعلى والنمط الزراعي الموجود في المنطقة، من اجل الحد من هدر المصادر المائية وتعظيم العائد من وحدة المياه المتاحة .

3.2 . أهداف الدراسة

- تهدف هذه الإستبانة إلى دراسة واقع المزارع الفلسطيني في تحديد وقت وكمية مياه الري التي يستخدمها في الزراعة المحمية ومدى كفاءة استخدام الوسائل التي يستخدمها في ري المزروعات للوصول إلى دراسة حقيقية تضع المزارع الفلسطيني في حقيقة الوضع الراهن من مصادر المياه في فلسطين وذلك لتكميم المياه المستخدمة في الزراعة والاستفادة المثلى من المياه المستخدمة .
- تحديد العلاقة المتبادلة بين الزراعة التي يمارسها المزارع والبيئة المحيطة به بحيث يمكن العمل للوصول إلى تنمية

بشكل عام تصل أسعار المياه التي يتم توفيرها بواسطة شبكة مركزية ما بين 3–5 شيكل للمتر المكعب الواحد ، أما سعر المياه الذي يتم نقله بواسطة الصهاريج المياه يصل بين 15–30 شيكل للمتر المكعب الواحد والذي يعتمد على المسافة والموقع . وقد بلغت أسعار المياه المشتراة من شركة المياه الإسرائيلية (ميكروت) في الأراضي الفلسطينية 2.56 شيكل لكل متر مكعب للاستخدام المنزلي ، و 0.425 شيكل لكل متر مكعب للأستخدام الزراعي كما يحصل في مدينة طوباس .

ونتيجة لسوء الأحوال الاقتصادية لدى الفلسطينيين باتت مصاريف المياه تثقل على المواطنين وتشكل عبء اقتصادي بالنسبة لهم، فقد وصلت التقديرات حسب مصادر مختلفة الى أن المصارف على الماء تصل في العديد من الاحيان الى 10% من اجملي المصاريف العائلية (مركز المعلومات الإسرائيلي لحقوق الإنسان، 2007) .

تعتبر الأراضي الفلسطينية من اكثر دول العالم شحا في مصادرها المائية، نتيجة للسيطرة الإسرائيلية على مصادر المياه وبسبب زيادة النمو السكاني والتطورات الاقتصادية والاجتماعية في الأراضي الفلسطينية، فقد تزايد الطلب على المياه التي تتسم بمحدوديتها واعتمادها على الأمطار المتذبذبة، حيث ارتفعت نسبة الأسر المربوطة منازلها بشبكات المياه العامة 83.6% سنة 1997

إلى 90.8% سنة 2006 ، وبلغ معدل نصيب الفرد من المياه حوالي 135.8 لتر/ فرد/ يوميا في عام 2007، منها حوالي 110.2 لتر/ فرد/ يوميا في الضفة الغربية و 174.1 لتر/ فرد/ يوميا في قطاع غزة، أي بزيادة 8% عن العام 2005، و 15 % عن العام 1997 مع العلم أن 51 % من مصادر المياه المتاحة يتم شراؤها من شركة المياه الإسرائيلية « ميكوروت»، من خلال دائرة مياه الضفة، أما النسبة المتبقية وهي 49 % فتأتي من الآبار الذاتية التابعة لسلطة المياه وبعض البلديات ومصالح المياه، بالإضافة إلى كميات محدودة تأتي من الينابيع والآبار الزراعية. أما بالنسبة لمعدل حصة الفرد على مستوى المحافظات، فان أعلى هذه المعدلات في محافظتي القدس وأريحا والأغوار التي تعتمد بشكل شبه كلي على الينابيع، حيث وصل معدل نصيب الفرد في هاتين المحافظتين إلى 296.6 لترا/ فرد/ يوم، ويليهما محافظة قلقيلية التي وصل فيها نصيب الفرد إلى 189.7 لتر/ فرد/ يوم، يليها محافظة طولكرم 143.1 لتر/ فرد/ يوم، ومحافظة رام الله والبيرة محافظة وبيت لحم 134.9 لتر/ فرد/ يوم 134.3 على التوالي، ونابلس 93.8 لتر/ فرد/ يوم (مع العلم أن نابلس تعتمد بشكل رئيسي على المياه التي يتم شرائها من ميكوروت الإسرائيلية) ومحافظة سلفيت 92.1 لتر/ فرد/ يوم، أما محافظة الخليل التي يقطنها أكبر عدد من السكان بين محافظات الضفة الغربية فيبلغ فيها معدل نصيب الفرد إلى 83.8 لتر/ فرد/ يوم، ويهبط معدل نصيب الفرد في كل من محافظتي جنين وطوباس إلى 56.8 لتر/ فرد/ يوم و 46.6 لتر/ فرد/ يوم على التوالي (Freijat، 2007) .

2 . منهجية الدراسة وعناصرها

1.2 . حدود الدراسة والموقع

شملت الدراسة أربع مناطق من الضفة الغربية وهي منطقة عتيل التابعة لمحافظة طولكرم، منطقة حبله التابعة لمحافظة قلقيلية، منطقة الجلمة التابعة لمحافظة جنين. منطقة طمون التابعة لمحافظة طوباس. حيث تشتهر هذه المناطق بزراعة الخضروات المروية (المحمية والمكشوفة) والأكثر إنتاجا على مستوى فلسطين ويوضح الشكل رقم (1) حدود الدراسة.

تتألف مصادر المياه في الضفة الغربية من تلك المصادر المتجددة للمياه العذبة القادمة من التجمعات المائية الجبلية، والتي تقدر بحوالي 650 مليون م3 سنويا، إضافة إلى المياه السطحية الجارية في الوديان، والتي تقدر كميتها بحوالي 70 مليون م3 سنويا (PHG، 2006).

قدر مجموع الاستهلاك الفلسطيني للمياه الجوفية في الضفة الغربية بحوالي 120 مليون م3 سنويا ويستخدم منها حوالي 86 مليون م3 سنويا (71%) في ري حوالي90 ألف دونم من الأراضي الزراعية، وتستخدم الكمية المتبقية 34) مليون م3(لأغراض الاستهلاك المحلي والصناعي، حيث تبلغ حصة القطاع الصناعي حوالي % 3 علما بأن نسبة الفاقد تصل إلى حوالي 40%.

بلغ مجموع استهلاك فلسطيني قطاع غزة للمياه حوالي 125 مليون م3 سنويا 70 مليون منها لأغراض الزراعة، تسيطر إسرائيل في الوقت الراهن، على حوالي 85 % من المياه الجوفية المتوفرة للشعب الفلسطيني، علاوة على أنها تنكر على الفلسطينيين حقهم في مياه نهر الأردن ووديان غزة، وقد أدت هذه السياسة الإسرائيلية إلى حدوث أزمة مياه حادة في فلسطين بشكل عام، ومحافظات قطاع غزة بشكل خاص (PHG، 2006).

تعاني الأراضي الفلسطينية من نقص المياه بشكل عام، حيث أنه علاوة على محدودية الموارد المائية، فإن سيطرة الاحتلال الإسرائيلي على هذه الموارد تؤدي إلى حرمان الفلسطينيين من نصيبهم الشرعي من المياه. ومن هنا تأتي أهمية توفير بيانات إحصائية دقيقة حول هذا الموضوع.

تنحصر مصادر المياه في الأراضي الفلسطينية في مصدرين رئيسيين، الأول: المياه الجوفية المتمثلة بالمياه المضخوخة من الآبار والمستغلة من الينابيع، والثاني: عبارة عن المياه المشتراة من شركة المياه الإسرائيلية (ميكروت) حيث بلغ مجموع كمية المياه التي تم توفيرها من هذين المصدرين 335.4 مليون متر مكعب عام 2007 وتشير بيانات عام 2007 إلى أن آبار المياه الجوفية تعتبر أكبر مصدر للمياه حيث تم ضخ حوالي 241.2 مليون م3 من المياه أي ما نسبته71.9%، يليها المياه المشتراة من شركة المياه الإسرائيلية(ميكروت) حيث بلغت كميتها49.4 مليون م3 بنسبة 14.7%، وأخيرا الينابيع حيث بلغ تصريفها السنوي 44.8 مليون م3 وشكلت ما نسبته 13.4 % من مصادر المياه التي يتم الاعتماد عليها لتغطية الطلب على المياه لمختلف الاستخدامات (PHG، 2006).

وعلى مستوى المنطقة يتم الاعتماد في باقي الضفة الغربية على الينابيع لتغطية جزء من الطلب على المياه في الاستخدام الزراعي والمنزلي، بينما لا يوجد ينابيع في قطاع غزة. وبلغ إنتاج الآبار في باقي الضفة الغربية 68.7 مليون م3 وشكلت ما نسبته 43.4% من مصادر المياه في باقي الضفة الغربية، وبلغ التصريف السنوي للينابيع 44.8 مليون م3 أي بنسبة 28.3%، كذلك بلغت كمية المياه المشتراة من شركة المياه الإسرائيلية (ميكروت) 44.8 مليون م3 وشكلت نسبة 28.3%من مصادر المياه في باقي الضفة الغربية. أما في قطاع غزة فقد بلغ إنتاج الآبار 172.5 مليون متر مكعب وشكلت 97.4 % من مصادر المياه في قطاع غزة، وبلغت كمية المياه المشتراة من شركة المياه الإسرائيلية (ميكروت) 4.6 مليون م 3بنسبة 2.6% من مصادر المياه.

هذا وقد اختلفت مصادر المياه المزودة للاستخدام المنزلي عام 2007 في الأراضي الفلسطينية حيث تم الاعتماد على المياه المضخوخة من الآبار المنزلية والزراعية للاستخدام المنزلي بحوالي 120.8 مليون م3، ثم على المياه المشتراة من شركة المياه الإسرائيلية) ميكروت (بحوالي 49.5 مليون م 3، وأخيرا تم الاعتماد على الينابيع بحوالي 5.4 مليون م3.

تشير البيانات إلى أن معدل سعر المتر المكعب من المياه المستخدمة في القطاع المنزلي للأراضي الفلسطينية بلغ 2.6 شيكل جديد/ متر مكعب للعام 2007، بينما بلغ سعر المتر المكعب في القطاع الزراعي في باقي الضفة الغربية 0.4 شيكل جديد/ متر مكعب (جهاز المركزي للإحصاء الفلسطيني، 2007).

دراسة حول آلية اتخاذ القرار عند المزارع الفلسطيني في ري المزروعات المحمية

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ملخص

تعاني الأراضي الفلسطينية من نقص المياه بشكل عام، حيث أنه علاوة على محدودية الموارد المائية، فإن سيطرة الاحتلال الإسرائيلي على هذه الموارد تؤدي إلى حرمان الفلسطينيين من نصيبهم الشرعي من المياه. من هنا تأتي أهمية توفير بيانات إحصائية دقيقة، كما يأتي هذا البحث ضمن الجهد الذي يبذله مركز الأبحاث التقنية في جامعة فلسطين التقنية–خضوري بالتعاون مع وزارة الزراعة الفلسطينية في إيجاد بيانات حول الزراعة في فلسطين وتحديدا احتياجات المزارعين من المياه والمحافظة على المصادر المائية، حيث تسعى هذه الأبحاث إلى توفير البيانات اللازمة لوصف واقع المصادر المائية في الأراضي الفلسطينية وخصوصا وضع المزارع الفلسطيني من مصادر المياه.

تهدف هذه الأستبانة إلى دراسة واقع المزارع الفلسطيني في تحديد وقت وكمية مياه الري التي يستخدمها في الزراعة المحمية في ومدى كفاءة استخدام الوسائل التي يستخدمها في ري المزروعات للوصول إلى دراسة حقيقية تضع المزارع الفلسطيني في حقيقة الوضع الراهن من مصادر المياه في فلسطين وذلك لتقليل المياه المستخدمة في الزراعة والاستفادة المثلى من مياه الري.

أشارت النتائج أن 58%من المزارعين يمارسون الزراعة المحمية فقط، كما أوضحت النتائج أن 68% من الإنتاج للبيع في السوق المحلي، وقد شكلت نسبة 58% من استخدام شبكة الري بالتنقيط وعزت ذلك إلى تقليل الوقت والجهد و محدودية المياه، وقد وصلت نسبة محدودية المياه إلى 75% بين المزارعين، ووصلت مديونية المياه إلى 65% بين المزارعين ، وقد أشار 70% أن فاتورة المياه تشكل نسبة كبيرة من تكاليف الإنتاج، و75% يعتبرون سعر المياه عامل محدد لوقت وكمية الري.

كلمات مفتاحيه: المياه، المزارع الفلسطيني، قرار الري، التوعية والإرشاد، تقنين الري.

1. المقدمة

تقدر مساحة الضفة الغربية وقطاع غزة بحوالي 6020 كم2، وتقدر مساحة الأراضي الصالحة للزراعة في الضفة والقطاع بحوالي 2.2 مليون دونم، أما المساحة المزروعة بالفعل فتقدر نسبتها 84.5% أي ما يعادل 1815 ألف دونم (87% منها زراعة بعلية، و 13% منها زراعة مروية) تتوزع نسبة 91% في الضفة، ما يعادل 1650 ألف دونم ، ونسبة 9% في قطاع غزة ما يعادل 164.9 ألف دونم (غازي الصوراني، 2006).

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3. يجب أن يتم الأخذ بعين الاعتبار مدى التقبل المجتمعي لإعادة استخدام المياه العادمة المعالجة في الزراعة وذلك قبل إنشاء أي مشروع لمعالجة المياه العادمة وإعادة استخدامها.

4. تعزيز ورفع الوعي العام بين مختلف شرائح المجتمع لأهمية إعادة استخدام المياه العادمة المعالجة في الزراعة. وذلك خلال تنظيم حملات توعية مجتمعية.

5. إشراك أفراد المجتمع المحلي في عملية صنع القرار عند تنفيذ مشاريع لمعالجة المياه العادمة.

إن عدم تقبل المجتمع لإعادة استخدام المياه العادمة المعالجة في الزراعة يحتاج إلى عناية خاصة، كإشراك أفراد المجتمع المحلي في عملية صنع القرار، حيث تعتبر عاملا أساسيا في إحداث تغييرات جذرية، بالإضافة إلى عمل حملات توعية لرفع الوعي العام لأهمية إعادة استخدام المياه العادمة المعالجة في الزراعة.

فمعالجة المياه العادمة وإعادة استخدامها في الزراعة يمكن أن تساهم في توفر جزء من الاحتياجات المائية لقطاع الزراعة في الأراضي الفلسطينية المحتلة، وأن تقلص من الكميات التي يتم استخراجها من المياه الجوفية. وبالتالي أن رفع القيود المفروضة من قبل الاحتلال وحصول الفلسطينيين على حقوقهم المائية وتوفير المياه الإضافية للزراعة سيعمل على النهوض بقطاع الزراعة وتطويره بالإضافة إلى زيادة مساهمة الزراعة في الناتج المحلي الفلسطيني.

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- التخطيط والإدارة غير السليمين .

لقد أجمع المواطنين الذي شملهم المسح الميداني أن أهم المعيقات أمام نجاح فكرة إعادة الاستخدام في الأراضي الفلسطينية تتمثل في عدم توافق معايير المياه العادمة المعالجة مع المعايير المطلوبة لإعادة استخدامها في الزراعة، تليها القيود المالية حيث أن أنظمة معالجة المياه العادمة وإعادة استخدامها تحتاج إلى تكاليف إنشائية وتشغيلية مرتفعة .

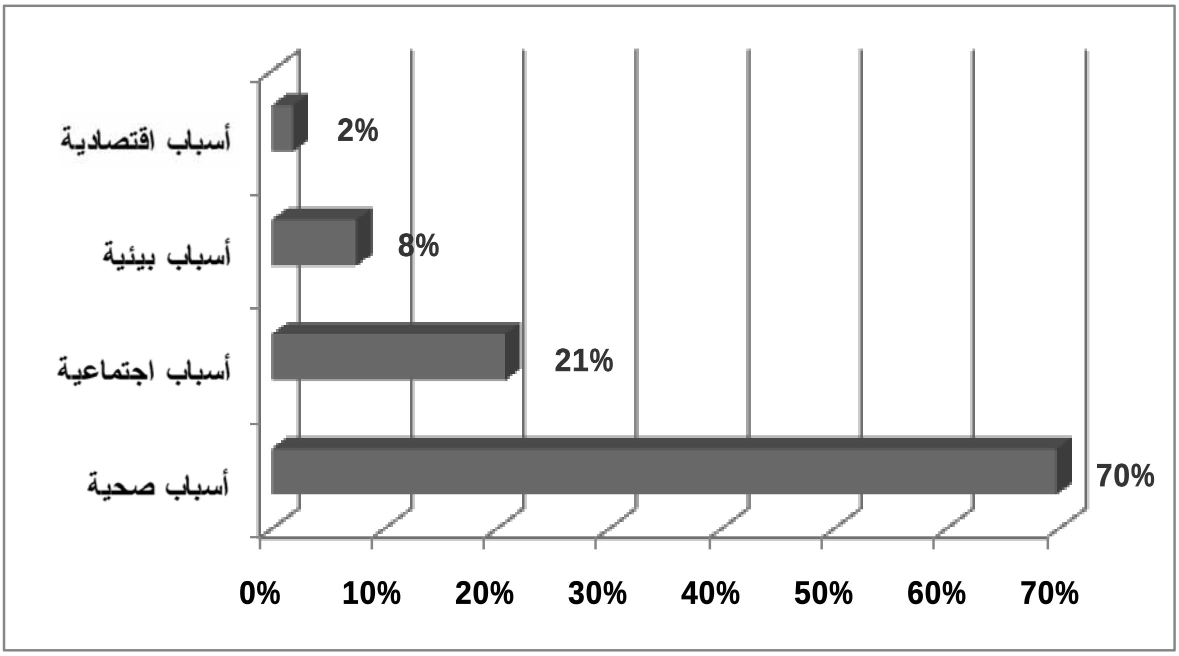
ومن جهة أخرى، وبالاستناد إلى آراء وانطباعات أصحاب العلاقة فإن المعيقات و القيود الرئيسة أمام إعادة استخدام المياه العادمة المعالجة في الأراضي الفلسطينية المحتلة هي :

- عدم وجود الوعي العام .
- القيود الاجتماعية (على سبيل المثال بسبب المعتقدات الدينية) .
- عدم قبول المزارعين وأفراد المجتمع بفكرة إعادة استخدام المياه العادمة لري المزروعات .
- عدم توفر محطات معالجة تعمل بكفاءة عالية .
- عدم توافق معايير المياه العادمة المعالجة مع المعايير المطلوبة لإعادة استخدامها في الري الزراعي .
- عدم القدرة على نقل المياه العادمة المعالجة لمواقع إعادة الاستخدام .
- عدم وجود كوادر لديها خبرة في هذا المجال .
- التخطيط والإدارة غير السليمين لمشاريع الصرف الصحي، وعدم توفر المتابعة الفنية بشكل دائم .
- عدم وجود هيئة مستقلة لإدارة وتوفير خدمات الصرف الصحي .
- عدم وجود خطة وطنية لإعادة استخدام المياه العادمة المعالجة على المستوى .
- عدم وضوح المسؤوليات في المؤسسات ذات الصلة .
- ضعف القدرات الإدارية والتقنية للسلطات المحلية .
- القيود المالية .
- ممارسات الاحتلال والتي تعيق إنشاء محطات لمعالجة المياه العادمة (مثل عدم الموافقة على مواقع المحطات أو الإصرار على ربط المستوطنات أو عدم إعطاء تراخيص لنقل المياه المعالجة لمواقع إعادة الاستخدام) .

وعند مقارنة آراء المواطنين مع أصحاب العلاقة فيما يخص المعيقات أمام استخدام المياه العادمة المعالجة في الأراضي الفلسطينية المحتلة، نجد أنها متوافقة ومتجانسة وذلك بالرغم من اختلاف المستوى المعرفي .

في ضوء النتائج التي تم التوصل إليها من هذه الدراسة، يمكن عرض بعض التوصيات الضرورية المتعلقة بمعالجة المياه العادمة ومدى التقبل المجتمعي لإعادة استخدامها في الزراعة .

1. اعتماد تكنولوجيا ملائمة لمعالجة المياه العادمة، مع الأخذ بعين الاعتبار ضمان جودة المياه العادمة المعالجة المقترحة لإعادة الاستخدام
2. استناد المعايير الأولية لمعالجة المياه العادمة واستخدامها على الاعتبارات الدينية والاجتماعية والاقتصادية والسياسية .

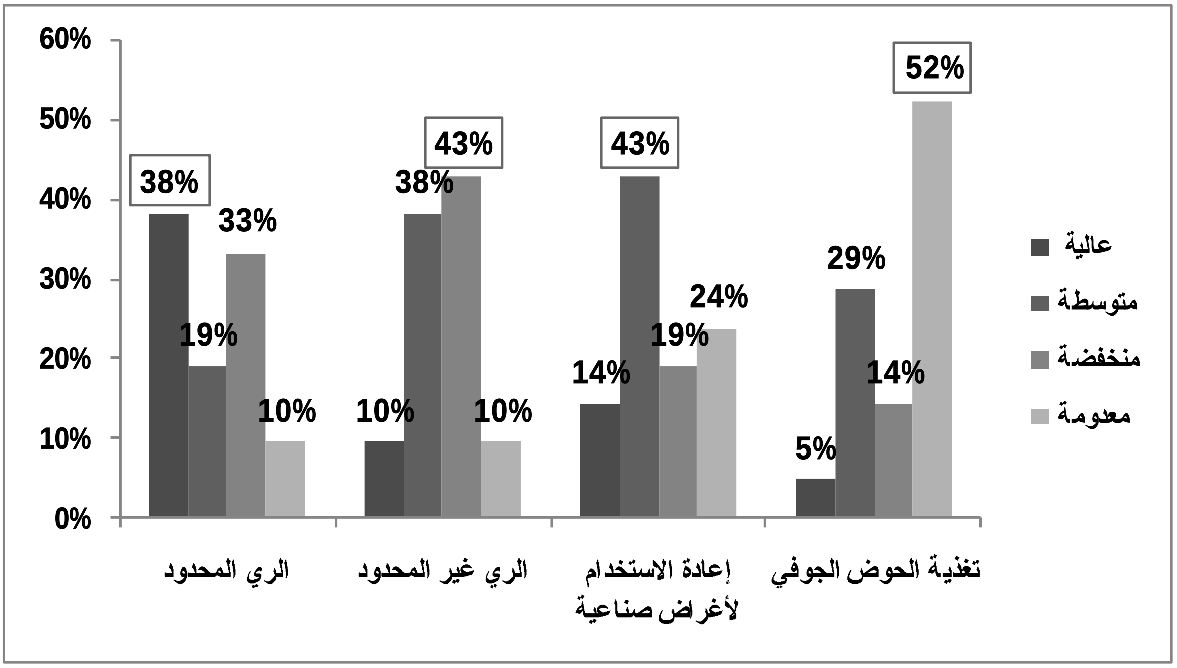


الشكل (7) الأسباب وراء عدم تشجيع المواطنين إعادة استخدام المياه العادمة المعالجة في الري المحدود

لقد تبين من الدراسة أن 25% من المزارعين لا يرغبون بدفع أية قيمة مالية مقابل المياه العادمة المعالجة، في حين أن 75% من المزارعين يرغبون بدفع قيمة متدنية مقابل المياه العادمة المعالجة بحيث لا تتجاوز 3 شيكل/ متر المكعب. ومن الجدير بالذكر هنا، أن سعر المتر المكعب من المياه العادمة المعالجة يعتبر من أهم العوامل التي تؤثر على رغبة المزارعين في إعادة استخدام المياه العادمة المعالجة في الزراعة، حيث أن انخفاض سعر المتر المكعب من المياه العادمة المعالجة من شأنه أن يكون القوة الدافعة لقبول المزارع فكرة إعادة الاستخدام.

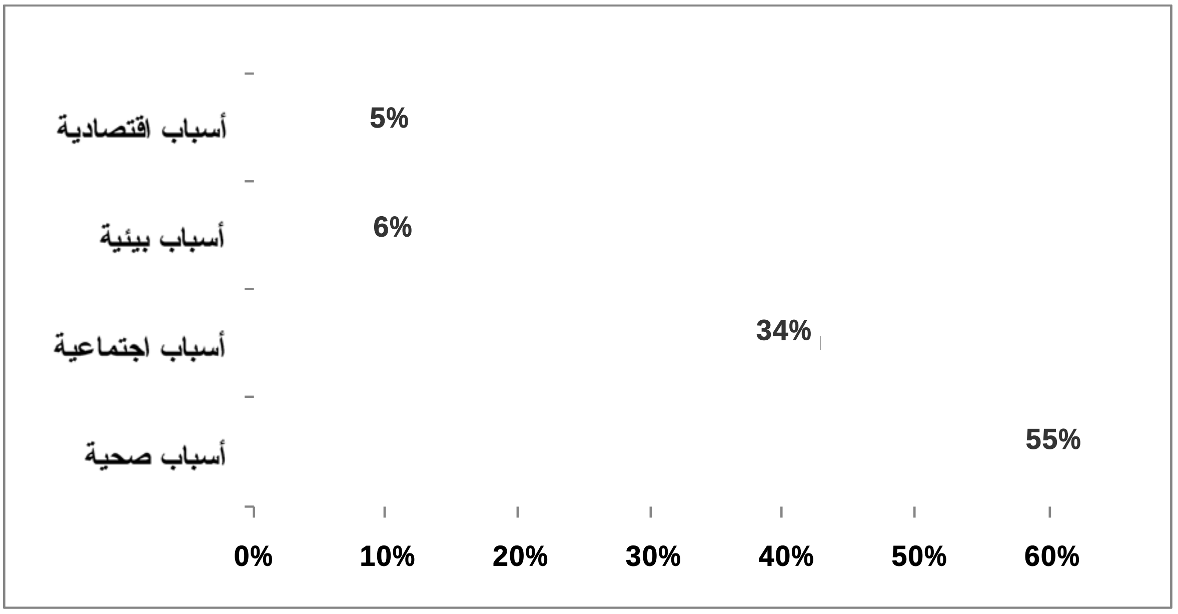
وبالاستناد إلى آراء المواطنين فإن أهم المعيقات أمام إعادة استخدام المياه العادمة المعالجة في الأراضي الفلسطينية المحتلة هي:

- عدم توافق معايير المياه العادمة المعالجة مع المعايير المطلوبة لإعادة استخدامها في الري الزراعي (عدم وجود محطات لمعالجة المياه العادمة ذات كفاءة عالية).
- القيود المالية (مثل الوسائل اللازمة لتخزين ونقل المياه العادمة المعالجة لمواقع إعادة الاستخدام والتي تتطلب تكاليف إنشائية وتشغيلية عالية).
- عدم توفر حملات وبرامج توعية تتعلق بمشاريع معالجة المياه العادمة وإعادة استخدامها في الري.
- عدم وجود كوادر لديها خبرة في هذا المجال.
- محدودية مواقع أعادة الاستخدام.
- عدم قبول المزارعين وأفراد المجتمع بفكرة إعادة استخدام المياه العادمة لري المزروعات.
- ممارسات الاحتلال الإسرائيلي والتي تعيق تنمية قطاع إدارة الصرف الصحي.
- تكلفة شراء المياه العادمة المعالجة مرتفعة.



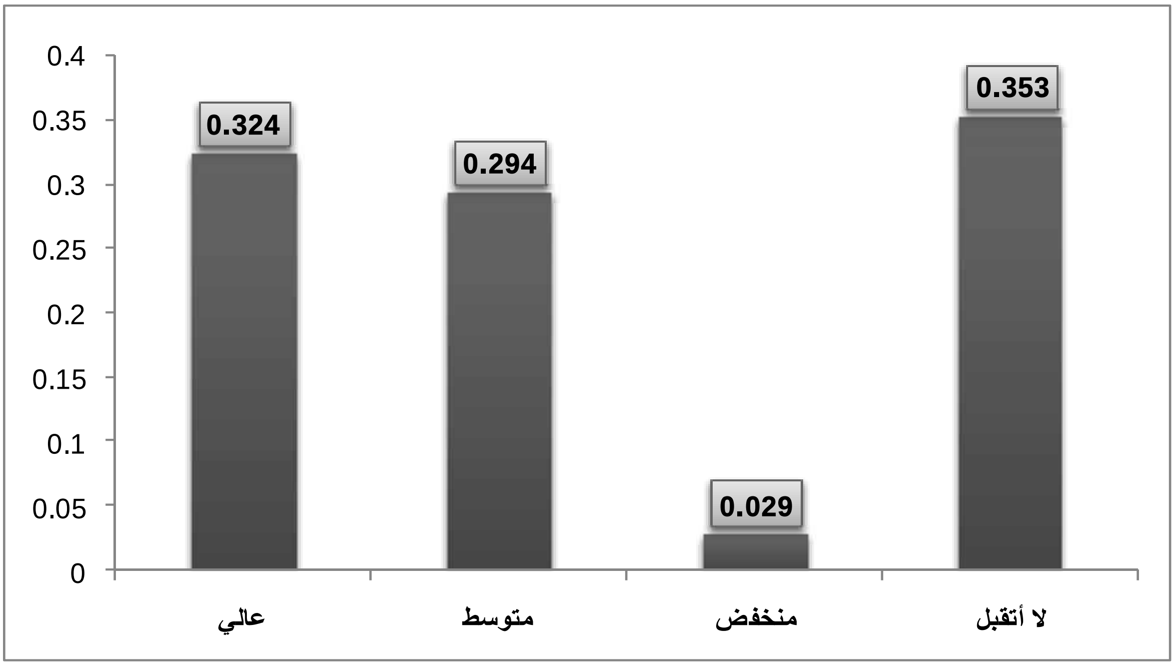
الشكل (5) إمكانية إعادة استخدام المياه العادمة المعالجة في مجالات متعددة

بالاستناد إلى آراء وانطباعات المواطنين الذين لا يشجعون إعادة استخدام المياه العادمة المعالجة في الري غير المحدود والمحدود فإن السبب الرئيسي لعدم تشجيعهم هي أسباب متعلقة بالصحة كتجنب الإصابة بأمراض في حال عدم كفاءة معالجة المياه العادمة. أما السبب الثاني هو سبب اجتماعي ونفسي كعدم تقبل فكرة إعادة الاستخدام بشكل عام ولأمور متعلقة بالمعتقدات الدينية. أما الأسباب الأخرى فقد كانت متعلقة بأمور بيئية كتلوث المحاصيل والتربة من المياه العادمة المعالجة، وأمور اقتصادية كرفض المواطنين شراء من المنتجات المروية بالمياه العادمة المعالجة (الشكل 6 و7).



الشكل (6) الأسباب وراء عدم تشجيع المواطنين إعادة استخدام المياه العادمة المعالجة في الري غير المحدود

أما عن مدى تقبل المواطنين لاستخدام منتجات زراعية مروية بالمياه العادمة المعالجة (الشكل 4)، فقد كانت نسبة المواطنين الذين لا يتقبلون استخدام منتجات مروية بالمياه العادمة المعالجة مقاربة لنسبة المواطنين الذين لديهم تقبل عال لاستخدام نفس المنتجات، حيث تمثل نسبة المواطنين الذين لا يتقبلون 35% ونسبة المواطنين الذين لديهم تقبل عال 32%.

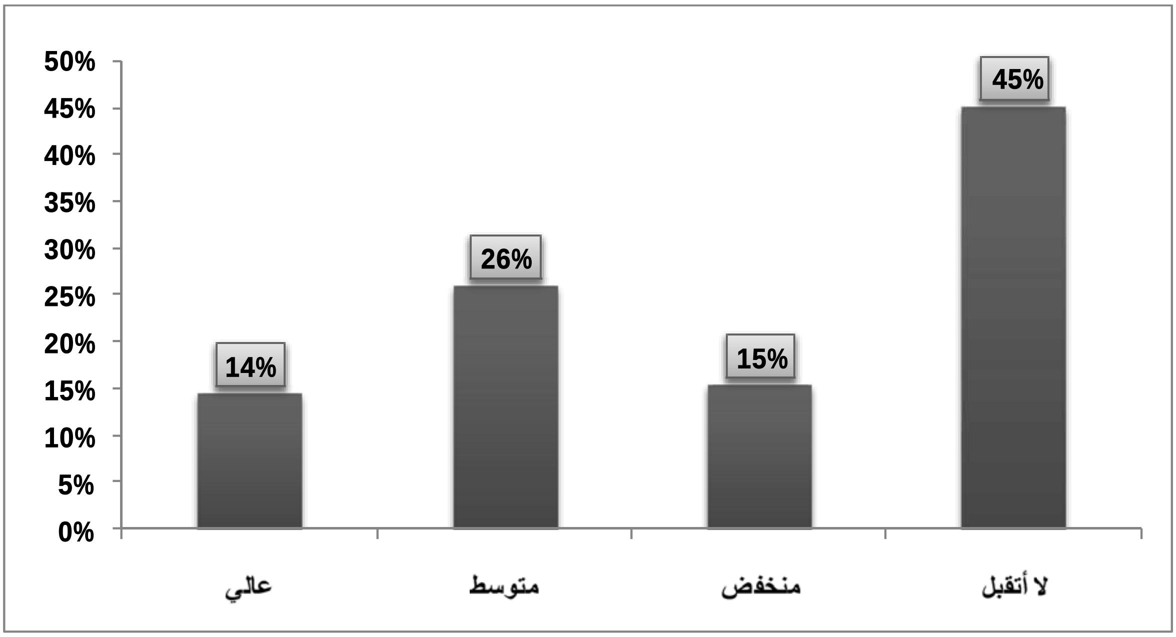


الشكل (4) مدى تقبل المواطنين لاستخدام منتجات زراعية مروية بالمياه العادمة المعالجة

وفي استبيان آخر[3] تم استهداف أصحاب العلاقة الرئيسيين به، تم تحديد إمكانية إعادة استخدام المياه العادمة المعالجة في مجالات متعددة بناءً على التجارب العملية لأصحاب العلاقة وآرائهم الشخصية (الشكل 5). وعند تحليل النتائج تبين ما يلي:

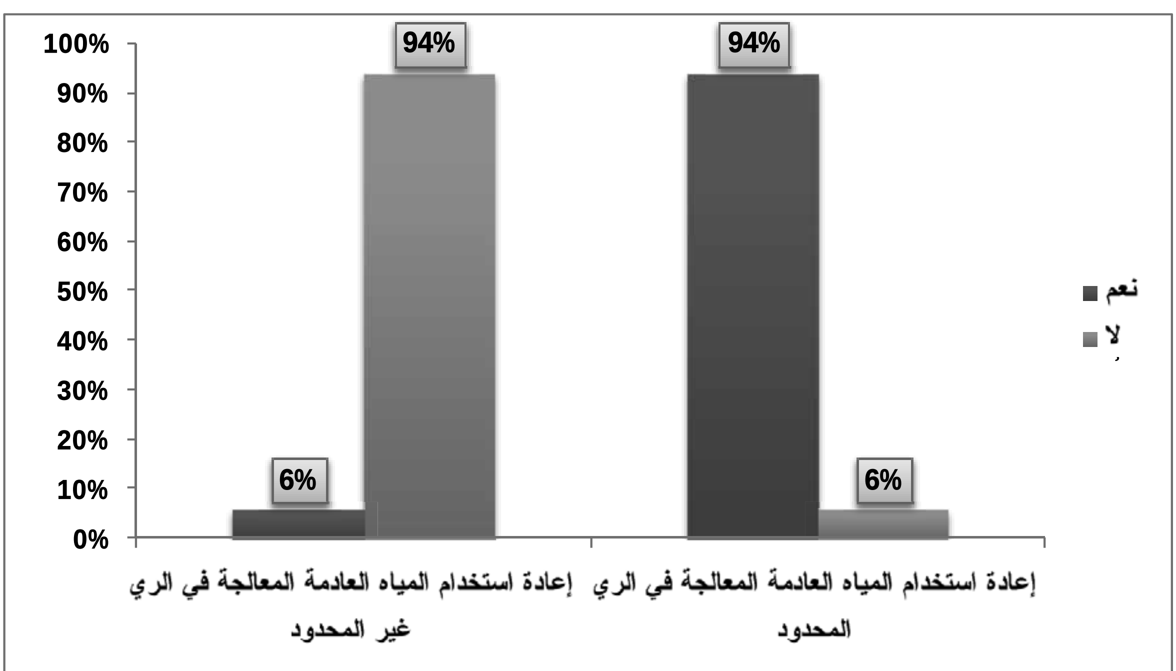
- إمكانية إعادة استخدام المياه العادمة المعالجة في الري المحدود مرتفعة أما عن إمكانية استخدامها في الري غير المحدود فهي منخفضة.
- إمكانية إعادة استخدام المياه العادمة المعالجة لأغراض صناعية متوسطة.
- ليس هناك إمكانية لإعادة استخدام المياه العادمة المعالجة في تغذية الحوض الجوفي.

[3] هدف هذا الاستبيان إلى تقييم آراء أصحاب العلاقة الرئيسيين في مختلف السلطات والمؤسسات الوطنية ذات العلاقة والمؤسسات غير الحكومية الوطنية والدولية العاملة في قطاع المياه والصرف الصحي وذلك حول الوضع الراهن لإدارة المياه العادمة في الضفة الغربية من مختلف الجوانب المؤسساتية والفنية.



الشكل (2) مدى تقبل المواطنين لاستخدام منتجات زراعية مروية بالمياه العادمة المعالجة

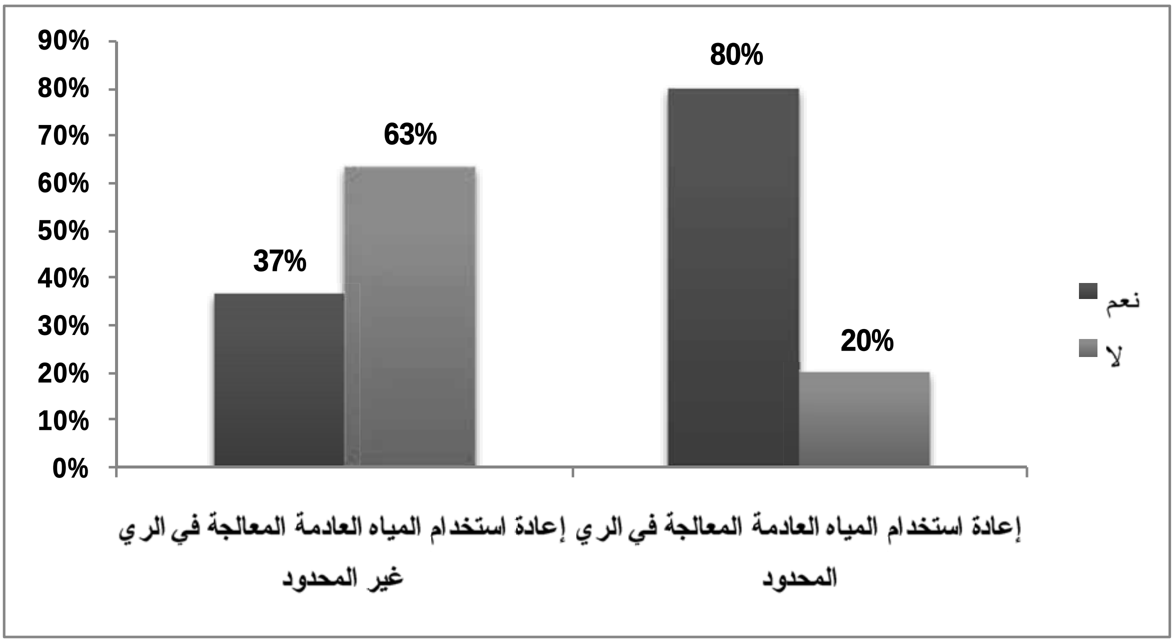
أما انطباعات المواطنين الذين يستخدمون محطات معالجة المياه العادمة المنزلية حول إعادة استخدام المياه العادمة المعالجة فقد أشارت نتائج اللقاءات شبه المنظمة إلى أن 94 % من المواطنين الذي تم استهدافهم لا يشجعون إعادة استخدام المياه العادمة المعالجة في الري غير المحدود بينما 94 % منهم يشجعون إعادة استخدام المياه العادمة المعالجة في الري المحدود (الشكل 3).



الشكل (3) انطباعات المواطنين حول إعادة استخدام المياه العادمة

المزروعات، في حين نجد أن مزارعين آخرين ذوي ظروف مشابهة، ويعيشون في المنطقة نفسها تقبلوا إعادة الاستخدام لنفس الغايات. حيث كان السبب الرئيس في عدم تشجيع المواطنين لإعادة استخدام المياه العادمة في ري المزروعات سبب نفسياً وليس ثقافياً.

بالنسبة لانطباعات المواطنين الذين يقطنون في تجمعات مجاورة لمحطات معالجة المياه العادمة (المحطات المركزية والمتوسطة الحجم) حول إعادة استخدام المياه العادمة المعالجة، واستنادا إلى نتائج اللقاءات شبه المنظمة قد تبيَن أن 63 % من المواطنين الذي تم استهدافهم لا يشجعون إعادة استخدام المياه العادمة المعالجة في الري غير المحدود[1] بينما 80 % منهم يشجعون إعادة استخدام المياه العادمة المعالجة في الري المحدود[2] (الشكل 1).



الشكل (1) انطباعات المواطنين حول إعادة استخدام المياه العادمة في الري

أما عن مدى تقبل المواطنين لاستخدام منتجات زراعية مروية بالمياه العادمة المعالجة (الشكل 2)، فقد كانت نسبة المواطنين الذين لا يتقبلون تمثل النسبة الكبرى والتي بلغت 45%.

[1] الري غير المحدود: ري المزروعات التي تؤكل نية أو طازجة كالخضروات.
[2] الري المحدود: ري المزروعات التي لا تؤكل نية أو طازجة كالأعلاف والزيتون واللوزيات.

المياه العادمة القائمة في مختلف أنحاء الضفة الغربية، والثاني إلى الحصول على آراء وانطباعات المواطنين الذين يستخدمون محطات معالجة المياه العادمة المنزلية، وذلك حول عمل هذه المحطات وأثرها على البيئة والصحة العامة وإعادة استخدام المياه العادمة المعالجة.

يتكون الاستبيان الأول والثاني من أسئلة رئيسية وفرعية مقسمة على ثلاثة أقسام رئيسية تتناول بيانات عامة حول المواطنين المستهدفين وغيرها من البيانات المتعلقة بانطباعات المواطنين حول عمل محطات المعالجة المركزية ومتوسطة الحجم والصغيرة وآثارها على البيئة المجاورة والصحة العامة بالإضافة إلى آراء المواطنين حول إعادة استخدام المياه العادمة المعالجة. ومن ثم، تم إدخال البيانات التي تم جمعها من خلال الاستبيان في برنامج التحليل الإحصائي (SPSS) لتحليلها.

4. الموقع الجغرافي

قد شمل المسح الميداني 231 عينة عشوائية من الأفراد الذين يقطنون في تجمعات مجاورة لمحطات معالجة المياه العادمة القائمة في مختلف أنحاء الضفة الغربية (جدول 2)، و35 عينة عشوائية من الأفراد الذين يستخدمون محطات معالجة المياه العادمة المنزلية في تجمعات مختلفة من محافظة بيت لحم والخليل.

جدول 2)) عدد العينات العشوائية في التجمعات المجاورة لمحطات معالجة المياه العادمة

اسم محطة معالجة المياه العادمة	العدد
محطة البيرة لمعالجة المياه العادمة	30
محطة رام الله لمعالجة المياه العادمة	30
محطة جنين لمعالجة المياه العادمة	30
محطة طولكرم للمعالجة الأولية للمياه العادمة	34
محطة نوبا لمعالجة المياه العادمة	15
محطة خاراس لمعالجة المياه العادمة	15
محطة دير سامت لمعالجة المياه العادمة	12
محطة بني زيد لمعالجة المياه العادمة	20
محطة زيتا لمعالجة المياه العادمة	13
محطة بديا لمعالجة المياه العادمة	15
محطة نحالين لمعالجة المياه العادمة	15

5. النتائج والتوصيات

إن فكرة إعادة استخدام المياه العادمة المعالجة في ري المزروعات تلقى انتشارا واسعاً، حيث أنها مطبقة على نطاق عالمي بغض النظر عن الخلفية الثقافية والاجتماعية والدينية لمستخدميها. إن الهدف من فهم الأبعاد الاجتماعية والاقتصادية والثقافية التي تؤثر على إعادة استخدام المياه العادمة المعالجة في الزراعة أمر هام لإنجاح عملية إعادة استخدام المياه العادمة المعالجة التي سوف تساهم بشكل كبير في إدارة أفضل للطلب على المياه والحد من ندرة المياه وحماية البيئة من خطر التلوث من المياه العادمة وتحسين الظروف المعيشية والاقتصادية للمزارعين في الأراضي الفلسطينية المحتلة.

وقد بيّن المسح الميداني أن بعض المواطنين في مناطق معينة يرفضون إعادة استخدام المياه العادمة المعالجة في ري

كجزء من مشروع "نظام مقترح لإدارة سليمة بيئيا للمياه العادمة في الضفة الغربية" الذي قام بتنفيذه معهد الأبحاث التطبيقية – القدس (أريج) والمركز الإسباني للتكنولوجيا الحديثة للمياه وبالتعاون مع سلطة المياه الفلسطينية تم دراسة التقبل المجتمعي إلى إعادة استخدام المياه العادمة المعالجة في ري المزروعات من الجوانب الاجتماعية والدينية والثقافية والاقتصادية والبيئية.

إن الهدف من المشروع هو تطوير نظام مقترح لإدارة سليمة بيئيا للمياه العادمة ليتم تطبيقه في مختلف محافظات الضفة الغربية وذلك من أجل ضمان تحسين ظروف الصرف الصحي الحالية. وعلى وجه التحديد، سعى المشروع إلى تحقيق الأهداف التالية:

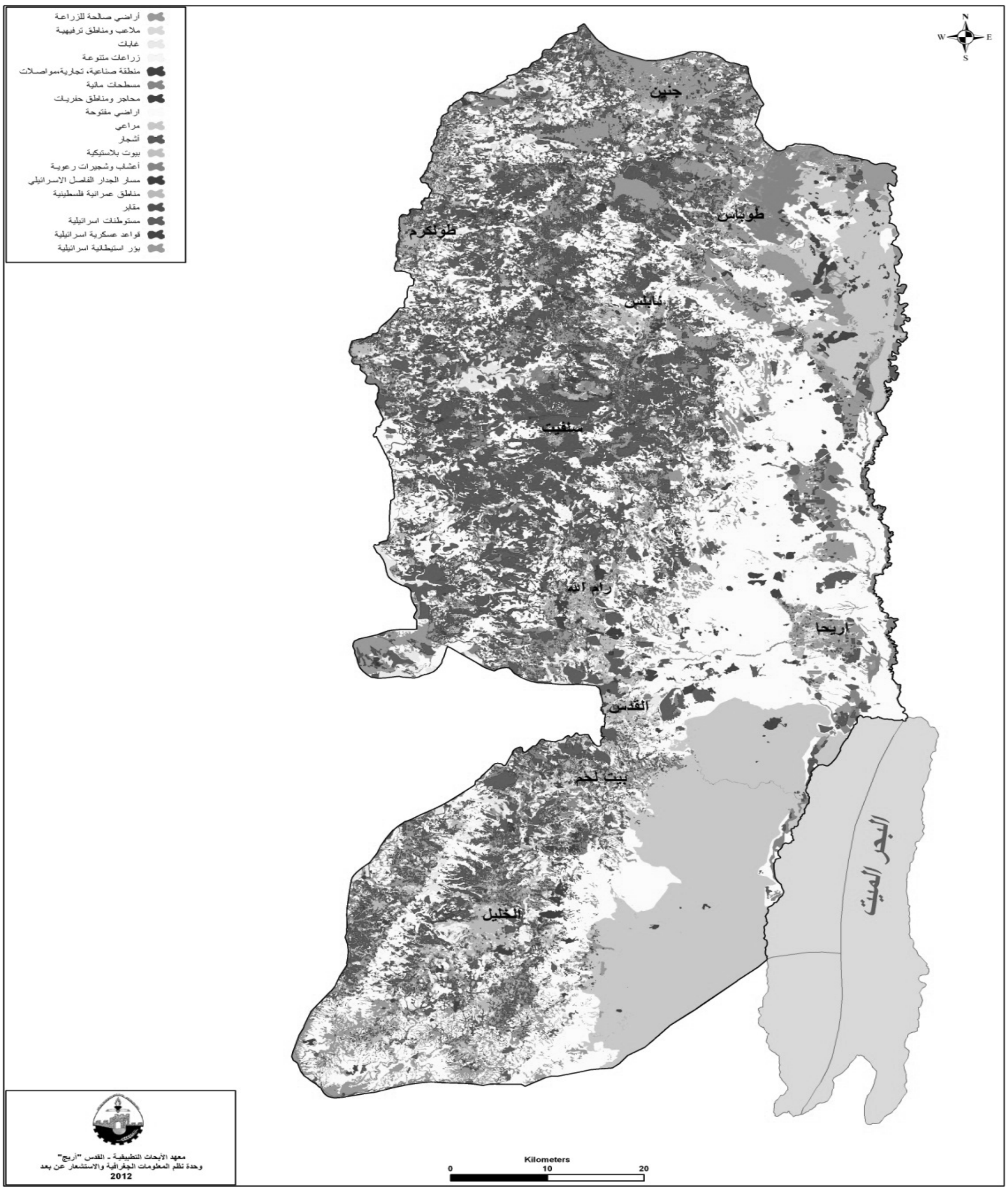
- تحديد أصحاب العلاقة الرئيسيين (قدراتهم وأدوارهم) وتقييم الوضع الراهن لإدارة المياه العادمة في الضفة الغربية.
- دراسة وتقييم أنظمة معالجة وإعادة استخدام المياه العادمة المطبقة حاليا في الضفة الغربية وتحديد الأنظمة الأكثر فاعلية.
- تطوير قدرات الكوادر الفنية الفلسطينية.
- تحديد المتطلبات الأساسية لتطوير مشروع صرف صحي تجريبي يشمل معالجة وإعادة استخدام المياه العادمة بالإضافة إلى تحديد واختيار المنطقة التي ستستهدف في هذا المشروع.

وبالرجوع إلى دراسات وأبحاث أخرى قام بها باحثين فلسطينيين لدراسة مدى التقبل المجتمعي لإعادة استخدام المياه المعالجة في المناطق الفلسطينية، ومن هذه الدراسات الدراسة التي قامت بها جامعة بيرزيت تحت عنوان "إمكانية التقبل الاجتماعي لإعادة الاستخدام مياه الصرف الصحي المعالجة في الزراعة في محافظة رام الله والبيرة" (حالة دراسية: دير دبوان)، أظهرت هذه الدراسة الى وجود علاقة وثيقة بين تقبل الناس لاستخدام المياه المعالجة في ري المحاصيل الزراعية والتقبل لاستهلاك المنتوجات الزراعية المروية بالمياه العادمة، حيث بينت الدراسة أن 76% من الذين يتقبلون اعادة استخدام المياه العادمة المعالجة في ري المحاصيل الزراعية يتقبلون استهلاكها لكن بعد طبخها. أي أن المواطنين يفضلون إعادة استخدام المياه العادمة المعالجة في الري غير المحدود مثل ري الاعلاف في حين لا يفضلون استخدامها للمحاصيل التي تؤكل طازجة. كما أوضحت الدراسة إلى وجود علاقة بين تقبل المياه العادمة المعالجة من الناحية الدينية وتقبل اعادة استخدامها في ري المحاصيل الزراعية حيث كان 59 % من الذين يتقبلون إعادة الاستخدام في ري المحاصيل الزراعية يعتبرون أن المياه المعالجة مسموحة دينيا.

كما أظهرت دارسة أخرى لمعهد الدراسات البيئية والمائية جامعة بيرزيت عام 2006 والتي تحمل عنوان "تقبل سكان ريف محافظة رام الله والبيرة لاستخدام المياه العادمة المعالجة" أن العامل النفسي يحتل المرتبة الأولى في رفض سكان الريف لإعادة استخدام المياه العادمة المعالجة ومن ثم العامل الصحي، فالعامل الديني. كما أظهرت النتائج أن استخدام المياه العادمة المعالجة بالطريقة المباشرة في الاستخدامات المرتبطة مباشرة مع الانسان احتلت النسبة الاقل من التقبل مقارنة مع الاستخدامات التي ليس لها صلة مباشرة بالإنسان، فمثلا كانت نسبة الذين تقبلوا إعادة الاستخدام في تغذية الخزان الجوفي 38% في حين نسبة الذين تقبلوا إعادة الاستخدام في الزراعة عادلت 80%.

3. منهجية الدراسة وأدواتها

وحتى يتم تحقيق أهداف المشروع، كان من الضروري إشراك أفراد المجتمع في عملية تحليل الوضع الراهن للمياه العادمة وتقييم أنظمة الصرف الصحي وإدارتها. وتم ذلك من خلال إعداد استبيانين خاصين تم توزيعهما على 266 عينة عشوائية. لقد هدف الاستبيان الأول إلى الحصول على آراء وانطباعات المواطنين الذين يقطنون في تجمعات مجاورة لمحطات معالجة



خريطة (1) استخدام الأراضي في الضفة الغربية

المصدر: أريج، 2012

تتوقف الجدوى من إعادة استخدام المياه العادمة المعالجة في الزراعة على الظروف والأحوال السائدة محلياً. فإن العوامل الاجتماعية والثقافية يمكن أن تشكل عائقاً أمام الكثير من التدابير التي يمكن إتباعها في إطار إدارة الطلب على المياه، مثل إعادة استخدام المياه العادمة المعالجة في الزراعة. حيث أن الطبيعة الاجتماعية الثقافية لأفراد المجتمع كالقيم، والمعتقدات الفكرية والدينية، والعادات تؤثر بشكل مباشر على تقبل فكرة إعادة استخدام المياه العادمة المعالجة لأغراض معينة.

المحافظة	اسم محطة المعالجة	نوع المحطة	الوضع القائم المحطة
الخليل	محطة خاراس	محطة متوسطة الحجم لمعالجة المياه العادمة	لا تعمل منذ آذار 2010
الخليل	محطة نوبا		تعمل بكفاءة متدنية
الخليل	محطة دير سامت		تعمل بكفاءة متدنية
رام الله والبيرة	محطة بني زيد		تعمل بكفاءة متوسطة
رام الله والبيرة	محطة عين سينيا		لا تعمل منذ منتصف عام 2009
قلقيلية	محطة حجا		تعمل بكفاءة متوسطة
قلقيلية	محطة صير		تعمل بكفاءة متوسطة
نابلس	محطة سرا		لا تعمل منذ عام 2006
سلفيت	محطة بديا		تعمل بكفاءة متدنية
طولكرم	محطة عتيل		تعمل بكفاءة متدنية
طولكرم	محطة زيتا		تعمل بكفاءة متوسطة
طولكرم	محطة شمال زيتا		تعمل بكفاءة متدنية
بيت لحم	محطة نحالين		تعمل بكفاءة عالية

وما يزيد من حدة المشكلة الناتجة من تدفق المياه العادمة دون إي معالجة هو التخلص العشوائي للمياه العادمة الناتجة عن المستوطنات الإسرائيلية ومصانعها المقامة على أراضي الفلسطينية. فمن المعروف أن المستوطنات الإسرائيلية غير الشرعية المقامة على الأراضي الفلسطينية تتخلص من مياهها العادمة غير المعالجة في الأودية والمناطق الزراعية الفلسطينية دون أي التزام بالمعايير البيئية أو الاكتراث بالمواطنين الفلسطينيين الذين يقطنون على مقربة من هذه الأودية والذين يعتاشون من نتاج أراضيهم الزراعية المتضررة. فقد بلغت كمية المياه العادمة التي تنتج عن حوالي نصف مليون مستوطن يقطنون تلك المستوطنات المقامة على الأراضي الفلسطينية وبما فيها القدس الشرقية 54 مليون متر مكعب سنويا (ARIJ & CENTA ، 2011).

تعتبر إعادة استخدام المياه العادمة المعالجة في الزراعة مصدراً هاماً وحيوياً في حل جزء من مشكلة العجز المائي الذي تعاني منه الأراضي الفلسطينية المحتلة نتيجة بسط إسرائيل سيطرتها على المصادر المائية الفلسطينية، بالإضافة إلى معوقات وتحديات أخرى مثل، عدم كفاءة استخدام الموارد الزراعية. ومن هنا تبرز أهمية عملية تطوير المصادر المائية المستخدمة في الزراعة ومن أهمها استغلال مصادر مائية غير تقليدية مثل إعادة استخدام المياه العادمة المعالجة كمصدر بديل خاصة وأن ري المزروعات يستنزف الجزء الأكبر من المياه المستهلكة في الأراضي المحتلة. حيث تقدر كمية المياه المستهلكة لغايات الري بحوالي 135 مليون متر مكعب سنويا والتي تشكل ما نسبته 48% من إجمالي المياه المستخدمة في كل من الضفة الغربية وقطاع غزة (PNA ، 2010). وبين المسح الأخير للأراضي الزراعية في الأراضي الفلسطينية والذي قامت به وزارة الزراعة والجهاز المركزي للإحصاء الفلسطيني أن مجمل مساحة الأراضي الزراعية وصل في عام 2010 إلى 061، 207، 1 دونما (91.6% في الضفة و8.4% في قطاع غزة). وبالمقارنة مع إحصائيات 2008 نجد أن المساحة الزراعية كانت تقدر بحوالي 000، 854، 1 دونما (منها 554، 694، 1 دونما في الضفة الغربية) (خريطة 1).

بالإضافة إن معالجة المياه العادمة تساعد على تخفيف تلوث البيئة المحيطة. كما أن استخدام المياه المعالجة في الزراعة سيخفف من العبء الاقتصادي على المزارع الناتج من التكاليف المرتفعة للأسمدة، وذلك لوجود المغذيات في المياه العادمة.

2. إدارة المياه العادمة في الأراضي الفلسطينية المحتلة

تعاني الأراضي الفلسطينية المحتلة من عدم توفر بنية تحتية سليمة للصرف الصحي، حيث تقتصر الإدارة الحالية للمياه العادمة في الأراضي الفلسطينية المحتلة على جمع المياه العادمة الناتجة من خلال شبكات الصرف الصحي و/ أو الحفر الامتصاصية، بالإضافة إلى التخلص من المياه العادمة عن طريق إلقائها دون أي معالجة في المناطق المفتوحة، بما في ذلك الأودية والأراضي الزراعية وبدون أي مراعاة للبيئة. وتجدر الإشارة إلى أن شبكات تجميع المياه العادمة تقتصر على المدن الرئيسية والمخيمات، حيث تخدم شبكات الصرف الصحي حوالي 30% من سكان الضفة الغربية (ARIJ & CENTA ،2011) و65% من سكان قطاع غزة (PWA ،2010)، فيما يستخدم باقي السكان وخاصة في المناطق الريفية الحفر الامتصاصية والقنوات المفتوحة لتجميع والتخلص من المياه العادمة. وفي النهاية يتم التخلص من المياه العادمة الناتجة جميعها حتى تلك التي يتم تجميعها بواسطة شبكات الصرف الصحي في الأودية والمناطق المفتوحة.

إن مشكلة المياه العادمة في الأراضي الفلسطينية المحتلة تعتبر من أهم المشاكل التي تحتاج إلى إجراءات عاجلة لحلها، حيث أن المياه العادمة غير المعالجة تتسرب وتختلط مع المياه الجوفية، مسببة وبشكل مباشر تدني نوعية المياه الجوفية مما يزيد من شح مصادر المياه في المنطقة. تقدر المياه العادمة المنتجة فلسطينياً بحوالي 106 مليون متر مكعب سنوياً ويتم معالجة فقط ما يقارب 10% منها (PWA ،2010). وبالرغم من وجود عدد من المحطات لمعالجة مياه الصرف الصحي في الأراضي الفلسطينية المحتلة إلا أن هذه المحطات غير كافية بالإضافة إلى أنها لا تعمل بكفاءة عالية. وباختصار يمكن القول أن وضع معالجة المياه العادمة مازال دون المستوى المطلوب. يوجد في الضفة الغربية 5 محطات مركزية و13 محطة متوسطة الحجم و180 محطة صغيرة لمعالجة المياه العادمة. أما في قطاع غزة، فيوجد 4 محطات مركزية لمعالجة المياه العادمة.

جدول (1) محطات معالجة المياه العادمة في الضفة الغربية (المحطات المركزية والمتوسطة الحجم).

المحافظة	اسم محطة المعالجة	نوع المحطة	الوضع القائم المحطة
رام الله والبيرة	محطة البيرة	محطة مركزية لمعالجة المياه العادمة	تعمل بكفاءة عالية
رام الله والبيرة	محطة رام الله		تعمل بكفاءة متدنية
طولكرم	محطة طولكرم للمعالجة الاولية		تعمل بكفاءة عالية
جنين	محطة جنين		قيد التأهيل
نابلس	محطة غرب نابلس		قيد الإنشاء

1 . المقدمة

إن معظم دول شرق حوض البحر الأبيض المتوسط تعاني من أزمة مياه تتفاوت في حدتها وذلك بسبب الاستغلال الزائد لمصادر المياه بمعدلات تفوق كمية المياه المتجددة طبيعيا وذلك لتغطية احتياجات النمو المتزايد للسكان والتوسع في قطاعي الزراعة والصناعة مما أسفر عن اختلال التوازن بين مصادر المياه المحدودة والاستهلاك. كما أن مصادر التلوث المختلفة ساهمت بتدهور نوعية المياه سواء السطحية أو الجوفية مما تسبب بانخفاض كمية المياه الصالحة للاستخدام.

وعلى الرغم من أن استنزاف مصادر المياه والتلوث يعدان من العوامل المؤثرة على وفرة المياه في هذه المنطقة إلا أن التوزيع غير المتساوي لهذه المصادر يعد من أهم العوامل لما خلفه وقد يخلفه من نزاعات. فإن الحصص الحالية لمصادر المياه المشتركة لم تتم بناءا على اتفاقيات أو مفاوضات أو خطط عادلة وإنما هي وليدة صراع القوى حيث يفرض الاحتلال الإسرائيلي نواياه على الفلسطينيين لتحقيق مطامعه المائية.

فمع التزايد الكبير لعدد السكان وازدياد احتياجاتهم اليومية للمياه وسيطرة الاحتلال الإسرائيلي على المصادر المائية الفلسطينية واستنزافها أصبحت أزمة المياه خطراً حقيقياً يهدد أجزاء الوطن كافة. فمنذ عام 1967 فرض الاحتلال قيوداً على استخدام المياه من قبل الفلسطينيين وأعلن الأراضي المحاذية لنهر الأردن مناطق عسكرية مغلقة وبالتالي حرم الفلسطينيين من حقهم الشرعي في استغلال مياه هذا النهر. كما أن إسرائيل تستنزف حاليا ما يقارب 90% من كمية المياه المتجددة سنوياً في الأحواض الجوفية في الضفة الغربية تاركاً ما يقل عن 10% ليتم استخدامه من قبل الفلسطينيين (Attili، 2011). ونتيجة استنزاف إسرائيل للأحواض الجوفية والقيود المفروضة على حفر الآبار وتأهيلها تقلصت كمية المياه المستخرجة من قبل الفلسطينيين خلال العشرة سنوات الماضية إلى اقل من الكمية التي نصت عليها اتفاقية أوسلو. حيث كان الفلسطينيون يستخرجون ما يقارب 138 مليون متر مكعب من المياه في الأحواض الجوفية للضفة الغربية في عام 1999 غير أن هذه الكمية انخفضت لتصل إلى اقل من 93 مليون متر مكعب في عام 2009 (World Bank، 2009). أما بالنسبة للحوض الساحلي فلقد قدرت كمية الاستخراج في عام 2010 بـ 170 مليون متر مكعب (PWA، 2011) وهو يفوق كمية الاستخراج الآمن للحوض بأكثر من ثلاثة أضعاف.

ففي حين يعاني الفلسطينيون في التجمعات الفلسطينية من أزمة حقيقية للمياه حيث بلغ معدل الاستهلاك اليومي في الضفة الغربية 73 لتر/اليوم وفي قطاع غزة 98 لتر/اليوم، يستهلك سكان المستوطنات الإسرائيلية غير الشرعية المقامة في الضفة الغربية ما يقارب الـ 350 لتر/الفرد/ اليوم. بالإضافة إلى التوزيع غير العادل للمصادر المائية، فإن كمية الاستهلاك في الأراضي الفلسطينية أقل من الحد الأدنى الذي توصي به منظمة الصحة العالمية والبالغ 100 لتر/ فرد/ اليوم (Jad Isaac & Jane Hilal، 2011).

ولأزمة المياه الخانقة التي تعاني منها الأراضي الفلسطينية المحتلة أثر سلبي على استدامة القطاع الزراعي وديمومته. ومن هنا تبرز أهمية عملية تطوير المصادر المائية المستخدمة في الزراعة ومن أهمها استغلال مصادر مائية غير تقليدية مثل إعادة استخدام المياه العادمة المعالجة كمصدر بديل خاصة وأن ري المزروعات يستنزف الجزء الأكبر من المياه المستهلكة في الأراضي الفلسطينية المحتلة. حيث تقدر كمية المياه المستهلكة لغايات الري بحوالي 135 مليون متر مكعب سنوياً (PNA، 2010) والتي تشكل ما نسبته 48% من إجمالي المياه المستخدمة، وتشكل الآبار الجوفية والينابيع المصدر الأساسي للمياه المستخدمة في الزراعة في كل من الضفة الغربية وقطاع غزة.

حيث أن مصادرنا المائية محدودة جداً ومهددة بالتدهور والاستنزاف، فلا بد من إيجاد مصدر بديل لمياه الري الذي يستنزف الجزء الأكبر من المياه، ومن هنا لابد من الأخذ بعين الاعتبار فكرة إعادة استخدام المياه العادمة المعالجة في الزراعة، حيث ان باستخدامها سيتم سد جزء من الفجوة من المياه العذبة واستهلاكها للأغراض المنزلية. فإن إعادة استخدام المياه العادمة المعالجة تعد ثروة يجب استغلالها ومكسباً متعدد الجوانب. حيث أن استغلال المياه العادمة المعالجة بصورة سليمة لأغراض زراعية بإمكانه أن يشكل إحدى الطرق للتعامل مع مشكلة ندرة المياه والتخفيف من الطلب على المياه العذبة في الزراعة،

دراسة بحثية حول مدى التقبل المجتمعي لإعادة استخدام المياه العادمة في الزراعة

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ملخص

تعتبر إعادة استخدام المياه العادمة المعالجة في الزراعة مصدراً هاماً وحيوياً في حل جزء من مشكلة العجز المائي الذي تعاني منه الأراضي الفلسطينية المحتلة نتيجة بسط إسرائيل سيطرتها على المصادر المائية الفلسطينية. ومن هنا تبرز أهمية عملية تطوير المصادر المائية المستخدمة في الزراعة ومن أهمها استغلال مصادر مائية غير تقليدية مثل إعادة استخدام المياه العادمة المعالجة كمصدر بديل خاصة وأن ري المزروعات يستنزف الجزء الأكبر من المياه المستهلكة في الأراضي المحتلة. حيث تقدر كمية المياه المستهلكة لغايات الري بحوالي 150 مليون متر مكعب (م م م) سنويا وتشكل الآبار الجوفية والينابيع المصدر الأساسي لهذه المياه. تقدر المياه العادمة المنتجة فلسطينياً بحوالي 106 (م م م)سنوياً ويتم معالجة فقط ما يقارب 10% منها. فمعالجة المياه العادمة وإعادة استخدامها في الزراعة يمكن أن تساهم في توفر جزء من الاحتياجات المائية لقطاع الزراعة.

إن العوامل الاجتماعية والثقافية يمكن أن تشكل عائقاً أمام الكثير من التدابير التي يمكن إتباعها في إطار إدارة الطلب على المياه، مثل إعادة استخدام المياه العادمة المعالجة في الزراعة. هدفت هذه الدراسة الى التعرف على مدى التقبل المجتمعي إلى إعادة استخدام المياه العادمة المعالجة في ري المزروعات من الجوانب الاجتماعية والدينية والثقافية والاقتصادية والبيئية، من خلال إعداد استبيان هدف إلى الحصول على آراء وانطباعات المواطنين. وقد شمل المسح الميداني 265 عينة عشوائية. وقد بيَن المسح الميداني أن بعض المواطنين في مناطق معينة يرفضون إعادة استخدام المياه العادمة المعالجة في ري المزروعات، في حين نجد أن مزارعين آخرين ذوي ظروف مشابهة، ويعيشون في المنطقة نفسها تقبلوا إعادة الاستخدام لنفس الغايات. حيث كان السبب الرئيس في عدم تشجيع المواطنين لإعادة استخدام المياه العادمة في ري المزروعات سبب نفسياً وليس ثقافياً. واستناداً إلى نتائج اللقاءات شبه المنظمة قد تبيَن أن 80 % من المواطنين الذي تم استهدافهم لا يشجعون إعادة استخدام المياه العادمة المعالجة في الري غير المحدود بينما 87% منهم يشجعون إعادة استخدام المياه العادمة المعالجة في الري المحدود. أما نسبة المواطنين الذين لا يتقبلون استخدام منتجات زراعية مروية بالمياه العادمة المعالجة تمثل النسبة الكبرى والتي بلغت 43%. إن عدم تقبل المجتمع لإعادة استخدام المياه العادمة المعالجة في الزراعة يحتاج إلى عناية خاصة، كإشراك أفراد المجتمع المحلي في عملية صنع القرار، حيث تعتبر عاملا أساسيا في إحداث تغييرات جذرية، بالإضافة إلى عمل حملات توعية لرفع الوعي العام لأهمية إعادة استخدام المياه العادمة المعالجة في الزراعة.

كلمات مفتاحية: إعادة استخدام المياه العادمة المعالجة، الوعي البيئي، المصادر المائية الزراعية، استخدام المياه التقليدية في الزراعة.

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جدول رقم (4) معدل عدد ثمار الزيتون للشجرة في الكيلوغرام الواحد

المعاملات	معدل عدد الثمار للشجرة	معدل عدد الثمار للكيلوغرام	معدل عدد ثمار الجول للشجرة	معدل عدد ثمار الجول للكيلوغرام
ماء وسماد	31200	400	3300	660
ماء	33700	556	2500	833
الشاهد (بعلي)	22600	667	2000	1000

4.3. امتصاص العناصر الغذائية:

تم فحص العناصر الكبرى والصغرى (N, P, K, Fe, Zn, Mn, Cu) في أوراق أشجار الزيتون في المعاملات المختلفة بتاريخ 20/ 10/ 2011. تبين نتائج تحليل العناصر الكبرى (النيتروجين والفسفور والبوتاسيوم) أن نسب هذه العناصر في أوراق الأشجار في المعاملات المروية والمضاف لها سماد اقل من نسبتها في الشاهد، وهذا يمكن تفسيره إلى أن إضافة السماد العضوي السائل أدى إلى زيادة كفاءة امتصاص هذه العناصر من التربة مما أدى إلى زيادة الإنتاج وبالتالي زيادة استهلاك هذه العناصر في مراحل التمثيل الغذائي. جدول (5) يبين نسب العناصر الغذائية الكبرى والصغرى في أوراق النباتات.

جدول رقم (5) نسبة العناصر الكبرى والصغرى في أوراق أشجار الزيتون

المعاملات	N (%)	P (%)	K (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
ماء وسماد	1.42	0.072	0.20	142.6	14.4	53	5.1
ماء	1.29	0.084	0.24	121	15	45	4.8
الشاهد (بعلي)	1.40	0.098	0.26	131	16.6	49.4	5.9

4. التوصيات:

- التوسع في الري التكميلي حيثما أمكن للمزارع بالموعد المناسب والطريقة المناسبة والكمية الصحيحة مع مراعاة الجدوى الاقتصادية لأثمان المياه والمردود الاقتصادي للماء.
- التوسع باستخدام الأسمدة العضوية السائلة مع مياه الري التكميلي بالكميات الموصى بها.
- فحص التوسع باستخدام التسميد العضوي السائل مع مياه الأمطار خلال أشهر الشتاء
- فحص امكانية اضافة أسمدة نيتروجينية كيماوية مع مياه الري التكميلي بتركيزات منخفضة PPM بالاضافة للأحماض الدبالية على أن تضاف لوحدها

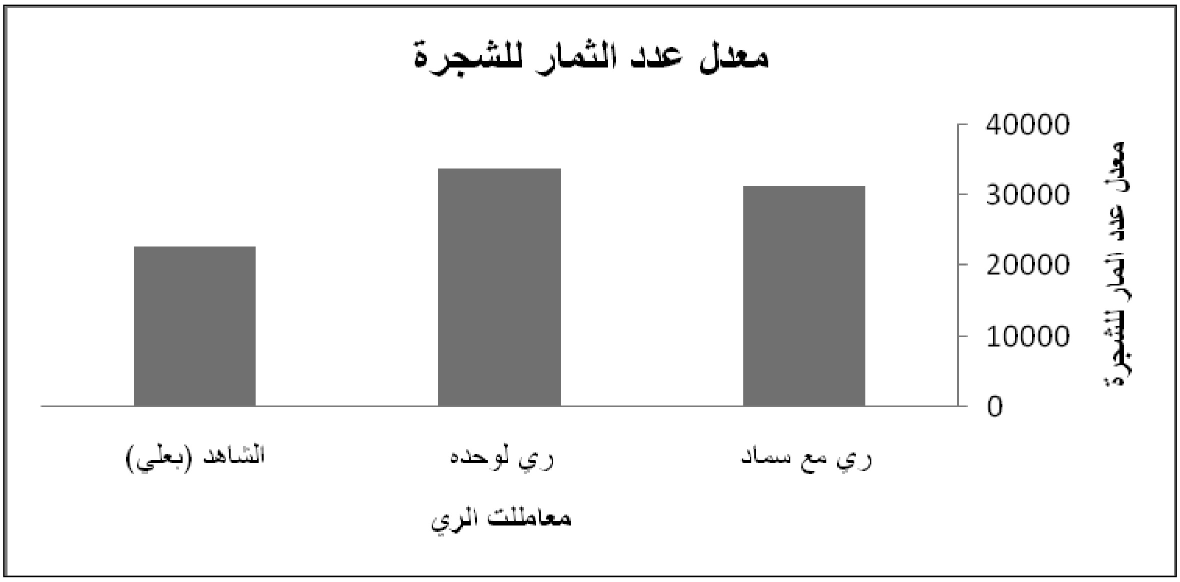
جدول رقم (3) معدل وزن الثمرة، معدل وزن النواه، ونسبة لب ثمار الزيتون

المعاملات	معدل وزن الثمرة	معدل وزن النواة	معدل وزن اللب	نسبة اللب إلى الثمرة	نسبة اللب إلى النواة
ماء وسماد	2.1 غم	0.54 غم	1.56 غم	74%	1:2.8
ماء	1.6 غم	0.47 غم	1.13 غم	71%	1:2.4
الشاهد (بعلي)	1.1 غم	0.43 غم	0.67 غم	61%	1:1.5

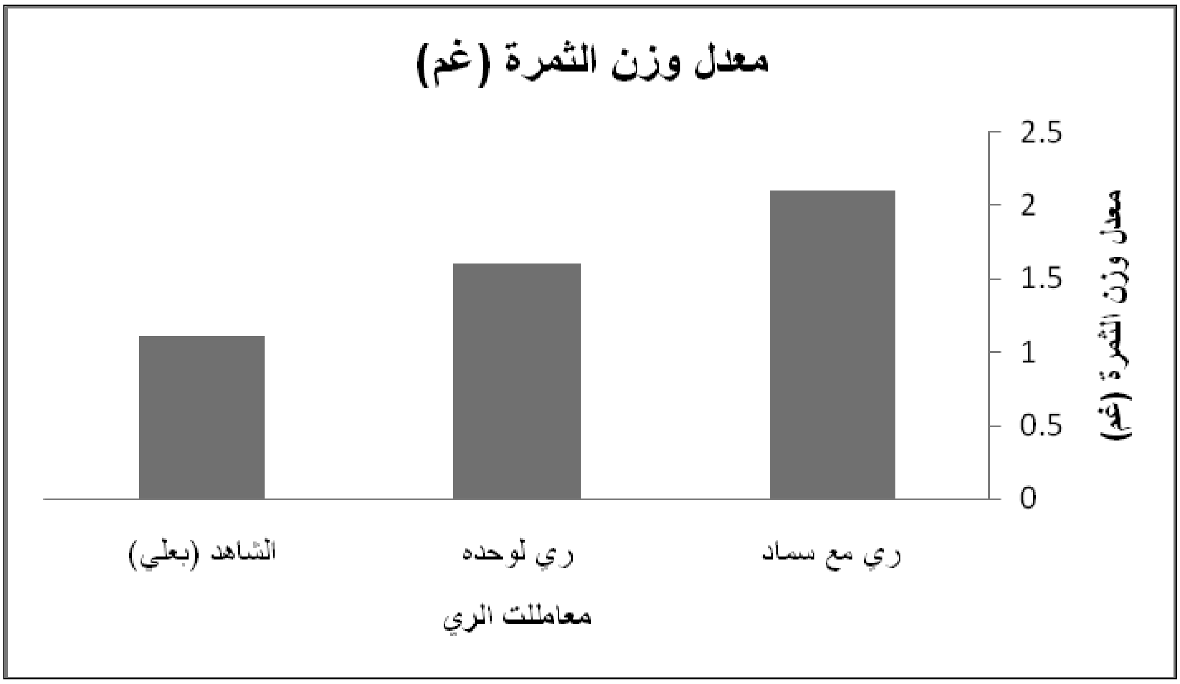
3.3. عدد الثمار :

تشير النتائج إلى أن معدل عدد الثمار للشجرة في المعاملات المروية والمضاف لها سماد أعلى من معدل عدد الثمار في الشاهد (بعلي) منحنى رقم (6) . بينما أظهرت النتائج أن معدل عدد الثمار في الكيلوغرام الواحد في المعاملات المروية والمضاف لها سماد أقل من معدل عدد الثمار في الشاهد (بعلي) . هذا بدوره يبين أن الري التكميلي مع إضافة السماد العضوي أدى إلى زيادة ملحوظة في حجم الثمار مما انعكس بشكل ايجابي على زيادة كمية إنتاج الثمار الكلي للدونم .

كذلك تشير النتائج إلى أن معدل عدد ثمار الجول في العاملات المروية والمضاف لها سماد أعلى من المعاملات المروية بالماء لوحده ومن الشاهد جدول رقم (4) . وهذا بدوره يعود إلى كبر حجم الثمرة في هذه المعاملة وسهولة تعرضها إلى الإصابة بذبابة الزيتون . كذلك لوحظ سقوط ثمار الزيتون في الشاهد في مرحلة مبكرة بسبب تعرض الأشجار إلى عجز مائي .

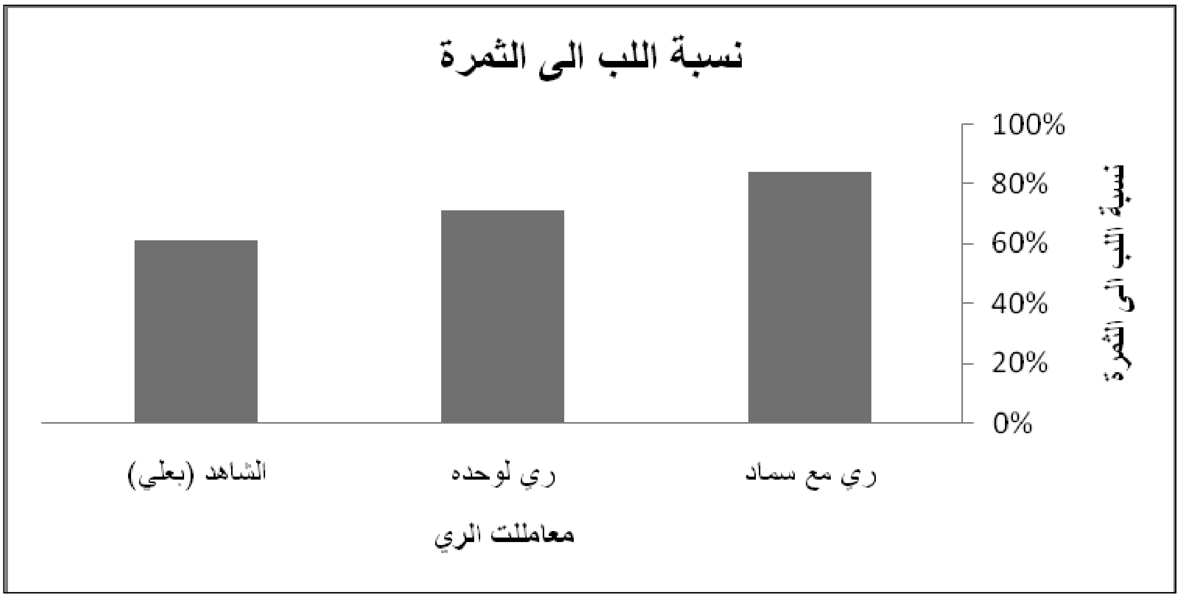


منحنى رقم (6) معدل عدد الثمار للشجرة تحت ثلاث معاملات ري

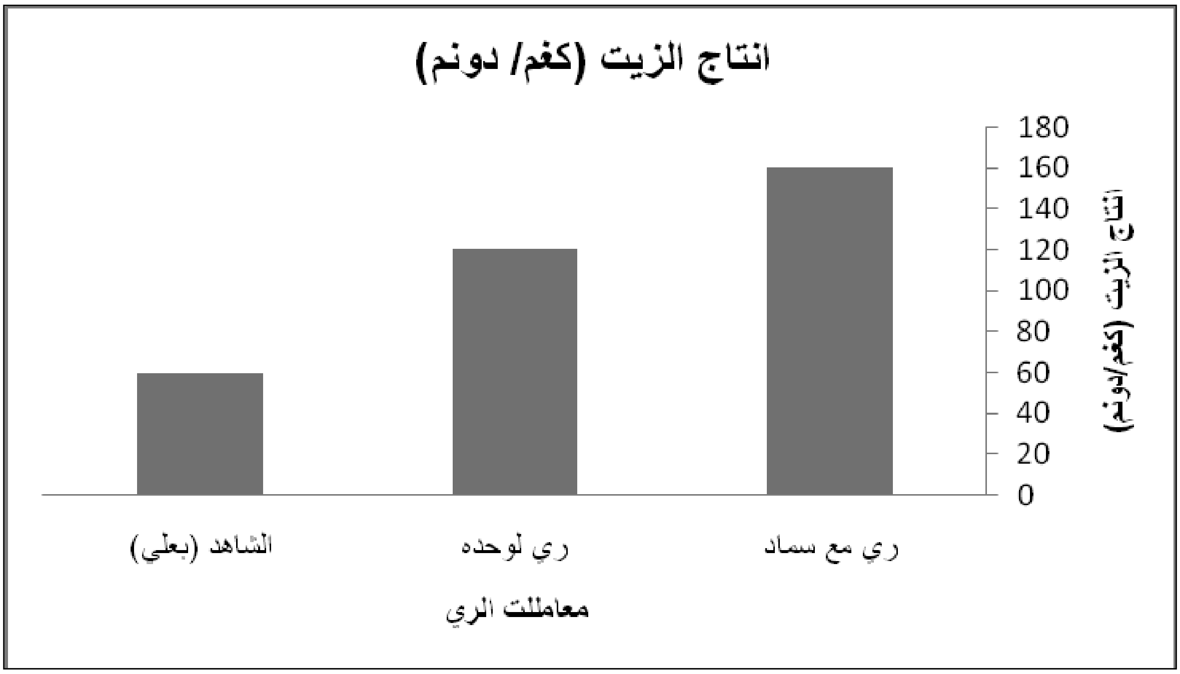


منحنى رقم (4) معدل إنتاج وزن الثمرة تحت ثلاث معاملات ري

كذلك أظهرت النتائج أن نسبة اللب إلى الثمرة الكاملة في المعاملات المروية بالماء والمضاف إليها سماد بلغت84%، بينما أظهرت النتائج أن نسبة اللب في المعاملات المروية بالماء لوحده بلغت 71%، أما نسبة اللب في الشاهد بلغت 61% منحنى رقم (5). هذه النتائج تشير إلى أن التدخل بالري التكميلي خلال فترة نمو الميزوكارب الثانية أدت إلى زيادة ملحوظة في نسبة لب الثمار والذي أدى بدوره إلى زيادة ملحوظة في كمية إنتاج الزيت.



منحنى رقم (5) نسبة اللب إلى الثمرة تحت ثلاث معاملات ري



منحنى رقم (3) معدل إنتاج الزيت للدونم تحت ثلاث معاملات ري

جدول رقم (2) معدل انتاج الثمار والزيت للشجرة ونسبة الزيت للوزن الرطب

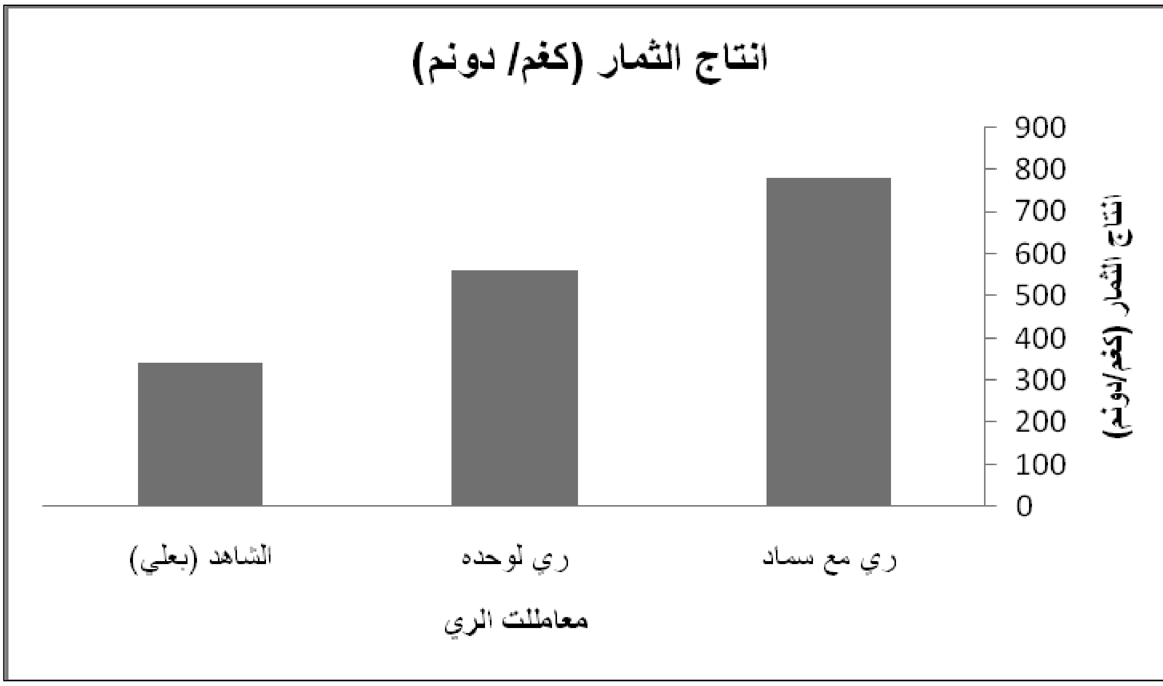
المعاملات	معدل انتاج الثمار للشجرة	معدل انتاج الزيت للشجرة	نسبة الزيت للوزن الرطب
ماء وسماد	78 كغم	16 كغم	20.5 %
ماء	56 كغم	12 كغم	21.4 %
الشاهد (بعلي)	34 كغم	6 كغم	17.6 %

إضافة إلى ما تقدم، فقد أظهرت النتائج عدم وجود تلون على الثمار في المعاملة المروية والمضاف لها سماد، ووجود بعض التلون على الثمار في المعاملة المروية بالماء لوحده، فيما ظهر تلون ملحوظ على الثمار في الشاهد (البعلي)، مما يدل على تعرض الأشجار في هذه المعاملة إلى عجز مائي بسبب نقص رطوبة التربة.

2.3. حجم الثمار:

أظهرت النتائج أن معدل وزن الثمرة في المعاملات المروية والمضاف لها سماد بلغت 2.1 غم، وبلغ معدل وزن الثمرة 1.6 غم في المعاملات المروية بالماء لوحده، أما معدل وزن الثمرة في الشاهد بلغ 1.1 غم منحنى رقم (4)، علماً بان النتائج تم حسابها قبل هطول الأمطار بتاريخ 13/ 10/ 2011.

أظهرت نتائج الدراسة أن معدل وزن نواة الثمرة في المعاملات المروية والمضاف لها سماد بلغت 0.54 غم، وبلغ معدل وزن النواة 0.47 غم في المعاملات المروية بالماء لوحده، أما معدل وزن النواة في الشاهد فقد بلغ 0.43 غم جدول رقم (3). هذه النتائج تبين انه لا يوجد فروقات كبيرة في وزن النواة ما بين المعاملات المختلفة وهذا يبين أن التدخل بالري بدأ بعد اكتمال تصلب النواة.



منحنى رقم (2) معدل إنتاج ثمار الزيتون للدونم تحت ثلاث معاملات ري

كذلك أظهرت نتائج الدراسة إلى أن معدل إنتاج الزيت في المعاملات المروية والمضاف لها سماد بلغ 160 كغم للدونم، والمعاملات المروية بالماء لوحده بلغ 120 كغم للدونم، أما الشاهد (بعلي) فقد بلغ معدل الإنتاج 60 كغم للدونم منحنى رقم (3). هذه النتائج تعزى إلى أن معدل وزن لب الثمار في المعاملة المروية بالماء والمضاف لها سماد بلغ حوالي ثلاثة أضعاف وزن لب الثمار في الشاهد (بعلي)، حيث من المعروف أن معظم الزيت يتخلق في لب الثمار. كذلك يبين جدول رقم (2) معدل انتاج الثمار والزيت للشجرة ونسبة الزيت للوزن الرطب.

تم إضافة مياه الري بمعدل 430 لتر/ الشجرة في كل ريه، وذلك خلال 7 ريات بتكرار كل أسبوعين مرة ابتداءً من تاريخ 15/ 7/ 2011 ولغاية تاريخ 6/ 10/ 2011. كمية المياه الكلية التي تم إضافتها خلال فترة الري بلغت 30 كوب/ الدونم. جدول رقم (1) يبين كمية ومواعيد الري.

جدول رقم (1) كمية مياه الري التي تم إضافتها خلال الموسم

تاريخ الري	14/ 7/ 2011	28/ 7/ 2011	11/ 8/ 2011	25/ 8/ 2011	8/ 9/ 2011	22/ 9/ 2011	6/ 10/ 2011
كمية الري(لتر/ الشجرة)	430	430	430	430	430	430	430

4.2. السماد العضوي السائل:

تم إضافة سماد عضوي سائل يحتوي على 12% حوامض ذبالية (هومية) بمعدل 250 ملم/ الشجرة أي ما يعادل 2.5 لتر/ دونم. كمية السماد تم إضافتها دفعة واحدة مع مياه الري خلال الرية الأولى بتاريخ 15/ 7/ 2011.

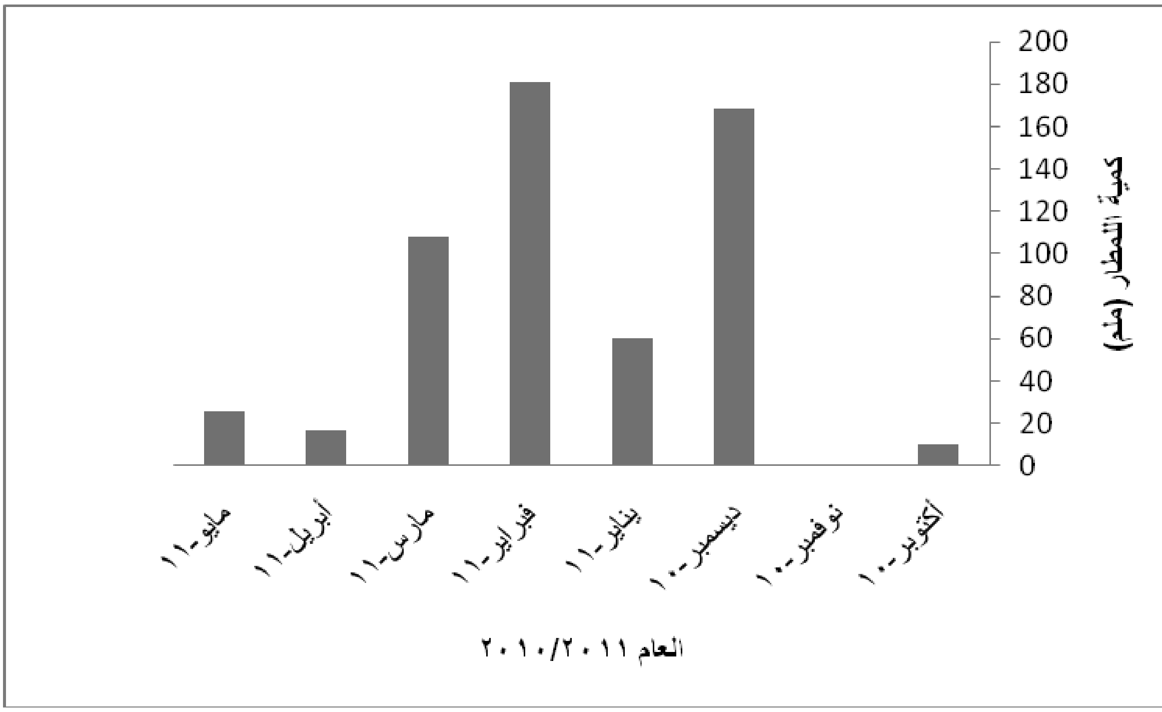
5.2. القياسات الحقلية:

تم إجراء العديد من القياسات الحقلية خلال مرحلة الإثمار ومرحلة القطاف على النحو التالي: 1) معدل إنتاج ثمار الزيتون (كغم/ الشجرة)، 2) معدل إنتاج الزيت (كغم/ الشجرة)، 3) معدل وزن الثمرة، 4) معدل وزن النواة، 5)، معدل عدد الثمار في الكيلوغرام، 6) معدل عدد ثمار الجول في الكيلوغرام 7) تركيز العناصر الغذائية في الأوراق، 8) معدل عدد ثمار الجول للشجرة، 9) معدل عدد الثمار للشجرة (تم حساب معدل عدد الثمار للشجرة عن طريق قسمة كمية الثمار الكلية للشجرة على معدل وزن الثمرة).

3. النتائج والمناقشة:

1.3. إنتاج ثمار الزيتون والزيت:

تشير نتائج الدراسة إلى أن كمية إنتاج ثمار أشجار الزيتون المروية بمعدل 30 كوب للدونم ومضاف لها سماد عضوي سائل بمعدل 2.5 لتر للدونم وصل إلى 780 كغم/ دونم، أما الأشجار المروية بالماء لوحده، فقد تبين أن معدل إنتاج الثمار وصل إلى 560 كغم/ دونم، بينما وصل معدل الإنتاج في الأشجار التي لم يتم معاملتها (الشاهد) إلى حوالي 340 كغم/ دونم منحنى رقم (2). هذه النتائج تبين أن الري التكميلي للأشجار بكميات قليلة مع إضافة السماد العضوي السائل أدى إلى مضاعفة إنتاج ثمار الزيتون مقارنة بالشاهد.



منحنى رقم (1) معدلات سقوط الأمطار الشهرية في منطقة عصيرة الشمالية- نابلس للعام 2010/ 2011

2.2. المعاملات:

تم اختيار مزرعة زيتون بمساحة 30 دونم مزروعة بأشجار زيتون صنف صوري. يتراوح عمر الأشجار فيها حوالي 70 سنة. تم تقسيم المزرعة إلى ثلاث معاملات، بحيث تتكون كل معاملة من 10 دونمات، بكثافة زراعه 10 أشجار/ دونم. المعاملات تم تقسيمها على النحو التالي: -

- المعالة الأولى: ري الأشجار بمعدل 30 متر مكعب للدونم، خلال 7 ريات مع إضافة السماد العضوي السائل مع مياه الري بمعدل 2.5 لتر/ دونم.
- المعاملة الثانية: ري الأشجار بمعدل 30 متر مكعب للدونم خلال 7 ريات.
- المعاملة الثالثة: الشاهد (بدون ري).

3.2. عمق الري:

تم تحديد موعد بدء الري التكميلي بناءً على فحص ومراقبة محتوى الرطوبة الأرضية للحقل، وفحص مدى اكتمال نمو وتصلب نواة الثمار، وبناءً على هذه المعطيات تم تحديد موعد بدء الري التكميلي من تاريخ 15/ 7/ 2011. تم توزيع برميل حديد سعة 200 لتر لكل شجرة، وتم ثقب البراميل بقطر 1سم لتوزيع مياه الري، وذلك لصعوبة توصيل نظام ري حديث بسبب جبلية المنطقة. كذلك تهدف عملية الري بهذه الطريقة إلى تقليل فقد المياه بواسطة التبخر، كذلك توصيل المياه إلى عمق 50 سم، حيث أن الطبقة السطحية من التربة (0-15 سم) تكون خالية من الجذور الشعرية الحية والتي تبدأ بالتخلق في بداية الربيع ثم تبدأ بالموت من أعلى إلى أسفل مع تقدم فصل الصيف.

الصيف يمكن اعتباره طريقة فعالة للمحافظة على النمو خضري وزيادة الإنتاج.

أشارت نتائج العديد من الدراسات إلى أن ري الزيتون يؤدي إلى زيادة ملحوظة في الإنتاج تصل إلى 100% مقارنة بالأشجار البعلية (Goldhamer, et. al., 1994) Pastor, et. al.,1998, Patumi, et al., 1999 وذلك تبعاً للظروف المناخية والصنف ومسافات الزراعة والعمليات الزراعية المتبعة. دراسات أخرى أشارت إلى أن حجم الثمار، نسبة اللب إلى النواة، حجم النواة، ونسبة الزيت في الثمار تأثرت بشكل ايجابي عند ري الأشجار (Costagli et al, . Grattan, et al., 2006 2003, Inglese et al 1996, Proietti and Antognozzi, 1996).

علاوة على ذلك فان الدراسات الحديثة تشير إلى انه ليس من الضروري توفير كافة احتياجات المياه السنوية لأشجار الزيتون، ولكن المطلوب هو توفير الاحتياجات الضرورية خلال فترات محددة من نمو الأشجار من اجل تجنب حدوث عجز مائي عند الأشجار وبالتالي محاولة زيادة إنتاج الثمار وكمية الزيت (Alegre et al., 2002 ,Moriana et al., 2003,). كذلك فقد أشارت نتائج الدراسة التي أجراها (Gucci et al., 2007) إلى أن ري أشجار الزيتون أدى إلى زيادة عدد الثمار للشجرة، زيادة الإنتاج الكلي (على مستوى الوزن الرطب والجاف)، زيادة وزن لب الثمرة، ونسبة الزيت في لب الثمار (على أساس الوزن الجاف) عند مرحلة الحصاد. كذلك أشارت الدراسة إلى انه لا يوجد فروقات معنوية في الإنتاج ما بين أشجار الزيتون المروية بشكل كامل، والمروية بنسبة 46% من الاحتياجات السنوية الكلية.

يهدف هذا البحث إلى دراسة اثر إضافة الري التكميلي لأشجار الزيتون وإضافة السماد العضوي السائل بعد مرحلة اكتمال تصلب نواة الثمار على إنتاج ثمار الزيتون، إنتاج الزيت، وامتصاص العناصر الغذائية الضرورية. حيث تتعرض أشجار الزيتون بعد هذه المرحلة إلى عجز مائي بسب انخفاض مستوى الرطوبة الأرضية والناتج عن التذبذب الحاد في معدلات سقوط الأمطار وسوء توزيعها في فلسطين من ناحية، وارتفاع دراجات الحرارة في فترة الصيف في السنوات الأخيرة من ناحية أخرى.

2. الأدوات والطرق:

1.2. وصف التجربة والموقع:

تم إجراء تجربة حقلية في منطقة عصيرة الشمالية- نابلس ابتداء من تاريخ 1/ 4/ 2011 ولغاية تاريخ 1/ 12/ 2011، وذلك لدراسة اثر الري التكميلي وإضافة السماد العضوي السائل على إنتاج ثمار الزيتون، إنتاج الزيت، وامتصاص العناصر الغذائية.

تشتهر منطقة عصيرة الشمالية بزراعة أشجار الزيتون وتقدر المساحة المزروعة بهذه الأشجار حوالي 15 ألف دونم، كما وتشكل زراعة الزيتون دخل للعديد من المزارعين في هذه المنطقة والتي يقدر تعدادها السكاني بحوالي 10 آلاف نسمة.

توصف منطقة عصيرة الشمالية بأنها جبلية وتعتمد معظم زراعة أشجار الزيتون فيها على سقوط مياه الأمطار والتي قدر معدلها السنوي للعام 2010 بحوالي 570 ملم. موعد الأزهار الكامل لأشجار الزيتون سجل بتاريخ 15/ 5/ 2011، ولوحظ اكتمال تصلب نواة الثمار بتاريخ 14/ 7/ 2011. منحنى رقم 1 يبين المعدلات الشهرية لسقوط الأمطار في منطقة عصيرة الشمالية خلال العام 2010/ 2011.

أثر الري التكميلي والتسميد العضوي السائل على إنتاج الزيتون

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المركز الفلسطيني للبحوث والتنمية الزراعية [1]
جامعة فلسطين التقنية- خضوري[2]

ملخص:

تم أجراء دراسة ميدانية في منطقة عصيرة الشمالية- نابلس خلال العام 2011، وذلك لدراسة أثر الري التكميلي وإضافة السماد العضوي السائل على إنتاج ثمار الزيتون، إنتاج الزيت وامتصاص العناصر الغذائية. ولإجراء هذه الدراسة، تم اختيار مزرعة زيتون بمساحة 30 دونم مزروعة بأشجار زيتون صنف صوري، وعمر الأشجار فيها حوالي 70 سنة. تم تقسيم الحقل إلى ثلاث معاملات، بحيث تتكون كل معاملة من 10 دونمات بكثافة زراعه 10 أشجار/ دونم. المعاملات تم تقسيمها إلى ثلاث معاملات على النحو التالي: - 1) المعاملة الأولى: ري الأشجار بمعدل 30 متر مكعب/ للدونم، مع إضافة السماد العضوي السائل مع مياه الري بمعدل 2.5 لتر/ دونم، 2) المعاملة الثانية: ري الأشجار بمعدل 30 متر مكعب/ للدونم، 3) المعاملة الثالثة: الشاهد (بعلي).

تم إضافة مياه الري بمعدل 30 متر مكعب/ دونم خلال 7 ريات، بتكرار كل أسبوعين مرة ابتداء من تاريخ 15/ 7/ 2011. تم إضافة سماد عضوي سائل بمعدل 2.5 لتر/ دونم دفعة واحدة مع مياه الري خلال الرية الأولى فقط.

تشير نتائج الدراسة إلى أن معدل إنتاج ثمار الزيتون في المعاملة الأولى بلغ 780 كغم/ دونم، وفي المعاملة الثانية بلغ 560 كغم/ دونم، بينما بلغ معدل الإنتاج في المعاملة الثالثة 360 كغم/ دونم. كذلك تشير النتائج إلى أن معدل وزن الثمرة في المعاملة الأولى بلغ 2.1 غم، والمعاملة الثانية بلغ 1.6 غم، أما المعاملة الثالثة فقد بلغ معدل وزن الثمار 1.1 غم.

كلمات مفتاحيه: ري تكميلي، سماد عضوي سائل، زيتون.

1. المقدمة:

تقدر المساحة المزروعة بأشجار الزيتون في فلسطين حوالي 45% من مساحة الأراضي الزراعية وحوالي 80% من مساحة الأراضي المزروعة بالأشجار المثمرة (الجابي، 2007). حيث تعتبر جميع مساحة الزيتون في فلسطين بساتين بعلية باستثناء مساحة قليلة تقدر بحوالي 15 ألف دونم تحت الري الكامل والمساعد في بعض مناطق الضفة الغربية وقطاع غزة وذلك بسبب شح المياه وصعوبة توصيلها إلى بساتين الزيتون.

يتعرض الزيتون في فلسطين إلى فترة طويلة من الجفاف ودرجات الحرارة العالية خلال فترة الصيف، خاصة في السنوات الأخيرة بسبب تأثر الأراضي الفلسطينية بالتغيرات المناخية التي أدت إلى تذبذب حاد في معدلات سقوط الأمطار وسوء توزيعها وارتفاع ملحوظ في درجات الحرارة والذي أثر بشكل كبير على إنتاج الثمار حيث انخفض معدل الإنتاج في الأربع سنوات الماضية ليصل إلى 14 ألف طن زيت (وزارة الزراعة، 2011). إضافة إلى ذلك فقد تبين أن النمو الخضري ونمو المجموع الجذري يتأثر بشكل سلبي تحت هذه الظروف (Togntti, et al., 2006). ولذلك فان الري التكميلي خلال فترة

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من الأهمية بمكان التزام السلطة الوطنية الفلسطينية الكامل ليس فقط بمتابعة وتقييم الإستراتيجية كأحد المتطلبات الأساسية لنجاح التنفيذ، ولكن أيضاً التزامها بمبدأ المساءلة والذي يرتبط بشكل مباشر بالشفافية واللذان يعززان بعضهما البعض ويسهمان أيضا بشكل مباشر في تحسين كفاءة وفاعلية وعدالة التنمية وإدارتها سواء في مؤسسات القطاع العام، القطاع الخاص، أو منظمات المجتمع المدني. إن المستهدفين والمستفيدين من نتائج التنمية وتدخلاتها لهم الحق والقدرة أكثر من غيرهم في الحكم على نوعية وملائمة وكفاءة الانجاز إذا ما امتلكوا المعلومات والحقائق اللازمة في الوقت المناسب لذا فانه في ظل غياب الشفافية فان المساءلة تكون ضعيفة كما وانه لن تكون هناك قيمة مرجوة للشفافية بدون وجود ادوات المساءلة العادلة التي تحكمها اطر قانونية وتشريعية وقضائية.

7. الخلاصة

من أهم النقاط التي تسجل لصالح هذه الإستراتيجية أنها بنيت واعدت من خلال الكوادر الوطنية الفلسطينية وبدون التدخل والتأثير من أي إطراف خارجية، كما أنها اعتمدت مبدأ المشاركة مع جميع إطراف الحقوق خاصة المزارعين الذين ساهموا مساهمة فاعلة في تحديد الأهداف والاحتياجات. وبالرغم من وجود بعض المبالغة في تقدير المشاريع المطلوبة، في خطة العمل، خاصة في قطاع غزة إلا إن هذا القصور تتحمله جميع الإطراف التي شاركت في إعداد خطة العمل ويتحمل واقع الانقسام السياسي جزءاً من المسؤولية في هذا الموضوع. وفي الاطار المؤسسي فمن المفروض ان تبدأ جميع المؤسسات بإعادة صياغة استراتجياتها وخططها لتكون متوافقة مع الإستراتيجية القطاعية الزراعية.

من بين الأهداف التي نصت عليها الإستراتيجية الزراعية فان الهدف الاستراتيجي الخاص بالموارد المائية، وهو تحسين إدارة مياه الري بكفاءة لتعظيم عائد المتر المكعب من مياه الري، يعتبر من الغايات الرئيسية التي يجب ضمانها لتحقيق التنمية لهذا القطاع. هذا الهدف يتم تحقيقه من خلال تبني السياسات الخاصة بزيادة المعروض وإدارة الطلب وتطوير الأطر القانونية والمؤسسية وخلق البيئة المناسبة لتطبيق مناهج الإدارة الرشيدة للموارد المائية المستخدمة في الزراعة، وتحفيز القطاع الخاص وتشجيعه للاستثمار في مشاريع المياه الزراعية وتكثيف ودعم أنشطة الإرشاد الزراعي والأبحاث ونقل التكنولوجيا.

من الملفت للنظر في الخطة الوطنية الفلسطينية 2011–2013 ان هناك اهتماماً واضحاً في قطاع الزراعة وان هذا القطاع كان له النصيب الاكبر في المشاريع والانشطة المزمع تنفيذها في الخطة الوطنية. فاللمرة الاولى تتربع الزراعة على راس نشاطات القطاع الاقتصادي بنسبة 43% وهي تعادل نسبة 13.4% (منها 3.2% مخصصة للمياه الزراعية) من مجموع الموازنة الكلية المقدرة للخطة الوطنية 2011–2013.

أن ضمان النجاح الفعلي للاستراتيجيات والخطط ذات الصلة بموضوع المياه لا يتوقف فقط على وضع الآليات المناسبة للمتابعة والتقييم وتحديد المؤشرات الدقيقة والواقعية والقابلة للقياس وربطها بشكل مباشر بالافتراضات الواجب توفرها لإنجاح تنفيذ الإستراتيجيات والخطط، بل يجب ان يكون مرتبط مع الجهود لتجسير الفجوة بين اصحاب العلاقة وان يكون هناك التزاماً فعلياً من قبل جميع الأطراف ذات الصلة بالاطر العامة التي تم الاتفاق عليها وبتنفيذ الخطط. ان التقليل من عوامل المخاطرة في العمل الزراعي والتي تعتبر مرتفعة مقارنة بالقطاعات الأخرى، وتحقيق نسبة نجاح مقبولة في تنفيذ خطط القطاعات الأخرى يعتبر اساساً في اشراك القطاع الخاص وزيادة حجم الاستثمار في قطاع المياه. كما ان توفير حد ادني من الاستقرار السياسي والاقتصادي، والتقليل من أثر الإجراءات المعيقة المفروضة من قبل الاحتلال الإسرائيلي، وتوفير الموازنات والسيولة المالية، والنجاح في التقليل من تأثير التقلبات المناخية على المزارعين والزراعة في فلسطين يعتبر من العوامل المهمة والمساعدة في التنفيذ الكفوء لعملية التخطيط واستكمال الخطط المرسومة للارتقاء في قطاع المياه الزراعية في فلسطين.

6. موضوع تعرفة المياه الزراعية هي من المواضيع ذات الأولوية فهي من أهم الأدوات التي من الممكن استخدامها لرفع نسبة كفاءة استخدام المياه فنياً واقتصادياً على مستوى المزرعة أو النقل أو التوزيع وهي الأسلوب الصحيح للتشجيع على تغيير الأنماط الزراعية من التقليدية الى المحاصيل ذات المردود النقدي للمزارعين. يجب هنا ان لا يتم استخدام هذا الأسلوب بشكل خاطيء ومبالغ به لان في معظم دول الإقليم أسعار مياه الري لا تتجاوز 7% من كلفة الإتاحة للمياه (جلوفور وهنتر 2010).

7. أن عزل موارد مائية خلف جدار الضم والتوسع أدى الى تقليل كمية المياه المتاحة لهذه المناطق حيث تم عزل ومصادرة 50 بئرا زراعيا، منها 36 بئرا عزلت خلف الجدار و 14 بئرا موجودة في المنطقة العازلة للجدار، بمعدل ضخ تجاوز معدل الـ 7 مليون متر مكعب سنوياً (عداله وحثناوي 2007)، علما بان المعلومات المتوفرة في وزارة الزراعة حول الآبار الزراعية المعزولة خلف الجدار بلغت 20 بئر زراعي عامل (وزارة الزراعة / قاعدة المعلومات 2011) ولهذا وضع هذا الموضوع على قمة سلم الأولويات لأهميته السياسية.

8. استخدام التقنيات الحديثة في أنظمة الري أدى إلى تقليل الفاقد من المياه وإتاحة كميات أكبر من المياه لاستخدامها في ري مساحات محصولية إضافية، وان التحول في أنظمة الري من القنوات المفتوحة في الينابيع الى نظام الري بالأنابيب المغلقة قد يؤدي الى زيادة كمية المياه المتاحة للري وتقليل الفاقد بنسبة تصل إلى حوالي 35% (دراسة الجدوى لتنمية وإدارة المصادر المائية في منطقة وادي الأردن، 2008).

9. ان استخدام المياه غير التقليدية، المياه المسوس، في زراعة بعض الأصناف أدى إلى إتاحة كمية أكبر من المياه العذبة لاستخدامها في زراعة محاصيل حساسة لملوحة التربة ومياه الري وغالبا ما تتميز بانها محاصيل ذات عائد اقتصادي مرتفع، كما ان خلط المياه شبه المالحة بالمياه العذبة لري المحاصيل أدى إلى تبني نهج جديد في ادارة المياه والاراضي المالحة يهدف بالنهاية الى استدامة الموارد وزيادة كمية ونوع المنتج الزراعي (وزارة الزراعة / قاعدة المعلومات 2011). ولا يمكن ان نغفل الجهود المبذولة في استخدام تقنيات الحصاد المائي التي ادت الى زيادة في كميات المياه المتاحة للري التكميلي وهذا أنعكس ايجابيا على انتاج المحاصيل كماً ونوعاً وعلى زيادة المساحة المزروعة.

إن سيطرة إسرائيل شبه الكاملة على الموارد المائية الفلسطينية جعل من أزمة المياه حالة مزمنه في غزة وفي أجزاء واسعة من الضفة الغربية، وهذا جعل جميع المؤسسات العاملة تنتهج نظم الإغاثة والطوارئ الذي أثبتت التجارب ليس عدم فعاليتها وحسب بل نتج عنها زيادة في الإجهاد والضعف الاقتصادي والاجتماعي والبيئي (البنك الدولي 2009). لقد نوه التقرير المذكور بالمشاكل الرئيسية القائمة والتي تعيق التخطيط المستدام مثل غياب نظام الإدارة الرشيدة، ووجود قوى وقدرات غير متكافئة إشارة إلى الاحتلال الإسرائيلي، والتي تعيق التنمية والتخطيط الرشيد للموارد المياه الفلسطينية والبنية التحتية والبيئة الاستثمارية، الأمر الذي يؤدي إلى خلل في الجدوى الاقتصادية بسبب ارتفاع التكاليف. إن القيود المفروضة من قبل سلطات الاحتلال بالإضافة إلى ضعف القدرات المؤسسية لمعظم الجهات الفاعلة في القطاع، وتطوير الشراكات يخضع لقيود سياسية، وهي حبيسة سياسات ردود الفعل بدلا من العمل الاستراتيجي الممنهج (البنك الدولي 2009).

بالرغم من تركيز الإستراتيجية الزراعية على عملية المتابعة والتقييم من خلال وضع الآليات المناسبة والمؤشرات الدقيقة والواقعية والقابلة للقياس وربطها بشكل مباشر بالافتراضات الواجب توفرها لإنجاح تنفيذ الإستراتيجية، إلا أن ضمان النجاح الفعلي لهذه الإستراتيجية يتوقف على توفر الآتي: الالتزام الفعلي للأطراف ذات الصلة بالقطاع بتنفيذ الخطط، التقليل من عوامل المخاطرة في العمل الزراعي والتي تعتبر مرتفعة مقارنة بالقطاعات الأخرى، نسبة نجاح مقبولة في تنفيذ خطط القطاعات الأخرى، الاستقرار السياسي والاقتصادي، التقليل من أثر الإجراءات المعيقة المفروضة من قبل الاحتلال الإسرائيلي، الموازنات والسيولة المالية، وأخيراً النجاح في التقليل من تأثير التقلبات المناخية على المزارعين والزراعة في فلسطين.

والمؤسسات الدولية من جهة أخرى ثانياً . وهنا يأتي الدور المهم في تعزيز مفاهيم الحوكمة في هذا التأطير المؤسسي مثل المساءلة والشفافية والنزاهة ، وتضافر الجهود للدفع باتجاه السياسات التنموية بدلاً من الاغاثية والطارئة .

2 . هناك حاجه ملحة لبناء قاعدة معلومات خاصة بموضوع المياه الزراعية وان يكون هناك توافق ومعرفة بمعايير ومواصفات تجميع وتخزين البيانات وتعزيز القدرة على الوصول الى هذه المعلومات من قبل المعنيين والإطراف ذات العلاقة . على سبيل المثال فان عدة دراسات ومراجع لا تفرق بين المساحات المحصولية والمساحات الفعلية (جدول 4) وهذا عادة ما يسبب الإرباك للعديد من التوصيات والخلاصات عند إجراء الدراسات والنماذج الرياضية .

3 . من مجموع مساحة الأراضي المروية في الضفة الغربية وقطاع غزة (الجدول 4) يتبين ان المياه هي العامل المحدد للتنمية الزراعية في الضفة الغربية والأرض هي العامل المحدد للتنمية الزراعية في قطاع غزة . إن إمكانية زيادة رقعة الأراضي المروية في غزة محدودة نوعاً ما ولهذا يجب التركيز على سياسات تطوير إدارة الطلب بشكل اكبر من سياسة زيادة العرض .

4 . بالرغم من وجود الجزء الأكبر من الأراضي المروية في أريحا والأغوار ، الا ان هذا لا ينفي ويقلل من الإمكانيات الكبيرة للتوسع في هذه المنطقة ، بسبب خصوصية المناخ ووجود أكثر الينابيع . كما ان الجدول 4 يشير إلى الإمكانيات الكبيرة للتوسع في مناطق جنين وطوباس وطوكرم .

5 . بخصوص التوصيات بالتحول من زراعة المحاصيل ذات الاحتياجات العالية الى المحاصيل ذات الاحتياجات المنخفضة فمن المفضل اعتماد مبدأ الميزة النسبية بدلاً من الأخذ بالاحتياجات المائية فقط وذلك لافتقادها للشمولية .

جدول رقم (4) مساحات والنسب المئوية للأراضي المروية و الأراضي القابلة للري

المحافظة	الاراضي المروية		الاراضي القابلة للري	
	المساحة دونم	%	المساحة دونم	%
جنين	20,727	7.7	163,000	21.9
طوباس	20,160	7.5	82,000	11
طولكرم	16,927	6.3	27,500	3.7
قلقيلية	9,095	3.4	17,500	2.4
سلفيت	1,566	0.6	49,000	6.6
نابلس	9,827	3.6	68,000	9.1
رام الله والبيرة	988	0.4	35,000	4.7
القدس	103	0	3,000	0.4
أريحا والأغوار	45,607	17	45,000	6.0
بيت لحم	1,844	0.7	12,000	1.6
الخليل	10,022	3.7	110,000	14.8
الضفة الغربية	136,866	51	612,000	82
قطاع غزة	132,826	49	133,000	17.9
الأراضي الفلسطينية	269,692	100	745,000	100

المصدر : الإحصاءات الزراعية / الجهاز المركزي للإحصاء2009

للسنوات 2011 و 2012 و 2012 على التولي. من الجدير بالذكر هنا بان هذه المخصصات لا تتضمن المياه المخصصة للشرب والمياه العادمة، حيث خصص لهما 134 و 72 مليون دولار خلال سنوات الخطة على التوالي. تشتمل مشاريع المياه العادمة على بناء شبكات الصرف الصحي وإنشاء محطات معالجة وإعادة استخدام للمياه العادمة في الزراعة (الخطة الوطنية الفلسطينية 2011-2013).

6. النقاش والاستنتاجات

إن وجود تناقض وعدم وضوح في المعطيات والإحصاءات لا يلغي دور قطاع الزراعة في إن يكون مستقبلا المحرك والدافع للتنمية الاقتصادية في فلسطين. فمن ناحية تشير المعلومات إلى إن مساحة الأراضي المزروعة بشكل عام والأراضي المزروعة بالخضروات والمحاصيل الحقلية قد تناقصت بمعدل 4%، 10% و 13% على التوالي (عدالة وحثناوي 2007)، يقابلها من الناحية الأخرى إحصائيات تشير إلى زيادة في المساحة المحصولية للزراعة المروية من 200.7 ألف دونم في عام 1999 (الإستراتيجية الزراعية 2000) الى 269 الف دونم في عام 2007 (الجهاز المركزي للإحصاء الفلسطيني/ الإحصاء الزراعي 2008). وبالرغم من ان البيانات تشير إلى تناقص في كميات المياه المخصصة لأغراض الري من 172 مليون متر مكعب سنويا في عام 1999 (الإستراتيجية الزراعية 2000) إلى 150 مليون متر مكعب عام 2007 (الجهاز المركزي للإحصاء الفلسطيني/ الإحصائيات المائية 2008) و (البنك الدولي 2009)، إلا أن هناك زيادة في كمية الإنتاج للزراعة المروية وزيادة في القيمة المضافة للإنتاج الزراعي من 431 مليون دولار في عام 1999 إلى 876 مليون دولار في عام 2008 (الجهاز المركزي للإحصاء الفلسطيني/ الإحصاء الزراعي 2009). إن هذه المعطيات ما هي إلا مؤشر واضح ودليل على تعظيم العائد من استخدام المتر المكعب من المياه في الري (الكفاءة الاقتصادية) للمياه المستخدمة في الزراعة وعلى زيادة كفاءة استخدام مياه الري (الكفاءة الفنية). هذه القراءات والاستخلاصات تشير إلى وجود فرصة سانحة لقطاع الزراعة لزيادة مساهمته في التنمية الاقتصادية في فلسطين في حال توفر مياه إضافية ووجود رؤية واضحة لأنواع الأنماط الزراعية المطلوبة مستقبلا وتوفير بيانات وإحصائيات دقيقة لمعرفة أهمية ودور قطاع الزراعة في تقليل الفقر، وزيادة فرص العمل، وتحسين الدخل والأمن الغذائي.

إن تطبيق مفاهيم الإدارة المتكاملة للموارد المائية الزراعية قد واجه العديد من المعوقات والمشاكل التي تصنف إلى حزمتان، أولها هو المعوقات والمشاكل بسبب الاحتلال الاسرائلي للأراضي الفلسطينية وثانيها هو المعوقات والمشاكل التي مصدرها الجانب الفلسطيني نفسه، وبدون تحديد طرف معين لان الإدارة لهذه الموارد هي مسؤولية جماعية تقع على كاهل جميع الإطراف العاملة والمعنية بالموارد المائية الزراعية. إن عدم تحديد حصة القطاع الزراعي من المياه وتحديد الاحتياجات المستقبلية بشكل علمي أدى إلى خلل في نظم الإدارة مما جعل الاهتمام ينصب على السياسات الخاصة بإدارة الطلب فقط. ويتحمل المزارعين واصحب الآبار جزء من المسؤولية بسبب التعديات والتجاوزات على الحصص المائية والحفر العشوائي للآبار ووجود ثقافة سلبية ناتجة عن تراكمات طويلة سببها الاحتلال، ويتحمل القطاع الخاص حصة من المسؤولية بسبب الإحجام عن الاستثمار في هذا القطاع بمعزل عن الدعم والمساعدات والأموال الخارجية. هذا النهج قابلة فرض أجندات وشروط للدول المانحة ساهمت في زيادة الفجوة بين المؤسسات الحكومية ومؤسسات المجتمع المدني وخلق حالة من الفوضى بسبب تنفيذ المشاريع العشوائية ذات المردود السلبي على قطاع الزراعة المروية. إن دور المؤسسة الحكومية وخاصة وزارة الزراعة خلال المرحلة المقبلة يجب إن يتركز في تقييم الجدوى الاقتصادية للأموال التي أنفقت على قطاع المياه الزراعية خلال العقد الماضي ووضع أسس جديدة لتقييم القيمة الاقتصادية للمياه كواحد من أهم مدخلات الإنتاج في القطاع الزراعية أخذين في الاعتبار جميع العوامل الاجتماعية والتاريخية والثقافة المجتمعية للمياه.

بالرغم من ان هذه الدراسة لا يمكن ان تغطي جميع جوانب موضوع السياسات الخاصة بالمياه، إلا إن هذا المؤتمر سيشكل محطة مهمة في وضع بعض النقاط والملاحظات على طاولة النقاش وهي ستشكل مدخلاً مهماً لبلورة أسس المعالجة ووضع الحلول المناسبة لهذه المواضيع والتي هي كالتالي:

1. ضرورة مأسسة قطاع المياه الزراعية في فلسطين على المستويات السياسية والتنظيمية والتشغيلية وذلك دعماً لتنسيق الجهود فيما بين المؤسسات العاملة في هذا القطاع أولا، وما بين هذه المؤسسات من جهة مع الجهات المانحة

السياق ونظرا لأن تحديد مؤشرات تقييم ومتابعة دقيقة تعتمد كما ذكر سابقا على الموازنات الكلية السنوية على مستوى النشاط والمشروع والتي سيتم توفرها خلال سنوات الخطة –2011 2013 ، فان المؤشرات العامة والقطاعية التالية سيتم إعادة تقييمها خلال سنوات تنفيذ الخطة :

1. زيادة نسبة الاكتفاء الذاتي من المنتجات الزراعية المحلية بنسبة 5% بنهاية عام 2013 .
2. تحسين القيمة المضافة للقطاع الزراعي بحيث تصل إلى مليار دولار بنهاية عام 2013 .
3. زيادة قيمة الصادرات الزراعية ، لتصل إلى (60) مليون دولار بنهاية عام 2013 .
4. استكمال إصدار وتعديل التشريعات الزراعية .
5. إعادة هيكلية وتنظيم عمل وزارة الزراعة وإنشاء المجالس الإشرافية والسلعية .

أما بخصوص المؤشرات الخاصة بموضوع المياه الزراعية وكما وردت في تقرير الموارد الطبيعية (وزارة الزراعة / تقرير الموارد الطبيعية 2010) فهي كالتالي :

- استكمال انجاز الأنظمة والقوانين اللازمة لإدارة وتنمية وحماية الموارد المائية .
- كمية المياه المتاحة للزراعة سواء كانت مياه عذبة أو غير تقليدية .
- نسبة المياه المستخدمة في الزراعة إلى عدد السكان .
- عدد المشاريع المائية الزراعية التي تم تنفيذها .
- الزيادة في مساحة الأراضي المروية ونسبتها من الأراضي القابلة للري .
- كمية المياه التي تم توفيرها من الفاقد .
- انخفاض كلفة تزويد وحدة مياه الري .
- كمية المياه المحصودة سنوياً .
- نسبة مساهمة الزراعة المروية في الناتج القومي .

5 . الخطة الوطنية الفلسطينية 2011 – 2013

لقد أدت هذه الجهود إلى دمج الإستراتيجية الزراعية وخطة العمل المنبثقة في خطة التنمية الوطنية (2011 – 2013) التي ركزت على تنمية الأركان الأربعة : الحكومة والواقعي الاجتماعي والاقتصادي والبنية التحتية بميزانية كلية قدرت بـ 1.326 مليار دولار . ومن أصل حصة القطاع الاقتصادي التي بلغت 412 مليون دولار (31% من الموازنة الكلية)، كان للزراعة والتنمية الريفية النصيب الأكبر في هذا القطاع حيث بلغت الميزانية المقترحة لتنفيذ خطة الإستراتيجية الزراعية 178 مليون دولار وهي تعادل نسبة 43% من القطاع الاقتصادي . ما يميز هذه الخطة هو وجود قطاع الزراعة على قمة الأهمية الاقتصادية ويليه قطاع الصناعة بنسبة 29% ومن ثم السياحة بنسبة 12.5% (الخطة الوطنية الفلسطينية 2011–2013) .

فيما يتعلق بالمياه الزراعية والري ، فان ما تم تخصيصه لهذا الموضوع في القطاع الاقتصادي ، (42.5 مليون دولار من مجموع ما خصص للزراعة 178 مليون دولار) يعادل نسبة 24% وزعت على 3 سنوات وهي 7.5 و 13.9 و 21.1 مليون دولار

4. إعادة تأهيل وإنشاء خطوط النقل (107 كم) في جميع المحافظات بقيمة 2.3 مليون دولار .

5. إنشاء خزانات معدنية سعة 375 كوب (عدد 135) في جميع المحافظات بقيمة 2.2 مليون دولار .

6. توزيع خزانات بلاستيك 5 كوب (عدد 100) في قرى شرق القدس بقيمة 40.1 الف دولار .

7. إعداد البرامج الإرشادية وحملات التوعية الإعلامية في جميع المحافظات بقيمة 64.7 آلف دولار .

8. إنشاء محطات رصد مناخي زراعي في جميع المحافظات بقيمة 481.3 آلف دولار .

9. تأهيل الآبار (عدد 10) في محافظات قطاع غزة بقيمة 213.9 آلف دولار .

10. إعادة استخدام المياه العادمة في الزراعة (4 محطات) في محافظات قطاع غزة بقيمة 374.3 مليون دولار .

11. تشجيع الحصاد المائي (عدد 100 بركة أسمنتية) في محافظات قطاع غزة بقيمة 534.8 آلف دولار .

12. تصليح شبكات الري (10000 دونم) في محافظات قطاع غزة بقيمة 1.34 مليون دولار .

13. إنشاء محطات رصاد جوية في محافظات قطاع غزة بقيمة 160.4 آلف دولار .

14. إنشاء خطوط ناقله للمياه (60 كم) في محافظات قطاع غزة بقيمة 160.4 الف دولار .

3.2.4 . الأنشطة التي ستنفذ تحت سياسات ذات صلة بالتغير المناخي وبرامج التنمية الريفية المتكاملة :

1. برنامج إنشاء نظام الإنذار المبكر في جميع المحافظات بقيمة 267 الف دولار .

2. برنامج تنمية مرج صانور بقيمة 15.2 مليون دولار .

المؤشرات ونظم التقييم والمتابعة :

ستكون عملية التقييم والمتابعة احد الوسائل والأدوات الرئيسية التي ستساهم في تحسين الأداء والإدارة من خلال قياس مدى الانجاز والانحرافات الايجابية والسلبية للمشاريع والخطة، وبالتالي تحقيق أهدف الخطة بسوية وكفاءة عاليتين. وحيث إن أنشطة المتابعة والتقييم ستتم على مستويات مختلفة سواء كان على مستوى المشروع، البرنامج، المحافظة، القطاع الفرعي، المؤسسة وكامل الخطة وعلى مراحل زمنية مختلفة، فانه من الأهمية بمكان، بالإضافة إلى اعتماد المؤشرات التي ستشكل أساسا للقياس، تدعيم البنية المؤسسية للتقييم والمتابعة على المستويات المختلفة ومراعاة موائمة وتماشي نظام متابعة وتقييم الخطة ومشاريعها مع الأنظمة والآليات ذات العلاقة (خطة عمل قطاع الزراعة 2011–2013) وبشكل خاص :

1. أنظمة المتابعة والتقييم وقواعد البيانات المعتمدة في وزارة التخطيط والتنمية الإدارية بما في ذلك نظام DARP (Dynamic Asset Replacement Planning)).

2. أنظمة المتابعة والتقييم وقواعد بيانات وزارة الزراعة والقطاع الزراعي وبشكل خاص نظام APIS (Agricultural Projects Information System)

3. أنظمة المتابعة والتقييم المعتمدة من قبل الدول المانحة و الشركاء الآخرين .

كما ويتوجب مراعاة التسلسل المنطقي عند تصميم وإعداد مؤشرات التقييم والمتابعة حيث إن انجاز وتنفيذ الأنشطة والمشاريع سيؤدي إلى تحقيق أهداف التدخلات وان تحقيق أهداف التدخلات بدورة سيؤدي إلى تحقيق السياسات والتي بمجموعها ستؤدي إلى تحقيق هدف استراتيجي، ومجموع الأهداف الإستراتيجية ستساهم في تحقيق رؤية القطاع الزراعي. في هذا

جدول (3) توزيع الأنشطة الخاصة حسب الأهمية والموقع والكلف (ألف دولار)

الأنشطة	تدرج الأهمية من (1-5)	المواقع	وحدة النشاط	الكلفة الكلية
إعادة تأهيل الآبار الجوفية	2	طولكرم والأغوار وقلقيلية	15 بئر	802.1
تأهيل الينابيع	3	الخليل	5 ينابيع	13.4
حفر آبار جمع	1	جميع المحافظات	1550 بئر	4090.9
تأهيل آبار الجمع	1	جميع المحافظات	710	911.2
توزيع شبكات ري	2	القدس وأريحا	120	32.1
تطوير آبار المياه الزراعية	1	محافظات غزة	300	4812.8
المجموع				10662.6

المصدر: خطة عمل قطاع الزراعة 2011-2013

2.4. الأنشطة التي ستنفذ تحت إستراتيجية الإدارة الكفؤة والمستدامة للموارد الطبيعية في الأراضي الفلسطينية

أ. الأنشطة التي ستنفذ تحت سياسة زيادة وفرة المياه وتحسين إدارة العرض:

1. حفر آبار جوفية (عدد 33) في المحطات الزراعية وفي مناطق أريحا ونابلس وجنين وطوباس بقيمة 7.06 مليون دولار.
2. إعادة تأهيل الآبار الجوفية (عدد 66) في محافظات قلقلية وطوباس وجنين وأريحا و نابلس بقيمة 4.4 مليون دولار.
3. إعادة تأهيل الينابيع (عدد 69) في محافظات الضفة بقيمة 1.5 مليون دولار.
4. إنشاء آبار جمع 70 كوب (عدد 4050) في محافظات الضفة بقيمة 16.2 مليون دولار.
5. إعادة تأهيل آبار الجمع (عدد 290) في محافظات الضفة بقيمة 465 آلف دولار.
6. إعادة تأهيل آبار جمع كبيرة 500 كوب (عدد 50) في بيت لحم بقيمة 267 آلف دولار.
7. تحلية واستخدام المياه المالحة في محافظة أريحا بقيمة 9.893 مليون دولار.
8. معالجة المياه العادمة واستخدامها في الزراعة في محافظات الضفة بقيمة 10.695 مليون دولار.
9. إنشاء وإعادة تأهيل البرك الترابية في محافظة أريحا بقيمة 120 آلف دولار.
10. إنشاء السدود في محافظتي أريحا وطوباس بقيمة 1.872 مليون دولار.
11. إنشاء حواجز ترابية صغيرة في محافظتي دورا والقدس بقيمة 32 آلف دولار.
12. تمكين مشاريع الحصاد المائي لمربي الثروة الحيوانية في محافظات الضفة بقيمة 14.513 مليون دولار.

2.2.4. الأنشطة التي ستنفذ تحت سياسة تحسين إدارة الطلب على المياه الزراعية:

1. تحديد وتطوير ومراجعة تعرفة المياه الزراعية بقيمة 10.7 ألف دولار.
2. وضع عدادات مياه زراعة أوتوماتيكية (عدد 4000) بقيمة 1.6 مليون دولار.
3. رفع كفاءة الري الحقلي (25000 دونم) في جميع المحافظات بقيمة 6.7 مليون دولار.

وكما هو وارد في الجدول 1 فان التكاليف المطلوبة لتنفيذ خطة العمل قدرت بـ 1.523 مليار دولار أميركي سيتم تمويلها من موازنة السلطة والمانحين ومنظمات المجتمع المدني والقطاع الخاص، ويبين الجدول (2) توزيع الموازنات حسب القطاعات الفرعية والأهداف الإستراتيجية. ومن الجدير بالذكر، فإن حصة مشاريع الموارد المائية من الميزانية المقدرة كان 483 مليون دولار وهي تعادل نسبة 31.7%. وقد تم تقسيم الأنشطة/ المشاريع حسب الأهمية (جدول 3) من 1-5 من الأهم فالأقل أهمية وذلك طبقا لمؤشرات ومعايير محددة. كما وتضمنت الخطة آلية لمتابعة وتقييم الخطة لضمان حسن التنفيذ والانجاز في إطار من الشفافية والمساءلة.

جدول (2) توزيع الموازنات حسب القطاعات الفرعية والأهداف الإستراتيجية (بالمليون دولار).

#	الأهداف الإستراتيجية	القطاعات الفرعية					
		المصادر الطبيعية	الإنتاج النباتي	الإنتاج الحيواني	الخدمات الزراعية	البناء المؤسسي	المجموع
1	صمود وتمسك المزارعين بالأرض والبقاء في الزراعة قد تعزز	31	48.4	81.8			161.2
2	الموارد الطبيعية في الأراضي الفلسطينية مدارة بكفاءة وبشكل مستدام	524.6		2.1			526.7
3	لدى القطاع الزراعي إطارا مؤسسيا ملائماً وقانونيا متكاملاً وقوى بشرية مدربة ومؤهلة تساهم في إنهاء الاحتلال وإقامة الدولة					15.8	15.8
4	إنتاجية الزراعة بشقيها النباتي والحيواني ومساهمتها في تحقيق الأمن الغذائي قد تحسنت		203.2	105.1			308.3
5	بنية تحتية وخدمات زراعية مناسبة				422.2		422.2
6	قدرة الإنتاج الزراعي الفلسطيني على المنافسة في الأسواق المحلية والخارجية قد تحسنت			22.5	55.3		77.8
7	جاهزية القطاع الزراعي للمساعدة في تحقيق متطلبات إقامة الدولة قد أنجزت				1.2 1		11.2
	المجموع:	555.6	251.6	211.5	488.8	15.8	1523.3

المصدر: خطة عمل قطاع الزراعة 2011-2013

ولذكر الأنشطة والمشاريع المقترحة ذات الصلة بموضوع زيادة المعروض وتحسين إدارة الطلب فقد تم تقسيمها حسب البنود المذكورة وهي ما سينفذ تحت بند تعزيز صمود وتمسك المزارعين بالأرض والبقاء في الزراعة وبند إستراتيجية الإدارة الكفؤة والمستدامة للموارد الطبيعية في الأراضي الفلسطينية و بند الأنشطة التي ستنفذ تحت السياسات ذات الصلة بالتغير المناخي وبرامج التنمية الريفية المتكاملة. ومن المتوقع أن يكون لهذه الأنشطة إذا ما تم تنفيذها بكفاءة وفعالية جيدة تأثير كبير على اقتصاديات الزراعة المروية ومصادر الرزق لقطاع العمالة الزراعية والأمن الغذائي. وهذه الأنشطة هي كالتالي:

1.4. الأنشطة التي ستنفذ تحت بند تعزيز صمود وتمسك المزارعين بالأرض والبقاء في الزراعة

الجدول رقم 3 يوضح أهم الأنشطة التي ستنفذ تحت هذا الهدف الاستراتيجي وسياسة إعادة تأهيل ما دمره الاحتلال ودعم المزارعين المتضررين من الاعتداءات الإسرائيلية في الأراضي الفلسطينية.

4 . خطة عمل إستراتيجية القطاع الزراعي (2011–2013)

قامت وزارة الزراعة وبمشاركة فاعلة من المؤسسات التي شاركت في إعداد الإستراتيجية وبدعم فني من منظمة الأغذية والزراعة للأمم المتحدة (الفاو)، بإعداد خطة العمل الكفيلة بتنفيذ الأهداف والسياسات الواردة في الإستراتيجية للفترة 2011–2013 . ومن خلال تبني النهج التشاوري والتشاركي خلال كافة مراحل إعداد الخطة، فقد روعي أن تشكل أنشطة ومشاريع الخطة استجابة مباشرة لحاجات وأولويات المزارعيtن وأصحاب العلاقة الآخرين، من الأسفل إلى الأعلى على مستوى المناطق والمحافظات . ونظراً للمعوقات والمحددات الجسام التي تواجه التنمية الزراعية في فلسطين، والتي يتطلب التغلب عليها وتفاديها موارد وإمكانيات اكبر بكثير مما يمكن توفيره خلال فترة تنفيذ الخطة، فانه لا بد من تحديد دقيق للأولويات، آخذين بعين الاعتبار مجموعة العوامل والمعطيات التالية (خطة عمل قطاع الزراعة، 2011–2013):

1 . حجم الموازنات والتمويل المتوقع توفيره من كافة الجهات، خلال سنوات الخطة (السلطة الوطنية الفلسطينية، والقطاع الخاص والمانحين والمنظمات الدولية).

2 . إيلاء اهتمام خاص بالنساء وكبار السن وصغار المزارعين والمناطق الأشد فقراً.

3 . الاهتمام بالجدوى الفنية والمالية والاقتصادية للتدخل و/ أو المشروع.

4 . استكمال الأنشطة والمشاريع القائمة، أو تلك المطلوب إنجازها كشرط مسبق أو متطلب لاستقطاب تمويل، أو للبدء بمشاريع أخرى.

5 . المشاريع التي تحقق الشراكة بين القطاعين العام والخاص، أو تلك التي يساهم المستفيدون فيها بنسبة عالية من تكاليفها.

6 . توفر القدرات والكفاءات البشرية والمؤسسية اللازمة للتنفيذ، ضمن الإطار الزمني المحدد.

7 . المشاريع التي تؤدي إلى استغلال الموارد الطبيعية بطريقة كفوءة ومستدامة، وبشكل خاص الموارد غير المستغلة، مثل مياه الأمطار والمياه المالحة العادمة المعالجة.

تضمنت خطة عمل إستراتيجية القطاع الزراعي 299 نشاطاً أو مشروعاً (الجدول1)، وهي تشكل ترجمة للسياسات التي تم اعتمادها في الإستراتيجية، ستساهم بشكل مباشر في تحقيق أهداف الإستراتيجية السبعة . وزعت هذه الأنشطة والمشاريع على القطاعات الفرعية والمحافظات والمواقع داخل المحافظات بشكل عادل وحسب تقارير الاحتياجات الواردة من المحافظات مع مراعاة إعداد المصفوفات الخاصة بالنوع الاجتماعي والتي تضمنت الأنشطة والتدخلات الحساسة للنوع الاجتماعي (خطة عمل قطاع الزراعة 2011–2013):

جدول رقم (1) توزيع النشاطات / المشاريع والموازنات المطلوبة حسب القطاع

#	القطاعات الفرعية	عدد المشاريع	الموازنة بالمليون دولار
1	المصادر الطبيعية	56	555.6
2	الإنتاج النباتي	44	251.3
3	الإنتاج الحيواني	48	211.8
4	الخدمات الزراعية	94	488.8
5	البناء المؤسسي	57	15.8
	المجموع	299	1.523

المصدر: خطة عمل قطاع الزراعة 2011–2013

ثالثاً : تقوية الأطر القانونية والمؤسسية لإدارة مياه الري

- تفعيل مجلس المياه الوطني لإقرار السياسات المائية خاصة موضوع تخصيص المياه للقطاعات المختلفة .
- تنظيم استخدامات المياه وإعادة النظر بالآبار غير المرخصة .
- وضع نظام الكوتا المائية للآبار الزراعية وتطبيق ومراقبة النظام للحد من الضخ الجائر .
- مراجعة وتعديل حصص الضخ في ضوء التغيرات لمستوى المياه الجوفية .
- تشجيع إنشاء تنظيمات مستخدمي المياه .
- وضع نظام تعرفة للمياه الزراعية .
- استكمال التشريعات والأنظمة الناظمة لمختلف الاستخدامات المائية .
- وضع الأنظمة لتشجيع الاستثمار في قطاع المياه الزراعية .
- تنمية وتطوير التعاون العربي والإقليمي في مجال تبادل الخبراء والمعلومات وتنمية الموارد المائية المستخدمة في الزراعة .

رابعاً : خلق البيئة المناسبة لتعزيز مفاهيم الإدارة الرشيدة لموارد المياه الزراعية

- تطوير ثقافة التخطيط ألتشاركي والإدارة التشاركية في مجال المياه الزراعية .
- تمكين وتحسين مشاركة صغار المزارعين ، فقراء الريف ، المجموعات المهمشة ، والنساء بإشراكهم في أنشطة الإدارة الرشيدة .
- ضمان الوصول إلى المعلومة وشفافيتها وتبادلها على المستوين الرأسي والأفقي .
- تعزيز مشاركة المجتمع المدني
- والقطاع الخاص والمرأة في الإدارة الرشيدة لموارد المياه الزراعية .
- تعزيز مفاهيم المساءلة والمحاسبة والمصداقية في إدارة المياه الزراعية .
- خلق البيئة المناسبة لتشجيع الشراكة مع القطاع الخاص في إدارة المياه الزراعية .

خامساً : بناء القدرات وتعزيز مجال البحوث والإرشاد

- تكثيف البحوث والإرشاد وتنفيذ المشاهدات لزراعة محاصيل مقاومة للملوحة .
- بناء قدرات المزارعين والعاملين في قطاع الزراعة .
- تطوير قواعد المعلومات الخاصة بالمياه وتطوير نقل وتبادل المعلومة .
- تطوير نظم المعلومات عن اقتصاديات المياه في الأنشطة الزراعية .

السياسات الهادفة إلى إدارة الموارد المائية بكفاءة وبشكل مستدام

الهدف الأساسي التي يجب تحقيقه في هذه الإستراتيجية، فيما يتعلق بالموارد المائية، يتمحور حول أدارة مياه الري بكفاءة لتعظيم عائد المتر المكعب من مياه الري . وانطلاقا من تحديد المعوقات التي تواجهه الإدارة المستدامة للموارد المائية خاصة فيما يتعلق في تناقض المعروض وسوء إدارة الطلب وعدم القدرة على تطبيق الأطر القانونية التي تحتاج إلى تطوير وقائمة طويلة من العوامل التي تزيد من نقاط الضعف وتقلل من الفرص المتاحة لتنمية هذا القطاع، فالسياسات المطلوب تبنيها لتحقيق الإستراتيجية ستكون كالتالي (وزارة الزراعة / تقرير الموارد الطبيعية، 2010):

أولاً: إدارة وتنمية وصيانة وحماية الموارد المائية الزراعية وزيادة كميات التزود بالمياه الزراعية

- العمل على زيادة حصة المياه الزراعية من خلال الحصول على الحقوق المائية الفلسطينية .
- تأهيل البنية التحتية للمصادر المائية المتوفرة .
- استغلال المياه المسوس والمالحة في الزراعة من خلال الإدارة السليمة مثل الخلط والتناوب ودراسة الجدوى الاقتصادية لمشاريع تحلية المياه المالحة وشبه المالحة لزراعة محاصيل ذات قيمة عالية .
- استغلال المياه العادمة المعالجة في الري والعمل على توفير مياه معالجة بمواصفات جيدة بالتنسيق والتعاون مع المؤسسات ذات العلاقة واختيار المناطق المناسبة للاستخدام .
- تنفيذ مشاريع الحصاد المائي المتوسط والصغير وتطوير تقنيات وأساليب الحصاد المائي .

ثانياً: تحسين إدارة الطلب على المياه الزراعية :

- رفع كفاءة استخدام مياه الري وتقليل الفاقد .
- تعزيز مفهوم المنظور الاقتصادي لاستخدام المياه في الزراعة .
- تأهيل البنية التحتية لأنظمة المياه القائمة (آبار، ينابيع، برك، قنوات، خطوط النقل والتوزيع وشبكات الري) .
- تحسين كفاءة أنظمة النقل والتوزيع .
- إدخال تقنيات الري الحديثة ووضع البرامج الإرشادية لترويجها .
- وضع برامج تأشيرية للتمييز بين المحاصيل المروية على أساس تعظيم صافي عائد المياه وتحديث وتنظيم قواعد البيانات الخاصة بذلك .
- وضع برامج لنشر ممارسة الري التكميلي .
- استخدام مياه الري المحدود في الفترات الحرجة خاصة في مواسم الجفاف وشحة المياه .
- إقامة محطات رصد مناخي زراعي للاستفادة منها في حسابات جدولة الري .
- استخدام المياه ذات النوعية المتدنية بشكل مستدام .
- وضع برامج التوعية المائية ونشر ثقافة ترشيد استخدام المياه في الزراعة .

رابعاً: إنتاجية الزراعة بشقيها النباتي والحيواني ومساهمتها في تحقيق الأمن الغذائي قد تحسنت.

خامساً: بنية تحتية وخدمات زراعية مناسبة.

سادساً: قدرة الإنتاج الزراعي الفلسطيني على المنافسة في الأسواق المحلية والخارجية قد تحسنت.

سابعاً: جاهزيه القطاع الزراعي للمساعدة في تحقيق متطلبات إقامة الدولة قد أنجزت.

المعوقات الخاصة بموضوع المياه المستخدمة في الزراعة

أهم المعوقات الخاصة بموضوع المياه الزراعية (وزارة الزراعة / تقرير الموارد الطبيعية، 2010):

- سيطرة الاحتلال الإسرائيلي على مصادر المياه وحرمان الفلسطينيين من الحصول على حقوقهم المائية من المياه الجوفية أو نهر الأردن وعدم تمكين الفلسطينيين من الوصول إلى مصادرهم المائية.
- انعكاس الواقع السياسي على عمل وأداء اللجنة الفلسطينية الإسرائيلية المشتركة مما أدى، بسبب ضعف الجانب الفلسطيني سياسيا وفنيا في بعض الأحيان، الى تعطيل وعدم منح الموافقات المطلوبة لتنفيذ المشاريع الخاصة بتطوير المصادر المائية (مشاريع الحصاد المائي وإعادة تأهيل الينابيع والآبار الزراعية وإقامة محطات المعالجة لمياه الصرف الصحي والمشاريع الأخرى المتعلقة بإدارة المصادر المائية).
- عدم وجود نصوص واضحة في قانون الزراعة حول صلاحية وزارة الزراعة في إصدار الأنظمة المتعلقة بإعادة استخدام المياه العادمة المعالجة في الزراعة، وإنشاء تنظيمات لمستخدمي المياه الزراعية، ووضع نظام تعرفة المياه الزراعية.
- تملح المياه الجوفية بسبب الضخ الزائد في المنطقة الساحلية وفي بعض الآبار الزراعية في الأغوار.
- ضعف تنفيذ القوانين والأنظمة التي تقيد عمليات حفر الآبار العشوائية واستخدام المياه بكفاءة متدنية وتقاطع هذا الموضوع مع إجراءات الاحتلال الإسرائيلي والأجندة الشعبية الوطنية.
- ضعف البنية المؤسسية للمؤسسات العاملة في قطاع المياه من الناحية الإدارية والفنية وضعف رأس المال التشغيلي والتطويري.
- عدم استخدام مياه الري بكفاءة عالية وخاصة المياه المتاحة من الينابيع.
- تدهور البنية التحتية لمصادر وأنظمة توزيع المياه وأماكن تجميعها.
- عدم وجود ملكية واضحة (حقوق استخدام المياه) لبعض الآبار والينابيع وهذا أدى بالتالي إلى عدم التحكم في استخدام المصدر المائي بكفاءة وظهور الصراعات بين المستفيدين.
- ضعف الأنظمة التي تنظم عملية توثيق وانتقال حقوق استخدام المياه الزراعية.
- تداخل الصلاحيات بين المؤسسات العامة على إدارة المياه وعدم وجود ناظم للعلاقة بين المؤسسات العامة والمؤسسات الأهلية.
- قلة الأبحاث والمشاهدات للمحاصيل المقاومة للملوحة والمحاصيل التي تروى بالمياه المعالجة.
- عدم استخدام المياه العادمة المعالجة في الزراعة.

خامسا: وثيقة الأهداف الإستراتيجية والتدخلات ذات الأولوية التي أعدتها وزارة الزراعة خلال شهر أيار 2009 بالشراكة مع المؤسسات الأخرى الناشطة في الزراعة (وزارة الزراعة – إستراتيجية الرؤى المشتركة، 2011)، وقد تضمنت تلك الوثيقة ستة أهداف إستراتيجية وهي:

- تحسين بيئة العمل للقطاع الزراعي.
- تحسين قدرات مختلف الجهات والمؤسسات العاملة في القطاع الزراعي.
- تحسين ظروف الأمن الغذائي.
- حماية وتطوير الأراضي الزراعية.
- حماية حقوق المياه الفلسطينية ونصيب الزراعة من المياه.
- زيادة ربحية الأنشطة الزراعية.

سادساً: رؤية المنظمات الأهلية الفلسطينية للقطاع الزراعي في الأراضي الفلسطينية «الواقع وأفاق التطوير» والتي تم إعدادها في أيار2009 وقد تضمنت تلك الرؤية ثلاثة اطر أساسية (الإطار الفني والتقني وإدارة الموارد الطبيعية والإطار المؤسسي والقانوني و الإطار الاجتماعي الاقتصادي) للوصول إلى قطاع زراعي فاعل ومستدام. وقد تم تحديد المرتكزات والمحاور لكل إطار بالإضافة إلى مجموعة السياسات والآليات المقترحة من اجل تحقيق الرؤية وأطرها الثلاث (وثيقة الواقع وأفاق التطوير، 2009).

سابعاً: السياسة الزراعية الفلسطينية التي أعدت عام 1999 وهي تعتبر أول سياسة زراعية فلسطينية.

ثامنا: الخطة والموازنة للعام 2010 التي أعدتها وزارة الزراعة وشملت تشخيصا للمشاكل والتحديات وظواهرها وأعراضها وأسبابها، بالإضافة إلى الأهداف الإستراتيجية والبرامج والاستهداف ومؤشرات الأداء حيث تضمنت الخطة ثمانية برامج غطت مختلف مناحي التنمية الزراعية.

تاسعا: السياسات القطاعية، عبر القطاعية وتحت القطاعية ذات العلاقة مثل إستراتيجية التنمية الزراعية المستدامة الفلسطينية، الإستراتيجية الوطنية للأمن الغذائي، إستراتيجية المياه، إستراتيجية البيئة، التنوع الحيوي، التنوع الحيوي الزراعي، إستراتيجية البحث والإرشاد الزراعي.

4.3. الأهداف الإستراتيجية للقطاع الزراعي

في ضوء الأطر والموجهات التي تم ذكرها سابقا فان الأولويات والأهداف الإستراتيجية للقطاع الزراعي حددت على النحو التالي وسيتم التركيز في هذه الدراسة على الهدف الخاص بالمياه كمورد طبيعي:

أولا: صمود وتمسك المزارعين بالأرض والبقاء في الزراعة قد تعزز.

ثانياً: الموارد الطبيعية في الأراضي الفلسطينية مدارة بكفاءة وبشكل مستدام. الأهداف الأساسية لهذا البند تتمثل في استعادة الحقوق المائية والسيطرة الكاملة على الأراضي بحدود الرابع من حزيران 1967 وإدارة الموارد الأرضية والمائية بطريقة متكاملة وبشكل يعظم الكفاءة والعائد الاقتصادي وبما يضمن الاستخدام الآمن والمستدام لتلك الموارد.

ثالثاً: لدى القطاع الزراعي إطارا مؤسسيا ملائماً وقانونيا متكاملاً وقوى بشرية مدربة ومؤهلة تساهم في إنهاء الاحتلال وإقامة الدولة.

2.3 . منهجية إعداد الإستراتيجية الزراعية

تم إعداد هذه الإستراتيجية استجابة لتوجهات وتوجيهات السلطة الوطنية الفلسطينية حيث قررت الحكومة الفلسطينية إعداد مجموعة من الاستراتيجيات القطاعية وعبر القطاعية كمدخل أساسي لإعداد الخطة الوطنية العامة للأعوام 2011 – 2013 والتي ستعنى بوضع الأهداف والأولويات الكفيلة بالتخلص من معوقات وأثار الاحتلال الإسرائيلي وتعمل على إقامة الدولة المستقلة. في هذا السياق أصدرت وزارة التخطيط دليل إعداد الاستراتيجيات القطاعية وعبر القطاعية وذلك لزيادة التنسيق والتكامل والتناغم بين الاستراتيجيات من خلال تحديد المبادئ الأساسية من النواحي التخطيطية والسياسية والفنية ولتزود المؤسسات بالنماذج الفنية والإلزامية (برنامج الحكومة الثالثة عشرة / فلسطين: إنهاء الاحتلال وإقامة الدولة 2009) التي ستساعد في أنجاز ما هو مطلوب.

بناء على هذا التوجه في خلق البيئة المناسبة لإنجاح مشروع الدولة من خلال بناء المؤسسات وإعداد الإستراتيجيات القطاعية التي تتبنى نهج المشاركة الفاعلة لكل المعنيين في هذا القطاع، فقد بادرت وزارة الزراعة بشكل مبكر وبدعم فني من منظمة الأغذية والزراعة للأمم المتحدة (الفاو) بالإعداد لصياغة إستراتيجية القطاع الزراعي حيث تم خلال المرحلة الأولية تشكيل الفرق الوطنية والفنية التي شملت ممثلين عن أصحاب العلاقة والعاملين في القطاع الزراعي وإعداد ورقة المفاهيم الأساسية «مسودة الرؤية المشتركة لتنمية القطاع الزراعي الفلسطيني» والتي هدفت إلى إعداد الإطار العام للإستراتيجية ولتشكل أساسا وقاعدة للنقاش والمشاورات مع مختلف أصحاب العلاقة. وتزامنت هذه الخطوات بجهود مميزة لإعداد آليات متابعة خطة العمل والخطوات اللاحقة لإعداد الإستراتيجية وتحديد البنود المرجعية للتقارير والدراسات المقترحة (وزارة الزراعة – استراتيجية الرؤى المشتركة، 2011).

3.3 . الأولويات والأطر وأسس تحديد الأهداف الإستراتيجية

من الضروري ذكر الأولويات والأطر والموجهات والخطوط المرجعية التي شكلت البوصلة والأسس المرجعية لتحديد الأهداف الإستراتيجية للقطاع والتي ستشكل الأساس الذي سيبنى عليه عند صياغة السياسات القطاعية، والتي كانت كالتالي (وزارة الزراعة – استراتيجية الرؤى المشتركة، 2011):

أولا: نتائج المشاورات والاجتماعات التي عقدت والتوصيات التي استخلصت من عقد 4 ورشات عمل مناطقية و 4 ورشات عمل مؤسساتية للفترة من 1/ 9/ 2009 إلى 8/ 10/ 2009 والتي تم فيها مناقشة محتوى الرؤية المشتركة مع أصحاب العلاقة وجمع الملاحظات والتوصيات من المشاركين وتحديد الاحتياجات الطارئة وذات الأولوية وإعلام المشاركين بمنهجية العمل. وشكلت مخرجات تلك الورشات أساساً وإطاراً وموجهاً لفريق الإستراتيجية القطاعية، إضافة لتوصية بتشكيل 4 فرق فنية متخصصة، ضمت خبراء ومختصين من وزارة الزراعة ومنظمات المجتمع المدني، لرفد فريق الإستراتيجية بالتوصيات الفنية.

ثانيا: نتائج عمل وتقارير الفرق الفنية الأربعة والتي شملت تشخيصاً وتحليلاً معمقين لواقع القطاعات الفرعية التي تناولتها بالإضافة إلى التدخلات والتوصيات ذات العلاقة بتطوير تلك القطاعات الفرعية وهي الإنتاج النباتي، الإنتاج الحيواني، المصادر الطبيعية والخدمات الزراعية. من أهم المخرجات في هذا البند هو إعداد تقرير الموارد الطبيعية الذي كان الأساس في تحديد الاستراتيجيات والسياسات المستقبلية الخاصة بالمياه المستخدمة في الزراعة (وزارة الزراعة – تقرير الموارد الطبيعية، 2010).

ثالثا: نتائج تحليل النماذج، التي أعدت لإغراض إعداد الإستراتيجية وهي نموذج ملخص السياسات ونموذج تنفيذ السياسات ونموذج سجل المشاورات.

رابعا: السياسات والبرامج الوطنية وبشكل خاص برنامج إنهاء الاحتلال وإقامة الدولة (برنامج الحكومة الثالثة عشرة / فلسطين: إنهاء الاحتلال وإقامة الدولة 2009).

تقاس كفاءة استخدام مياه الري بقياس المياه المستخدمة لوحدة الأرض (متر مكعب/ دونم) وتقدر بحوالي 600 متر مكعب / دونم في المتوسط وهذا يغطي اختلافات إقليمية واسعة تبعاً للمناطق المروية، حيث يتراوح معدل الاستخدام ما بين 400 إلى 500 متر مكعب / دونم في المناطق الساحلية وشبه الساحلية إلى حوالي 900 متر مكعب/ دونم في منطقة الأغوار (الإستراتيجية الزراعية 2000) و (أريج، 1998). تعزى الكفاءة العالية في المناطق الساحلية وشبه الساحلية إلى استخدام نظم الري المغلقة سواء في خطوط النقل أو التوزيع أو تقنيات الري الحديثة على مستوى المزرعة. أما الكفاءة المنخفضة لاستخدام مياه الري في منطقة الأغوار فتعزى إلى اعتمادها الكبير على الينابيع والتي يتم فيها توزيع المياه عن طريق قنوات ترابية أو إسمنتية مفتوحة مما يؤدي إلى ارتفاع نسبة الفاقد من المياه المستخدمة. من الجدير بالذكر التنويه، بان هناك تفاوت في تقدير كفاءة الاستخدام لوحدة الأرض، وهذا التفاوت يتراوح من 579 متر مكعب/ دونم (جلوفور وهنتر، 2010) إلى 741 متر مكعب/ دونم (جيوسي وسروجي 2009). إن هذا التفاوت يتم تبريره في اختلاف المنهجية وطريقة الحساب ولكن يجب الانتباه إلى أهمية توخي الدقة في التقدير لأنها ستؤدي فيما بعد إلى استنتاجات غير دقيقة خاصة إذا ما اعتبرت من ضمن المؤشرات المعتمدة في التقييم والمتابعة.

كما أن اختلاف أسعار المياه ينعكس على كفاءة الاستخدام تبعاً للمنطقة الجغرافية ومصدر مياه الري، وتتراوح أسعار مياه الري بين (0.15) دولار للمتر المكعب وهي تعتبر كلفة إتاحة مياه الري من الينابيع في منطقة الأغوار إلى مبلغ (0.30) دولار للمتر المكعب من الآبار التي تعمل بالطاقة الكهربائية، إلى حوالي مبلغ 0.50 إلى 1 دولار لكل متر مكعب يستخرج من الآبار التي تعمل على المحروقات (وزارة الزراعة / تقرير الموارد الطبيعية 2010)، حيث يعتمد سعر المياه المستخرجة من الآبار على سعر المحروقات وعمق البئر والقدرة الإنتاجية للبئر. أما إذا كانت المياه مصدرها الشبكة البلدية، فان الأسعار تتجاوز مبلغ (1.00) دولار للمتر المكعب. هذا الاختلاف في الأسعار أثر على المزارعين ودفعهم إلى استخدام الأساليب الحديثة في الري، خاصة في المناطق ذات الأسعار المرتفعة للمياه، والتوجه إلى الزراعات المكثفة داخل البيوت البلاستيكية (وزارة الزراعة / تقرير الموارد الطبيعية، 2010).

إن الطلب المتزايد على الغذاء ترافق مع ضعف في الأطر القانونية والمؤسسية وضعف إمكانية تنفيذ وتطبيق القوانين والأنظمة وتردد القطاع الخاص للاستثمار في مشاريع المياه الزراعية ومحدودية النشاطات البحثية والإرشادية الزراعية، وهذا أدى إلى اضطراب في المردودية الاقتصادية لقطاع الزراعة المروية في فلسطين. إلا إن ما ذكر لا يلغي الإمكانيات المهمة التي يوفرها قطاع الزراعة المروية للاقتصاد والإنتاج الزراعي وان توفير كميات إضافية من المياه لاستخدامها في الزراعة المروية إذا ما صاحبها إزالة للمعوقات التي يفرضها الاحتلال الإسرائيلي على حركة الأفراد والسلع سيؤدي إلى زيادة مساهمة القطاع الزراعي في الدخل المحلي الإجمالي بنسبة 10% وسيوفر حوالي (110) ألف فرصة عمل إضافية (البنك الدولي، 2009).

3. إستراتيجية الرؤى المشتركة

1.3. الرؤية

كان هناك إجماع على إن الرؤية المستقبلية للزراعة الفلسطينية هي «زراعة مستدامة ذات جدوى وقادرة على تحقيق الأمن الغذائي والمنافسة محلياً وخارجياً عبر الاستخدام الأمثل للموارد كجزء من التنمية الشاملة، وتعزز ارتباط وسيادة الإنسان الفلسطيني على أرضه وموارده وصولاً إلى بناء الدولة» (وزارة الزراعة – إستراتيجية الرؤى المشتركة، 2011). هذه الرؤية المستقبلية ستأطر وتحدد مسار التنمية الزراعية في فلسطين وستحدد المتطلبات والافتراضات والمرتكزات الواجب توفرها من أجل توفير البيئة المناسبة لتحقيق الرؤية.

الغربية (سلطة المياه الفلسطينية، 2005 وجيوسي وسروجي، 2009) ناكرة بذلك حق الفلسطينيين في الحصول على حقوقهم المائية من المياه الجوفية والوصول واستخدام مياه نهر الأردن كبلد مشاطئ.

تعتبر الزراعة في فلسطين جزءاً أساسياً من مكونات النسيج الوطني والثقافي والاقتصادي والاجتماعي الفلسطيني، وأشارت العديد من المصادر بان الفلسطينيون كانوا رواداً في نقل ونشر التقنيات الزراعية إلى دول عدة في الإقليم وخارجه (وزارة الزراعة – إستراتيجية الرؤى المشتركة، 2011). من البديهي القول إن للزراعة أهمية خاصة للفلسطينيين، بالإضافة لكونها مصدرا للدخل وللغذاء، فهي تمثل عنواناً للصمود والتصدي والتشبث بالأرض المستهدفة بالمصادرة والاستيطان.

لقد قامت وزارة الزراعة والمؤسسات الأخرى ذات العلاقة في السابق بإعداد سياسات واستراتيجيات وخطط لتنمية القطاع الزراعي ضمن افتراضات ورؤى معينة، والتي للأسف لم تتحقق لأسباب عديدة أهمها هو تعنت وتصلب الموقف الإسرائيلي المستمر في عدم تحقيق التسوية العادلة. من أهم هذه الاستراتيجيات هي الإستراتيجية الزراعية التي صدرت عام 1999-2000 وفيها تم الإعداد والبناء على افتراض إن عملية السلام ستكتمل وستكون هناك سيطرة فلسطينية على الموارد الطبيعة والحدود في دولة ذات سيادة حسب مقررات الشرعية الدولية. وجاء اندلاع الانتفاضة الثانية التي أدت إلى حدوث تغيرات تقاطعت مع الرؤى والافتراضات مما أدى الى حدوث تشوهات وتحويل الجهود والتوجهات من تدخلات التنمية إلى الإغاثة والطوارئ. إن جميع الخطط والبرامج التي اعتمدت افتقرت إلى الإطار والتوجيه التنموي وأدت محدودية الموازنات المخصصة للتنمية الزراعية، التي لم تتجاوز 1% من موازنة السلطة (وزارة الزراعة – إستراتيجية الرؤى المشتركة، 2011) أو مساعدات المانحين (3% من المناشدات الموحدة حسب تقرير خطة عمل الفاو، 2011–2013)، إلى محدودية أو عدم نجاح هذه الخطط والبرامج.

أما بخصوص الموارد المائية، فان تزايد المعوقات يوماً بعد يوم جعل من الإدارة المستدامة والرشيدة والمتكاملة للمياه في فلسطين أمراً صعباً ومعقداً، ويتفق معظم الخبراء وذوي الاختصاص على أن قوى التأثير السياسية والفنية والقانونية والاقتصادية والاجتماعية تكبح تسارع خطى التنمية الزراعية وتقلل من الفرص المتاحة لتطوير قطاعي الزراعة والموارد الطبيعية. ومما لا شك فيه فإن نتائج التغيرات السياسية الإقليمية والمناخية وسلسلة الأزمات المالية والاقتصادية والغذائية على المستويين الكوني والإقليمي وارتفاع أسعار الطاقة ستؤثر بشكل جلي على إدارة قطاعي الزراعة والمياه وستقلل من الفرص المتاحة لجعل الزراعة قطاعاً جاذباً للاستثمار.

2. المياه الزراعية

تعرضت المياه الزراعية إلى تراجع مستمر خلال العقود السابقة كماً ونوعاً، وهذا ممكن تعميمه على كامل الأراضي الفلسطينية، ففي الضفة الغربية تراجعت الكميات المتاحة خاصة من الينابيع وتدهورت نوعية المياه في كثير من الآبار الموجودة في منطقة الأغوار، وفي قطاع غزة تراجعت النوعية والكمية نوعاً ما بسبب تلوث وتملح الخزان الجوفي في قطاع غزة (وزارة الزراعة – تقرير الموارد الطبيعية، 2011). إن قدم المنشئات وعدم تحديث أو إعادة تأهيل البنية التحتية لهذا القطاع وازدياد الطلب وتنافس القطاعات الاقتصادية على المياه وارتفاع كلف التشغيل والصيانة هي من أهم العوامل التي أدت إلى انخفاض كمية ونوعية المياه المخصصة للاستخدامات الزراعية في الضفة الغربية وقطاع غزه من 172 مليون متر مكعب سنويا في عام 1999 (الإستراتجية الزراعية، 2000) إلى 150 مليون متر مكعب سنويا في عام 2007 (الإحصاء المركزي الفلسطيني، 2008) والى 123 مليون متر مكعب سنويا في عام 2008 (الإحصاء المركزي الفلسطيني، 2009). يتبين مما تقدم، إن الزراعة لا زالت هي مستهلكاً رئيسياً للمياه وبنسبة 45% من إجمالي الاستخدام الحالي للمياه وهو 335.4 مليون متر مكعب سنوياً (الإحصاء المركزي الفلسطيني، 2009)، وتوزع هذه الكمية (150 مليون متر مكعب سنويا) ما بين 70 و 80 مليون متر مكعب سنوياً في كل من الضفة الغربية وقطاع غزة على التوالي (الإحصاء المركزي الفلسطيني، 2007).

المياه في إستراتيجية القطاع الزراعي: واقع وطموح

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ملخص

يتفق معظم الخبراء وذوي الاختصاص على أن التداخل بين قوى التأثير السياسية والفنية والقانونية والاقتصادية والاجتماعية مع نتائج التغيرات السياسية الإقليمية والمناخية وسلسلة الأزمات المالية والاقتصادية والغذائية على المستويين الكوني والإقليمي وارتفاع أسعار الطاقة ستكبح تسارع خطى التنمية الزراعية وتقلل من الفرص المتاحة لجعله قطاعاً جاذباً للاستثمار. في إطار إستراتيجية الرؤية المشتركة لتنمية القطاع الزراعي الفلسطيني (2011 – 2013)، كان هناك توافق على أن تحسين إدارة مياه الري بكفاءة لتعظيم عائد المتر المكعب من مياه الري يمكن تحقيقه من خلال تبني السياسات الخاصة بزيادة المعروض وتحسين إدارة الطلب وتطوير الأطر القانونية والمؤسسية وخلق البيئة المناسبة لتطبيق مناهج الحوكمة في إدارة المياه الزراعية وتحفيز القطاع الخاص وتشجيعه للاستثمار في مشاريع المياه الزراعية وتكثيف ودعم أنشطة الإرشاد الزراعي والأبحاث ونقل التكنولوجيا.

لتحقيق الأهداف الإستراتيجية السبعة للقطاع الزراعي، تم إعداد خطة عمل للسنوات 2011 – 2013 تضمنت خمسون تدخلاً يشمل 299 نشاطاً/ مشروعاً تتقسم على تسعة عشر سياسة. وقدرت التكاليف لتنفيذ خطة العمل المنبثقة بـ 1،526 مليار دولار أميركي (خصص 30% منها لمشاريع المياه الزراعية)، سيتم تمويلها من موازنة السلطة والمانحين ومنظمات المجتمع المدني والقطاع الخاص. لقد أدت هذه الجهود إلى دمج الإستراتيجية الزراعية وخطة العمل المنبثقة في خطة التنمية الوطنية (2011 – 2013) التي ركزت على تنمية الأركان الأربعة: الحوكمة والواقع الاجتماعي والاقتصادي والبنية التحتية بميزانية كلية قدرت بـ 1،326 مليار دولار. ومن أصل حصة القطاع الاقتصادي التي بلغت 412 مليون دولار كان للزراعة والتنمية الريفية النصيب الأكبر (178 مليون دولار) حيث خصص لمشاريع المياه الزراعية 5،42 مليون دولار. بالرغم من وضع الآليات والمؤشرات المناسبة للمتابعة والتقييم إلا أن النجاح في تنفيذ الإستراتيجية مرتبط بالافتراضات الواجب توفرها مثل توفر الموازنات والتزام جميع الأطراف بتنفيذ الخطط والتقليل من عوامل المخاطرة في العمل الزراعي ووجود استقراراً سياسياً واقتصادياً مقترناً بالتقليل من أثر الإجراءات المعيقة المفروضة من قبل الاحتلال الإسرائيلي، وأخيراً التقليل من تأثير التقلبات المناخية على المزارعين والزراعة في فلسطين.

1. المقدمة

فلسطين، كجزء من الشرق الأوسط، تصنف كمنطقة شبه جافة كما هو الحال في دول جنوب وشرق البحر المتوسط وهي دول تعاني من شح المياه بسبب المناخ السائد وارتفاع الطلب على المياه بسبب النمو السكاني والطلب المتزايد على الغذاء. وبشكل خاص تواجه الأراضي الفلسطينية نقصاً شديداً في المياه المتاحة لمختلف الاستخدامات بسبب الظروف السياسية غير الطبيعية الناتجة عن الاحتلال الإسرائيلي، حيث تسيطر إسرائيل على 85% من موارد المياه الجوفية الفلسطينية في الضفة