I. INTRODUCTION

Whilst farming is the predominant profession for many Palestinians and Jordanians in the Jordan Valley region, the agricultural system still lacks proper planning and management. Along the region, most water and land resources are utilized for agricultural uses, and therefore, agricultural planning is more challenging under the existing conditions and limitations. Just like any other arid regions, groundwater is the main water source for drinking, agriculture, and industrial uses, in particular in the Palestinian side where Palestinians have no access to surface water and very limited access to ground water resources. In addition, land degradation is becoming increasingly clear due to both natural and anthropogenic implications. As a result, lights will be shed on the related literature for the targeted areas in the Jordan Valley given the current socio-economic status, water resources, crop production and climate change and food security.

This paper presents an overview of the main factors affecting agriculture in the Jordan Valley. It is constructed of two sections, one offering an overview about Jericho and Al-'Auja in the West Bank and the other about Al-Shouneh Al-Janoubeyeh in Jordan. The information presented in this paper offers a summary of the data found in the available literature concerning three main fields: Socio-economic status, natural resources and agricultural sector, and climatic change.

Most of the reviewed literature provided data on the governorate level, detailed information on the micro farm level was mainly collected through filed survey, focus group meetings and in person interviews with experts. The mentioned methods were used to bridge the gap existing in the reviewed literature such as: pricing, marketing, seasonal crop calendar, obstacles and limitations concerning water resources and land ownership.

The research conducted in this project provides detailed data that contributes to enriching the available official existing data for the target area of Jordan Valley. Moreover, the Decision Support System that will be built over this combination of official data and resulted data will be used to serve one of the major needs of the agricultural sector which is proper planning. This will lead to an increasing economic benefit on the household level and consequently contributing to self sufficiency on the household level and food security on the national level.

III. TARGET AREA - JORDAN

1. The Socioeconomic Status of Al-Shouneh Al-Janoubeyeh

1.1 Geography and Administrative divisions

The Jordan valley extends along the Jordan River with and area of 1554.3 sq km. It is between 200 and 400 m below sea level and is considered the lowest land in the world. It is made of four areas: Northern Ghors, Al-Shouneh Al-Janoubeyeh (area of study), Der Ala and Southern Ghors.

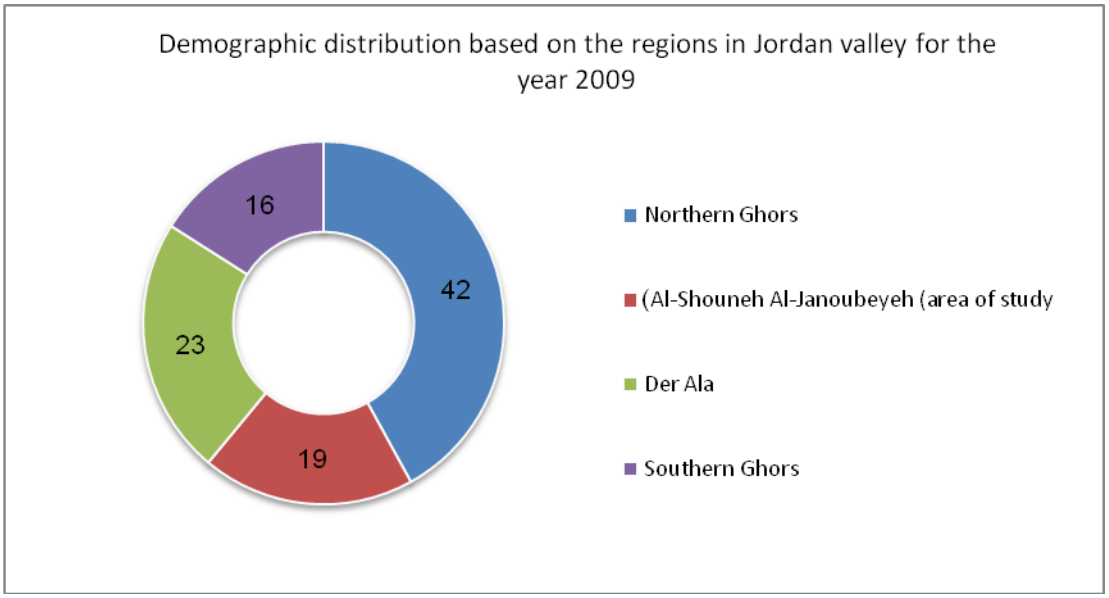
Al-Shouneh Al-Janoubeyeh is part of Balqa governerate and is situated 30Km to the west of Balqa. It is bordered by Jordan river to the west, Amman governerate, Madaba, Era and Yerqa to the east, Der Ala to the north and Kerak and madaba to the south. It is connected with international road network that services all neighboring governorates. It has an area of 294 sq km and constitutes about 25.3% of the total area of Balqa governorate (1119 sq km) (source: The Jordan Valley area development program for the three years (2012-2014)/ Ministry of planning and international cooperation).

1.2 Demography

1.2.1 Population

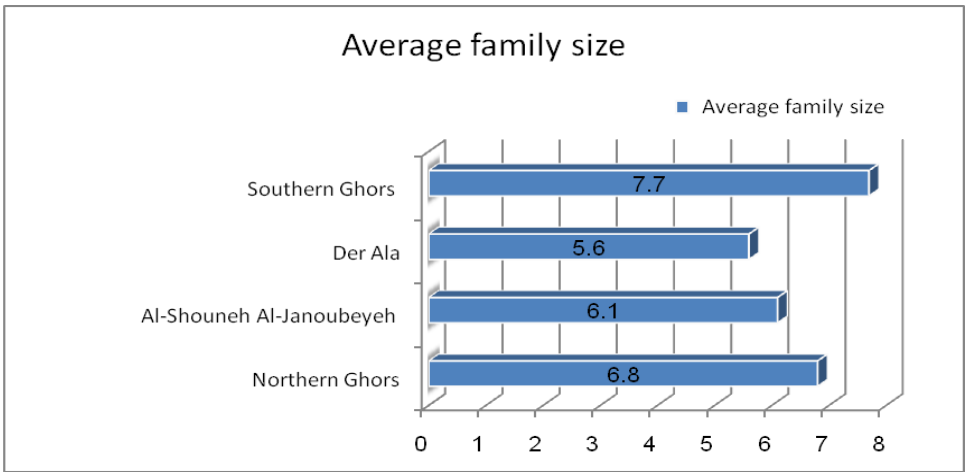
Based on the 2009 figures from the department of statistics (DOS, 2009), the total population of Jordan valley is 233,350 people which comprises 3.9% of the total population of the kingdom (5980000 people). The males in this region count for 121740 males (about 52%) and the females 111610 (48%).

As for Al-Shouneh Al-Janoubeyeh, the total population is 44830 people (19%) of the total Jordan valley population. This makes 11% of the total Balqa residents (400600 people). The males of this region count for 24250 and the females 20580. The population density is about 152.5 people/sq km. The following figure demonstrates the demographic distribution based on the regions in Jordan valley (DoS, 2009).



1.2.2 Family properties

There are about 35262 families in the Jordan valley region with an average of 6.6 people per family. Whereas the family size in the kingdom is about 5.4 people. As for the Al-Shouneh Al-Janoubeyeh, there are 6149 families compared to 70000 families in Balqa governorate. Also, the average family size in the Shouneh Al-Janoubeyeh was 6.1 people. The following figure shows the average family size based on the regions in the Jordan valley for the year 2009, (source: The Jordan Valley area development program for the three years (2012-2014)/ Ministry of planning and international cooperation).



1.2.3 Age Distribution

The age distribution in the area is made out of those who are under 15 years and make up about 40%, between 15-64 make about 57% and finally those above 65 years and make 3%. The table below shows the distribution.

Age distribution	*Jordan valley*	*Irbid governorate*	*Balqa governorate*	*Kerak governorate*	*kingdom*
% under 15 years	40	36.2	38.1	36.7	36.8
% between 15-64	57	56.8	58.9	58.8	59.1
% above 65 years	3	4	4	4.5	4.1

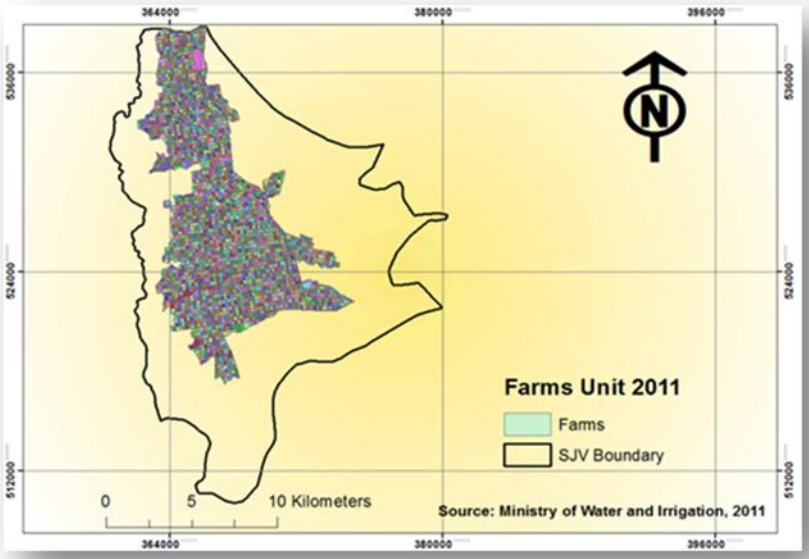
As noted from the above, the high percentage of ages below 15 years and 15-64 years makes the society young societies who are economically active. Table below shows number of inhabitants in the study area, Al-Shouneh Al-Janoubeyeh, over the last ten years.

Year	*Males*	*Females*	*Total*
2004	20903	17854	38757
2005	21130	18160	39290
2006	22710	19270	41980
2007	23210	19690	42900
2008	23720	20130	43850
2009	24250	20580	44830
2010	24784	21039	45823
2011	25340	21500	46840
2012	25900	21990	47890

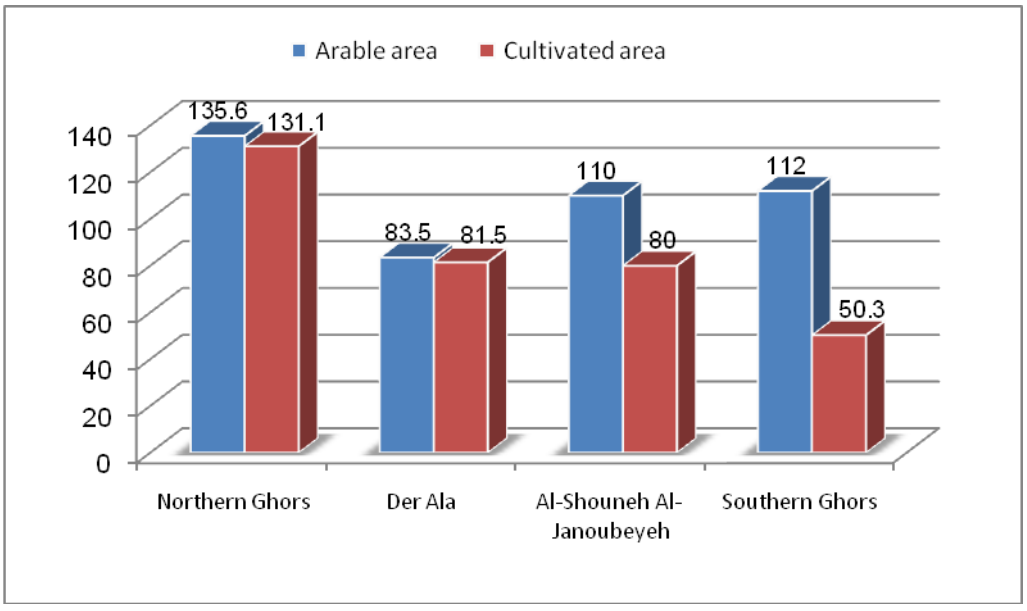
*: Source: DoS, 2013.

2. Agricultural Sector

The Jordan valley is blessed with fertile land and is considered the main food provider in Jordan. It has a warm climate in the winter and very hot in the summer which makes it suiting for many vegetables, fruits and other kinds of trees. The arable land is estimated around 451000 donums and is used for production of grains, vegetables and fruits. The cultivated area in 2011 was estimated to be about 352000 donums. This area is divided into farms units that count to more than 9500 units (Ministry of Agriculture (MOA),2011). Most of these units are serviced with an internal irrigation network. The arable land can be distributed as following:



The distribution of arable land in the Jordan valley for the year 2009 (DoS 2011)



The agricultural sector contributes to about 2.9% of the GDP of the Kingdom with a total estimate of 476 million JDs. The agricultural export of Jordan is around 801

thousand tons. The Jordan valley contributes to more than 66% of the kingdom's production of vegetables and 98% of citrus production (DoS, 2011).

2. 1 Types of field crops in Jordan valley in 2011 in comparison with the Kingdom

2.1.1 Vegetables

The area planted with vegetables in the Jordan valley (180,731 donums) makes around 53% of the total area planted with vegetables in Jordan (341,422 donums). As for production, Jordan valley produces 66% (876,138 tonns) of the total vegetable production in Jordan (1,326,268 tonns).

As for the study area, the area planted with vegetables in Al-Shouneh Al-Janoubeyeh is (39,844 donums) and comprises about 12% of the total area planted with vegetables in Jordan. As for the production, it produces 13% (176,491 tonns) of the total vegetable production in Jordan (1,326,268 tonns).

2.1.2 Citrus

The area planted with citrus trees in the Jordan valley (66,542 donums) makes around 96% of the total area planted with citrus trees in Jordan (66,542 donums). As for production, Jordan valley produces 98% (105,464 tonns) of the total citrus production in Jordan (107,569 tonns).

As for the study area, the area planted with citrus trees in Al-Shouneh Al-Janoubeyeh is (1,517 donums) and comprises about 2% of the total area planted with citrus in Jordan. As for the production, it produces 2% (1913 tonns) of the total citrus production in Jordan (107,569 tonns).

2.1.3 Grain field production

The area planted with grain crops (winter and summer) in the Jordan valley (21,315 donums) makes around 2% of the total area planted with grains crops in Jordan (1,091,513 donums). As for production, Jordan valley produces 20% (30,686 tonns) of the total grains production in Jordan (151,298 tonns)

As for the study area, the area planted with grain crops (winter and summer) in Al-Shouneh Al-Janoubeyeh is (6,193 donums) and comprises about 0.6% of the total area planted with grain crops in Jordan. As for the production, it produces 7.8% (11,829 tonns) of the total grain crops production in Jordan (151,298 tonns).

2.1.4 Fruit trees

The area planted with fruit trees (figs, bananas, guava, dates, grapes, olives, almonds, peaches, plums, apricots, pomegranate) in the Jordan valley (42,508 donums) makes around 6% of the total area planted with fruit trees in Jordan (703,804 donums). As for production, Jordan valley produces 25.6% (66,080 tonns) of the total fruit production in Jordan (258,175 tonns).

As for the study area, the area planted with fruit trees in Al-Shouneh Al-Janoubeyeh is (19,837 donums) and comprises about 2.8% of the total area planted with fruit trees in Jordan. As for the production, it produces 13.5% (34,930 tonns) of the total fruit trees production in Jordan (258.175 tonns).

The Pie-chart below shows the distribution of area according to land use in Al-Shouneh Al-Janoubeyeh (DoS, 2011). As can be seen, the highest area is for vegetables (open air and covered) (39,844 donums), more than 20 vegetable species are grown in Al-Shouneh Al-Janoubeyeh (eggplants, tomatoes, squash, sweet pepper, cucumber, potatoes, cabbages, cauliflower, hot peppers, broad beans, peas, okra, jews mallow, lettuce, radish, carrots, sweet melons, onion, are the most common). The second largest area is for fruit trees with 21,354 dunums. Moreover, the lowest area was for nurseries with (1,366 dunums).There are two main cropping seasons (October-January and February-May) and the harvest period lasts over eight months (November-June) depending on the crops and the sub-region considered.

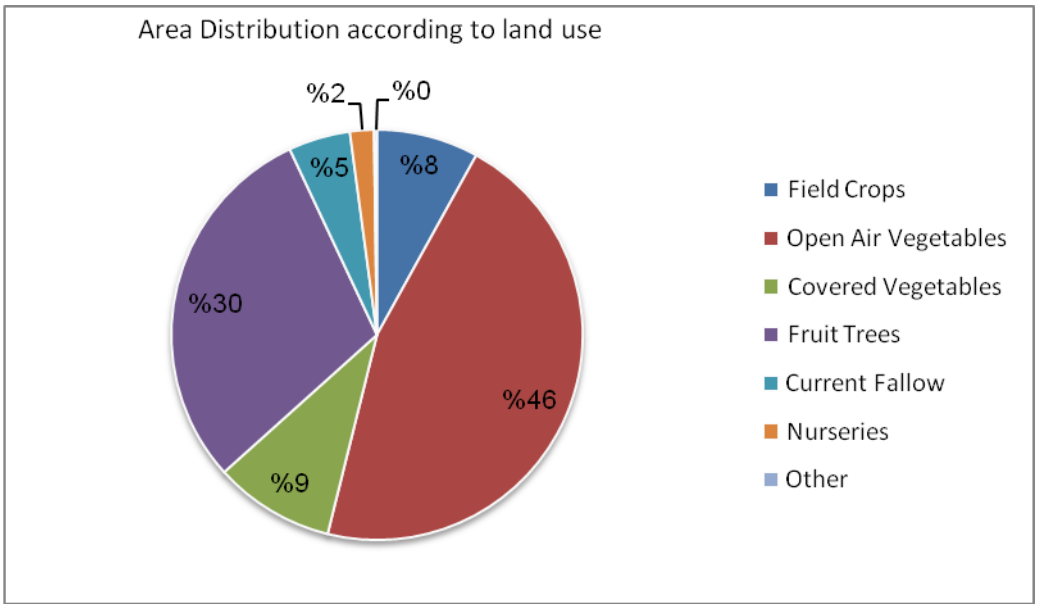
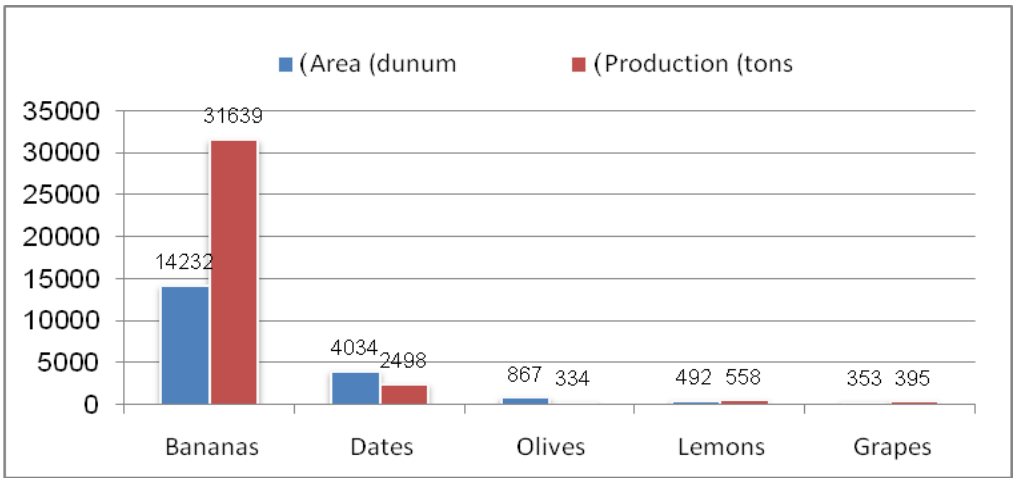


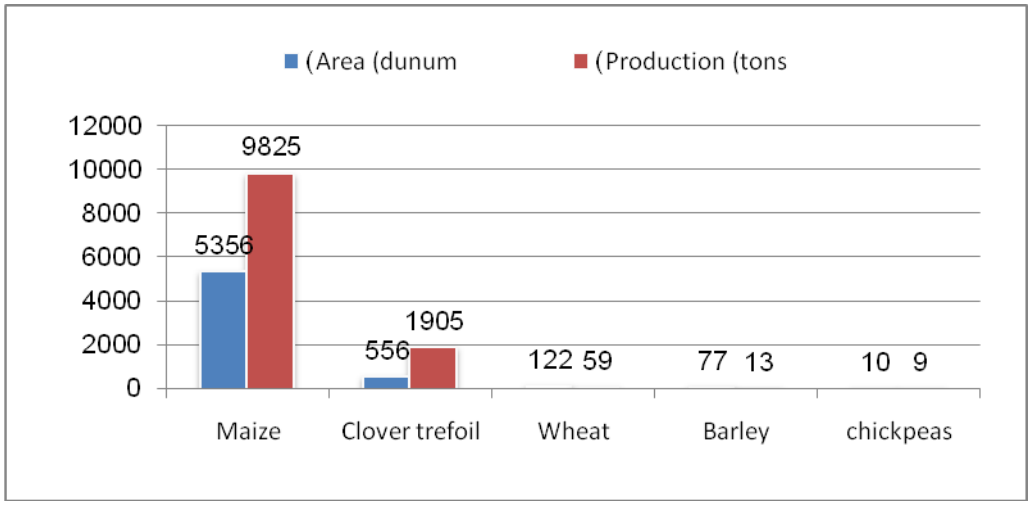
Chart below shows the Cultivated area and production of the main five production crops of different kinds of crops (fruits, field Crops, and Vegetables (autumn &

summer)) in Al-Shouneh Al-Janoubeyeh (source: Directorate of Agricultural Statistics 2011).

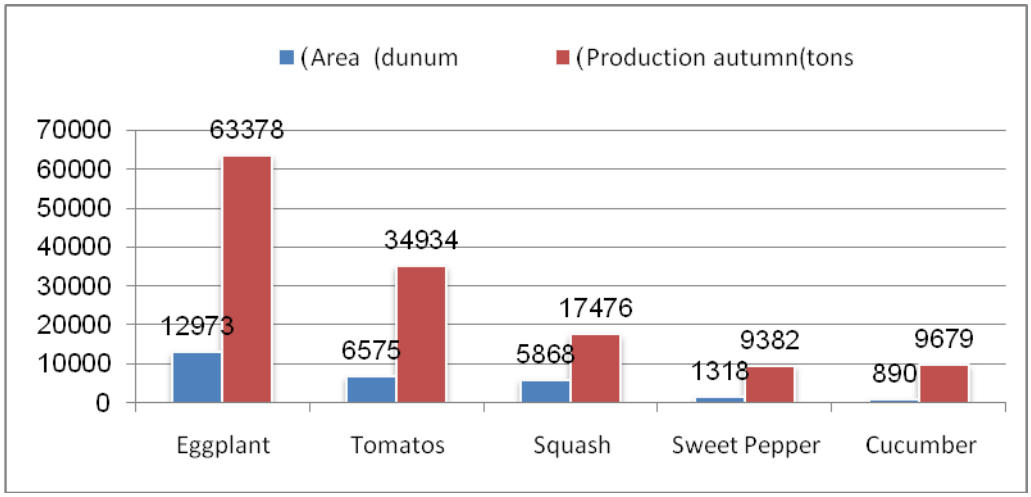
- Main five fruit crops



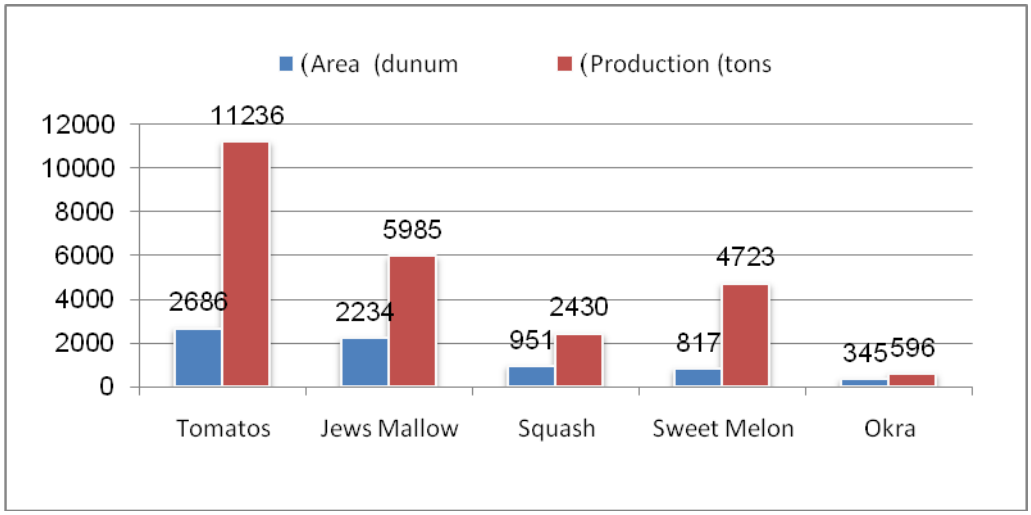
- Main five Field crops



- Main five vegetables crops (Autumn)

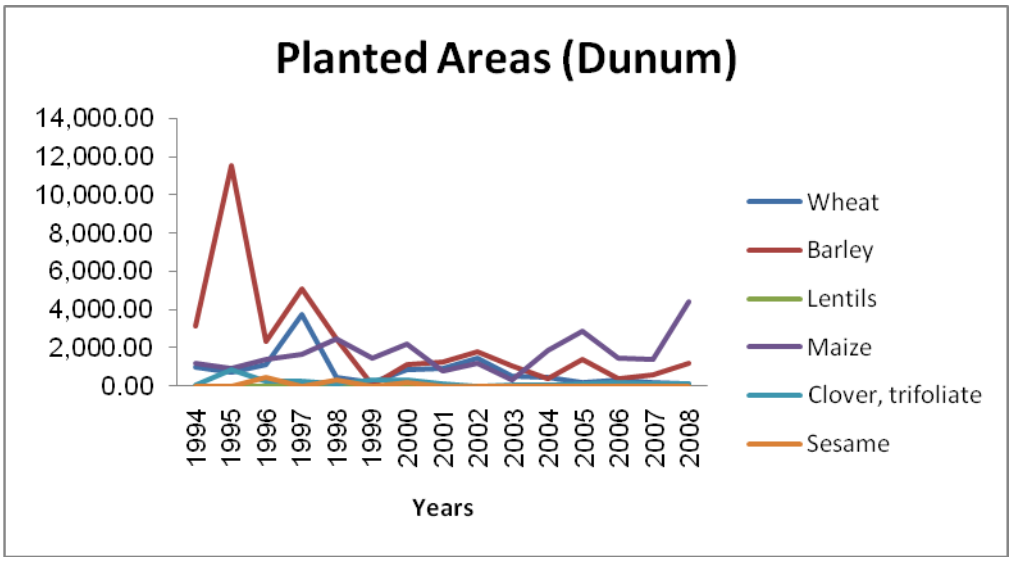


- Main five vegetables crops (Summer)

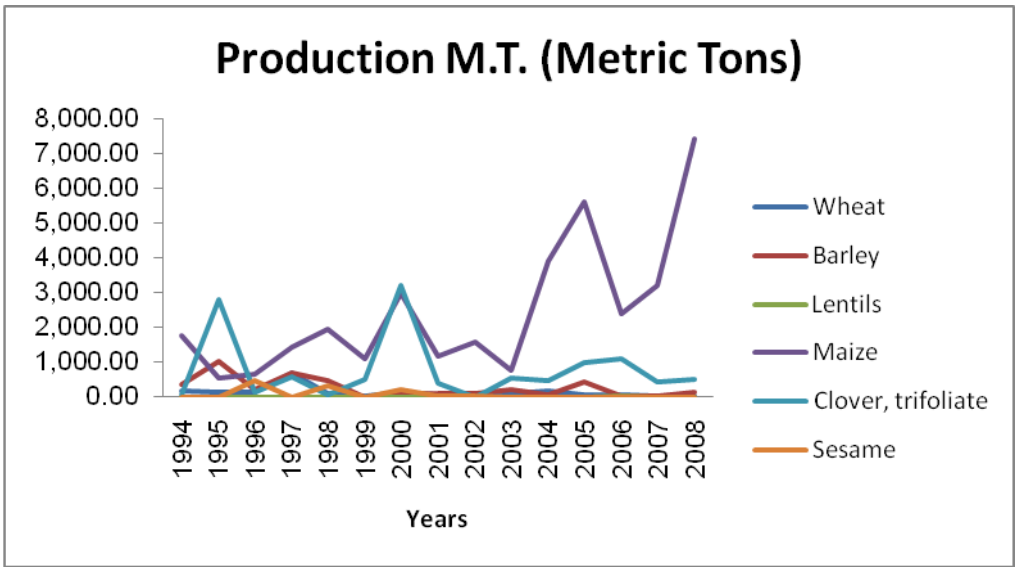


Charts below show the changes on planted area and production of field crops, fruit trees, and vegetables during the period 1994-2008 in Al-Shouneh Al-Janoubeyeh (source: DoS, 1978-200)

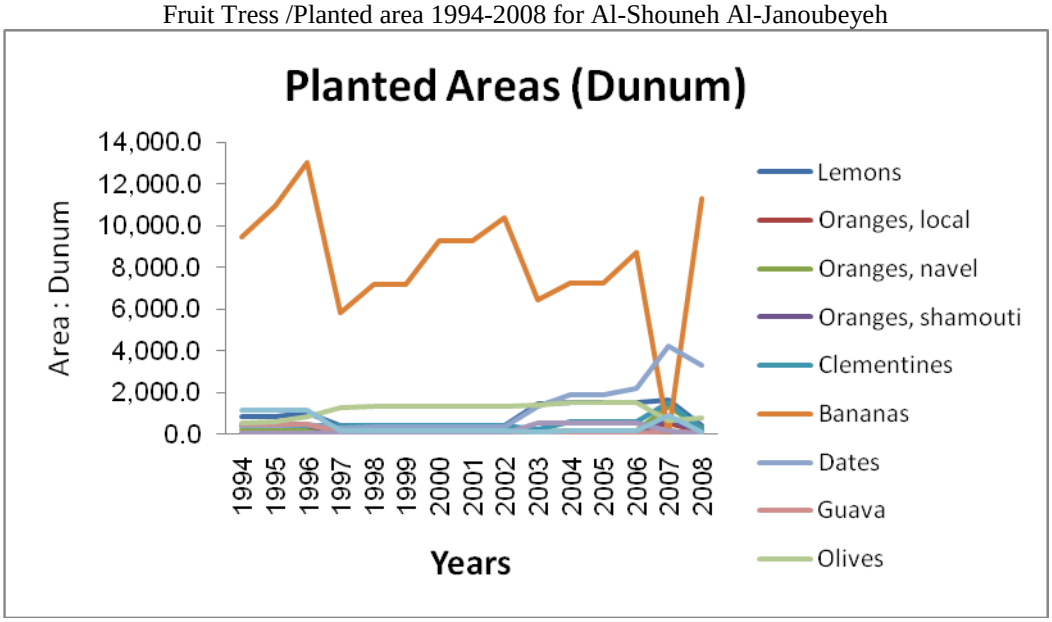
Filed Crops/Planted area 1994-2008 for Al-Shouneh Al-Janoubeyeh



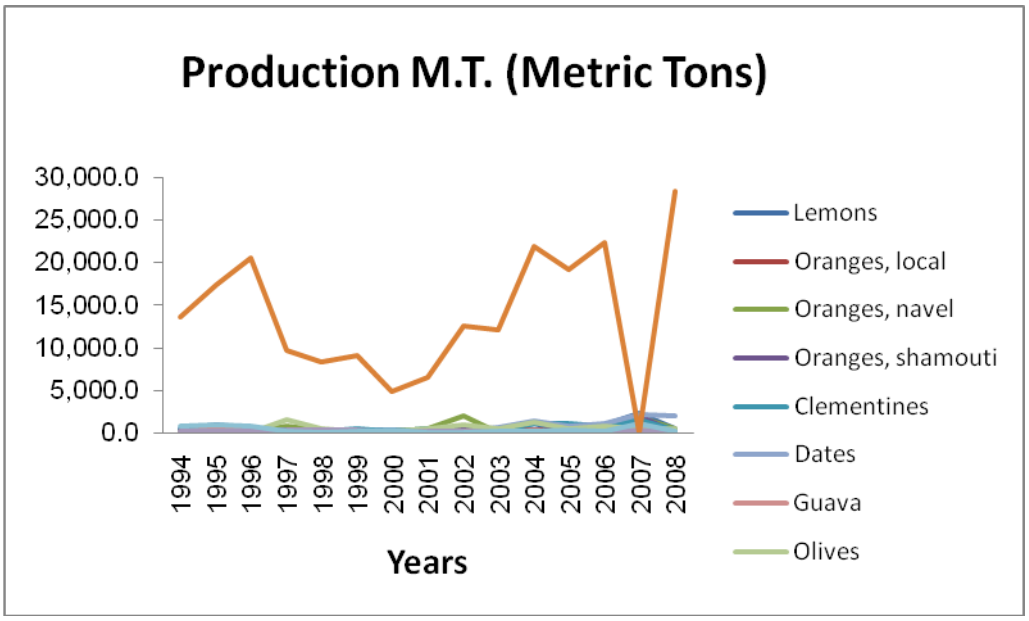
Filed Crops/Production 1994-2008 for Al-Shouneh Al-Janoubeyeh



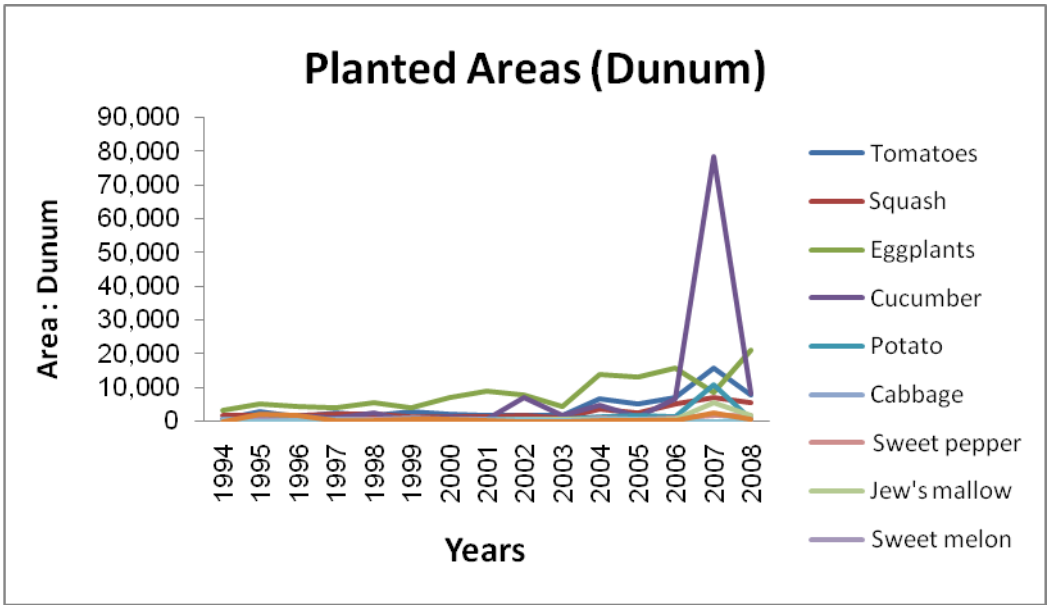
Fruit Tress /Planted area 1994-2008 for Al-Shouneh Al-Janoubeyeh



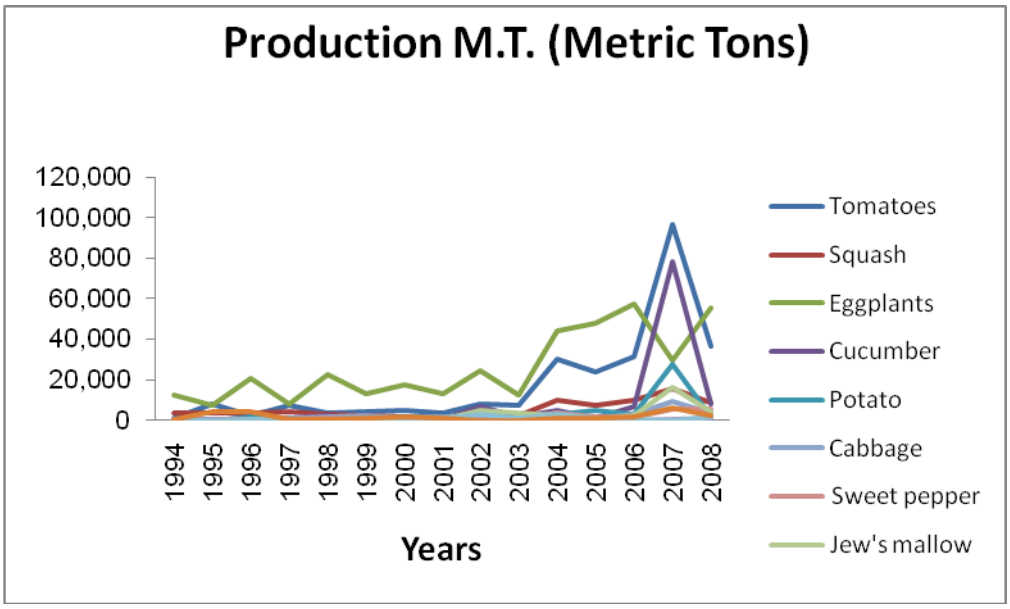
Fruit Tress /Production 1994-2008 for Al-Shouneh Al-Janoubeyeh



Vegetables /Planted area 1994-2008 for Al-Shouneh Al-Janoubeyeh



Vegetables /Production 1994-2008 for Al-Shouneh Al-Janoubeyeh



3. Climate Change

The country, located about 80 km east of the Mediterranean Sea, has an altitude that ranges from less than –400 m at the Dead Sea surface (lowest point on earth) up to 1,750 m at Jebel Rum. The country has three distinguished bioclimatic zones. The first zone is the Jordan Valley, which forms a narrow strip that is situated below the mean sea level with warm winters and hot summers and where irrigation is practiced. The second zone is the western highlands, where precipitation is in the range of 300 to 600 mm. The third zone, known as the "Badia", includes the arid and semi-arid areas in the eastern parts of the country, where the annual rainfall is below 200 mm. Badia is an Arabic word describing the open rangeland inhibited by Bedouins (nomads).
The climate of the country varies from one ecological zone to another. A dry sub-humid Mediterranean climate dominates a small area in the northwest of the country, where rainfall is more than 600 mm, while an arid climate dominates the areas with rainfall below 200 mm. An extremely dry hyper arid climate is found in the east, where rainfall is less than 50 mm. The rainy season is between October and May, with 80% of the annual rainfall occurring between December and March. The low rainfall amounts in Jordan limit the rain-fed agriculture to the zone of the western highlands, where fruit trees and cereals are cultivated and to parts of the steppe (area between western highlands and the Badia), where barley is cultivated to support grazing herds of sheep and goats.
Jordan recognizes that climate change is a serious and pervasive threat to humanity. The Intergovernmental Panel on Climate Change (IPCC), the highest scientific body of the United Nations Framework Convention on Climate Change (UNFCCC) responsible for evaluating the risk of climate change, affirmed in its Fourth Assessment Report (2007) that the "warming of the earth's climate system is unequivocal" and that this warming is attributed to the dramatic rise in human-induced greenhouse gas emissions since the mid-20th century.

Jordan faces potential serious impacts on its natural ecosystems, on its river basins and watersheds, on biodiversity, then cascading to impacts on food productivity, water resources, human health, public infrastructure, and human settlements. Climate change will have serious implications on the country's efforts to eradicate poverty and realize sustainable development for current and future generations, ultimately making climate change an issue of intergenerational equity. Climate change scenarios indicate that Jordan and the Middle East could suffer from reduced agricultural productivity and water availability among other negative impacts. At the same time, a substantial potential for cost-effective reduction of Green House Gases (GHG) emissions exists in Jordan.

Agriculture is one of the most sensitive sectors to climate change induced impacts. The increased temperatures and lower precipitation resulting from climate change would adversely affect crops and water availability, critically influencing the patterns of future agricultural production in Jordan. The main expected impacts of these scenarios are:

1. Decrease in available soil moisture for crops in the rain-fed areas,
2. Increased crop water requirement,
3. Increased crop/weed competition,

4. More frequent drought,
5. Decreased stream flow,
6. Changes in rainfall intensity with more possible floods,
7. Shortened growing season, and
8. Reduction in yield of rain-fed and irrigated crops.

As a result, the climatic change could affect agriculture in several ways:

- Productivity, in terms of quantity and quality of crops;
- Agricultural practices, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers;
- Environmental effects, in particular in relation of frequency and intensity of soil drainage, soil erosion, and reduction of crop diversity; and
- Land use: through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities.

3.1 Research Studies

The adverse impacts of climate change and global warming are mainly threatening water and food security in developing countries. The vulnerability of agriculture and food security to both climate change and climate variability is well established. The general consensus is that changes in temperature and precipitation will impact plant growth and crop yield and, subsequently, affect food security. In many developing countries, climate change is also expected to change farming systems and to put more pressure on the rural community to cope with these changes and build up their adaptive capacities. The problems resulting from climate change are also worsening by the rapid population growth and the unplanned conversion of cultivable lands into urban areas.

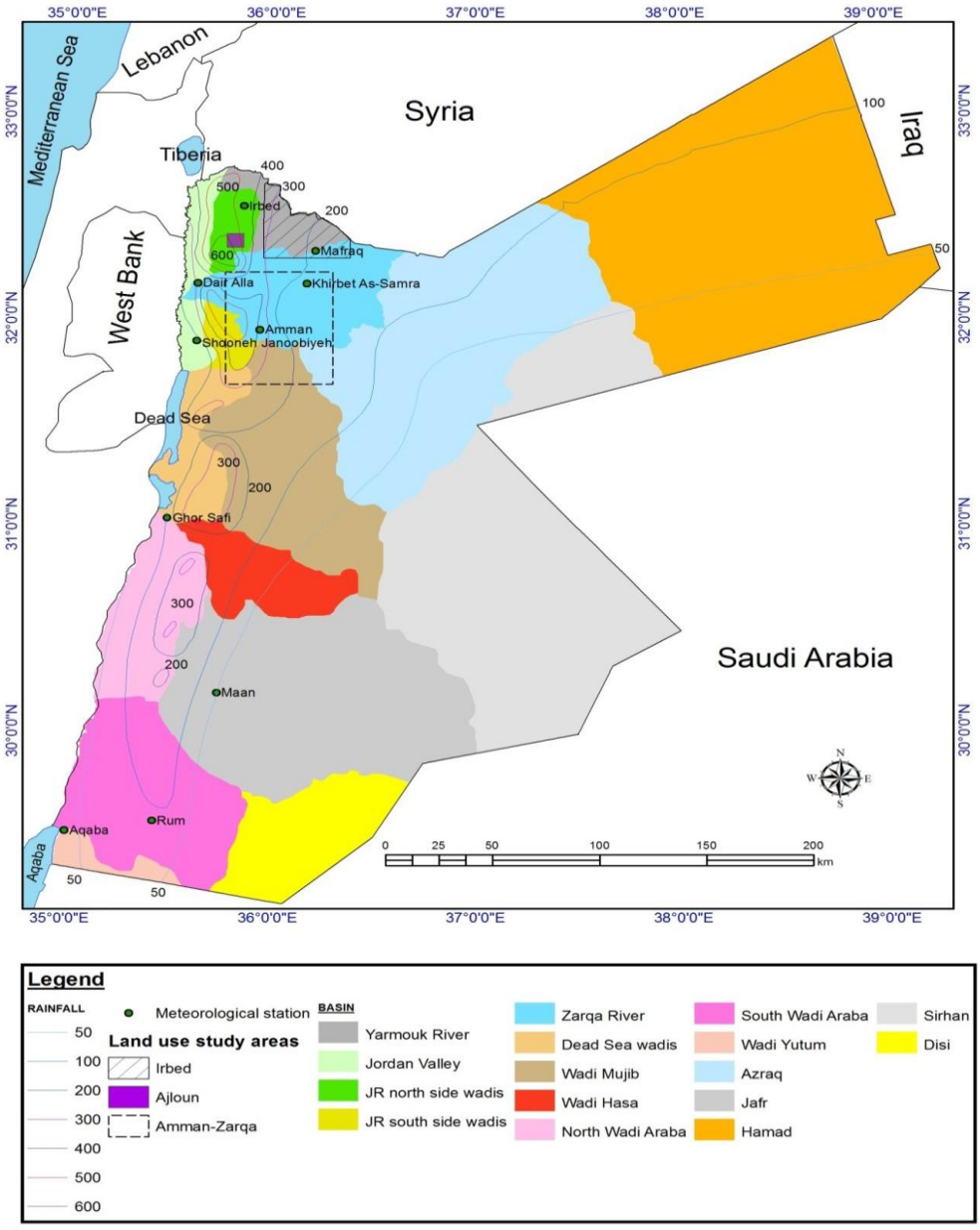
The link between adverse climate change and water and food security is related to changes in crop yield and levels of water consumption by agriculture and other sectors. The projected temperatures increase and precipitation reduction would adversely affect crops and water availability, thus critically influencing the patterns of future agricultural production.

In Jordan, the challenge to meet population needs from food and water is well-known at all levels. Water availability is likely to be the most sensitive to climate change induced impacts. In terms of water availability, Jordan is among the four driest countries in the world, with a per capita fresh water share of 145 m^3 per year, which is far below the international water poverty line of 500 m^3 per year. Due to the country's location (Figure 1) in the mid-latitudes, climate change is expected to have significant impacts on water supplies and agricultural production in Jordan. The country has limited water and land resources, which increases the competition for water among the different sectors. Jordan suffered from a high rate of population growth that resulted from the waves of refugees from the surrounding countries (Iraq and Syria) suffering from the political instability. The combined effects of climate change and population growth are expected to put more pressure on the limited land resources in Jordan and to increase the challenge of sustainable development in the country.

Several studies were carried out to characterize climate change in Jordan. A detailed analysis of mean monthly air temperature and mean annual rainfall was included in the country's second national communication (SNC) report to the UNFCCC. The

analysis was carried out for a time series of 45 years extending from 1961–2005 using a parametric trend test (linear trend) and non-parametric Mann-Kendall rank trend test. The data included the normal period of 1970–2005, which complied with the requirements of the World Metrological Organization (WMO) regulations, stating that the latest "normal period" extends from 1970 to 2000. The main findings were 8–20% decrease in rainfall occurring in most of the weather stations, with warming trends that showed an increase in the range of 1.0–1.8 °C in six stations, 0.5–0.9 °C in seven stations and 0.8–2.0 °C in nine stations.

Figure 1: The map of Jordan with surface water basins, rainfall isohyets and locations of land use study sites.



3.1.1 Climate Change and Crop Production in Jordan

A study was conducted by Jawad Al-Bakri *et al* (2013) and aimed at assessing the risks of climate change, population growth and land use change on water resources and food productivity in Jordan. The study formed a part of the efforts of the Food and Agriculture Organization of the United Nations (FAO) to support Jordan's activities in the area of capacity building and adaptation to climate change. In this study, impacts of climate change, land use change and population growth were assessed in relation to water and food security in Jordan.

Land use mapping was carried out using a set of images of Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) with a resolution of 15 meters and Landsat Thematic Mapper (TM) with a resolution of 30 meters. The approach was based on a combination of digital classification and visual interpretation of the images. The images were geometrically corrected using an image-to-image approach, while radiometric correction was carried out using the histogram matching method. To improve the mapping accuracy, a GIS layer of urban and agricultural areas was created using an on-screen interpretation and digitizing for the images. A layer of protected areas and grazing reserves was intersected with the map.

In order to estimate the available agricultural lands in the future, trends of land use/cover change were identified by mapping current and historical land use and its change for three representative sites (Figure 1) that would represent most of the land use/cover changes in the country. The first site extends from the capital, Amman, to Zarqa City, where more than half of the country's population is living. The site suffers from intensive urbanization at the cost of rain-fed and irrigated lands. The second site includes the city of Irbid and represents an area that suffered from urbanization, desertification, deforestation and the change of land use from rain-fed cereals into open rangelands. The third site is located in the Ajloun highlands, where forests are shifted into agricultural lands and land degradation is accelerated by mis-management of soils and crops. The selection of three sites can be justified by the fact that 76% of the country's population is living in these areas, which extended over the high rainfall zone and the Badia. As for Jordan Valley, land use is assumed to remain unchanged, as the reclaimed agricultural lands in this area are owned by the Jordan Valley Authority (JVA), which leases the units of lands for farmers to cultivate irrigated crops.

A summary of production changes for the major irrigated crops in the Jordan Valley and highlands is shown in Table 1. The irrigated area for each crop was obtained from the records of the DoS, while the ETc values were calculated using the FAO-56 method for the daily weather data for the period 1994–2008. The changes in production included the impacts of climate change (10% reduction by year 2050) and the trends of land use change in each area. Analysis of figures presented in Table 1 showed that the increase of air temperature by 2 °C would increase the net irrigation amount for potato and squash by 23%, while the combined impacts of increased air temperature and land use change would reduce the total production of most irrigated crops by 27%. These figures were pretty close to those reported for similar conditions in the West Bank.

Important findings from this study were also the variations in ETc and productivity among crops. These variations would suggest possible shifts in cropping patterns to cope with the problem of water shortage in the country. Apparently, banana and alfalfa would be seen as the main crops with highest water consumption among the irrigated crops, as their average annual ETc values reached 1,536 and 1,935 mm, respectively. Considering the ratio between productivity and ETc, known as water use efficiency (WUE), farmers might abandon the cultivation of important crops like wheat and olives. This could be concluded from the results of this study, which showed that WUE was higher for the vegetable crops of tomato and potato than for wheat and olives. Under climate change scenarios, WUE would decrease for all crops planted in Jordan (Table 1). Without improving irrigation efficiency, the average decrease in WUE would reach 9 and 17% by years 2030 and 2050, respectively.

Table 1: Current and projected change in crop production for major irrigated crops in Jordan.

Crop	Location	Present				Year 2050			
		ETc (mm)	Area (ha)	Production ($\times 10^3$ ton)	WUE (kg/ha/mm)	ETc (mm)	Area (ha)	Production ($\times 10^3$ ton)	WUE (kg/ha/mm)
Alfalfa	Khirbet As-Samra	1673	609	34.2	33.6	1754	444	24.9	32.0
Alfalfa	Aqaba	1935	479	25.5	27.5	2092	349	18.6	25.5
Apple	Maan	505	1,293	18.3	28.0	561	944	12.1	22.8
Banana	Shooneh Janoobiyeh	1536	826	13.7	10.8	1640	603	10.0	10.1
Citrus	Shooneh Janoobiyeh	731	388	5.3	18.7	781	283	3.8	17.2
Citrus	Deir Alla	834	661	6.7	12.2	929	483	4.9	10.9
Egg Plant	Deir Alla	267	532	17.2	121.1	305	389	11.3	95.2
Olive	Mafraq	562	7,039	11.2	2.8	607	5,138	7.3	2.3
Potato	Deir Alla	205	888	21.4	117.6	253	648	14.1	86.0
Potato	Rum	512	282	8.8	60.9	547	206	5.8	51.5
Squash	Deir Alla	185	580	10.6	98.8	228	424	7.0	72.4
Tomato	Ghour Safi	218	2,441	101.5	190.7	253	1,782	66.7	147.9
Tomato	Deir Alla	254	870	46.9	212.2	299	635	30.8	162.2
Tomato	Mafraq	499	1,850	96.2	104.2	533	1,350	63.2	87.8
Wheat	Irbed	736	5,027	6.2	1.7	832	3,519	3.5	1.2

Results showed that climate change and land use change would have adverse impacts on water and food security. Although the conversion of agricultural land to urban land use might be considered beneficial to water budget, as the municipal water requirements would be lower than the irrigation water requirements. This conversion, however, would indirectly increase water demand as more crop production would be needed to achieve food security. Therefore, building the adaptive capacity would still be needed at all levels to move towards transcendence. Adaptation measures in Jordan could include a wide range of activities targeting water scarcity. Findings from this study, however, implied that all measures should minimize the gap between supply and demand. Since the agricultural sector would remain the main consumer of water, some of the proposed measures at farm and community level might include, but are not limited to, the following:

(a) Modification of cropping pattern

This adaptation measure was supported by findings from this study, which showed that some crops had lower WUE than other crops, *i.e.*, they consumed more water and produced less food. Among these irrigated crops are banana and olives. Also, WUE

would differ from one geographical location to another. For example, WUE for potato in the Jordan Valley would reach 86 kg/ha/mm compared to 52 kg/ha/mm for the same crop in Rum (desert area). These figures would favor the cultivation of potato in the Jordan Valley rather than in the highlands. This adaptation measure would also include the intrusion of new crop varieties with high WUE.

(b) Reuse of treated wastewater

Due to population growth, more wastewater would be generated from urban and rural areas. Therefore, this source of water should be developed and utilized in a sustainable manner. One option would be the reuse of treated wastewater for irrigating fodder crops, provided that water would meet the standards for its reuse. Also, soil suitability for this option should be investigated. It should be mentioned here that treated wastewater is being reused for irrigation in the Jordan Valley for more than two decades.

The impact of climate change on agricultural sector was addressed in the Jordan's Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). In order to assess the vulnerability of agriculture sector to climate change, the sub-sectors of plant and animal production were analyzed using the data from DoS for the period 1996-2006. This period was only used to analyze agricultural sector (baseline conditions) and not to assess the impact of climate change, which was assessed by the use of longer period of data (27 years). The trends and variations among years were evaluated in relation to rainfall.

Data from DoS showed that during 1996-2006, the irrigated area was about 75 thousands ha while the total rain-fed area was about 132 thousands ha. On average, 33 percent of rain-fed areas were cultivated with wheat while 58 percent were cultivated with barley. Both crops formed important source of feed for sheep and goats whose numbers were estimated at 2.7 million heads. Data showed that the harvested areas for both wheat and barley were less than the cultivated ones, which was attributed to crop failure due to drought conditions and erratic rainfall distribution. Therefore, both crops were selected to assess the impact of climate change on rain-fed agriculture in Jordan.

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